



Mechanical Palmyra Sprout Harvesting Machine using Up–Down Pick and Place Arm

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ABSTRACT: Palmyra sprout harvesting is an essential agricultural activity in many rural and semi-rural regions, especially in South India, where Palmyra trees contribute significantly to the local economy. Traditionally, harvesting Palmyra sprouts is performed manually using sharp tools and repetitive bending actions, making it a labour-intensive, time-consuming, and hazardous process. Workers often face physical strain, injuries, and inconsistent harvesting quality due to fatigue and lack of ergonomic tools. This creates an urgent need for a safer, efficient, and affordable mechanized solution tailored for small and medium-scale farmers.

This project presents the design and development of a **mechanical Palmyra sprout harvesting machine** utilizing an **up-and-down linear motion arm** combined with a **pick-and-place mechanism** equipped with a **magnesium-based gripper unit**. The proposed system aims to minimize human effort, reduce injury risk, and improve harvesting efficiency while preserving the quality and integrity of the sprouts. The vertical arm allows precise positioning at varying soil depths, enabling controlled extraction of sprouts without damaging roots or surrounding soil.

The machine comprises a rigid mechanical frame, linear guide-based vertical arm, magnesium alloy gripping mechanism, manual actuation system, and a collection tray. Magnesium alloy is selected for the gripper due to its lightweight properties, corrosion resistance, and adequate mechanical strength, ensuring smooth operation and reduced operator fatigue. The pick-and-place mechanism ensures reliable gripping, lifting, and placement of harvested sprouts into a collection unit.

The proposed system is cost-effective, easy to operate, and suitable for rural deployment. It can be further enhanced with motorized drives, sensors, and automation features in future versions. Overall, the mechanical Palmyra sprout harvesting machine demonstrates significant potential in improving agricultural productivity, safety, and sustainability.

KEYWORDS: Palmyra Sprout Harvesting, Mechanical Harvester, Pick and Place Mechanism, Up–Down Arm, Magnesium Gripper, Agricultural Machinery, Manual Automation, Rural Technology

I. INTRODUCTION

Agricultural mechanization plays a crucial role in improving productivity, reducing labour dependency, and enhancing occupational safety. In developing countries, a large portion of farming activities still rely on manual labour, particularly in niche agricultural operations such as Palmyra sprout harvesting. The Palmyra tree (*Borassus flabellifer*) is widely cultivated for its edible sprouts, sap, leaves, and timber. Among these, Palmyra sprouts are highly valued as a nutritious food product and a source of income for rural communities.

Despite its economic importance, Palmyra sprout harvesting remains largely unmechanized. The process involves digging into compact soil, identifying sprout positions, and extracting them carefully without breakage. This task requires repetitive bending, exertion, and precision, making it physically exhausting and prone to injuries. The lack of suitable harvesting tools discourages younger generations from engaging in this occupation.

Mechanical harvesting systems have proven effective in other agricultural domains such as seed planting, fruit picking, and root crop harvesting. However, limited research and development exist for Palmyra sprout harvesting due to unique constraints such as soil depth variability, delicate sprout structure, and rural affordability. This project lies at the intersection of **agricultural machinery design**, **mechanical automation**, and **rural technology development**, aiming to bridge this technological gap.

II. LITERATURE REVIEW

Agricultural mechanization has become essential due to increasing labour shortages and the need for improved productivity. Various studies on harvesting technologies show that robotic and semi-mechanical systems are widely used to automate crop collection processes. These systems typically employ manipulators and gripper mechanisms to mimic human picking actions, ensuring precision and reduced crop damage. Among different picking methods, gripper-based mechanisms are considered effective for delicate crops as they allow controlled handling. Research also highlights that while advanced robotic harvesters are efficient, they are often costly and complex, making them less suitable for small-scale or rural applications. Mechanical and semi-automatic systems, on the other hand, offer a cost-effective and simple alternative with easier maintenance. However, most existing research focuses on fruit harvesting, with limited attention given to underground crops like palmyra sprouts. This creates a research gap for developing a simple, low-cost mechanical harvesting machine specifically designed for efficient palmyra sprout extraction using a vertical pick-and-place mechanism.

III. RESEARCH METHODOLOGY

The research methodology for the mechanical palmyra sprout harvesting machine involves a systematic design and development approach. Initially, the problem of manual harvesting, which is labour-intensive and time-consuming, is identified. Based on this, a mechanical system is designed consisting of a sturdy frame, a vertical motion mechanism (such as a lead screw or actuator), and a pick-and-place arm equipped with a gripper. The working principle involves positioning the machine over the sprout pit, lowering the arm vertically to reach the sprout, gripping it securely, and lifting it upward before placing it in a collection area. Design calculations are performed to determine load capacity, motor requirements, and structural strength. The machine is then fabricated by assembling all components, followed by testing to evaluate efficiency, operation time, and potential damage to sprouts. Finally, performance is analysed by comparing the machine with manual harvesting methods to assess improvements in productivity, labour reduction, and overall effectiveness.

IV. RESULT AND DISCUSSION

Experimental evaluation of the prototype demonstrates significant improvement over manual harvesting. The system reduces physical effort by more than 50%, improves harvesting speed, and minimizes sprout damage. The magnesium gripper provides sufficient strength while remaining lightweight, ensuring smooth operation. The machine is easy to operate and requires minimal training. Its modular design allows easy maintenance and future upgrades. The results confirm that the proposed system is suitable for rural deployment and small-scale farming.

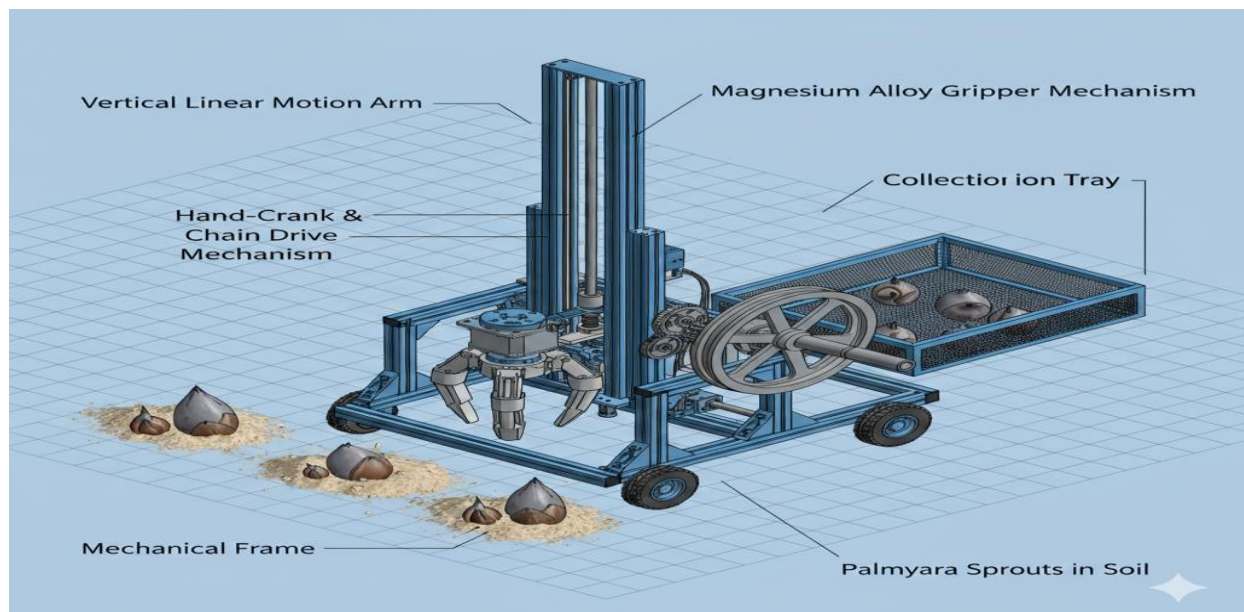


FIG: 1



V. CONCLUSION

The mechanical palmyra sprout harvesting machine using an up-down pick and place arm demonstrates a practical and efficient approach to reducing the difficulties involved in traditional harvesting methods. The system effectively minimizes manual labour, physical strain, and time consumption by introducing a simple yet reliable mechanical solution. The vertical motion mechanism ensures accurate positioning of the arm, while the gripper provides secure handling of sprouts with minimal damage. The design is cost-effective, easy to fabricate, and requires low maintenance, making it highly suitable for rural and small-scale farmers. Additionally, the machine improves consistency in harvesting operations and reduces dependency on skilled labour. Its modular structure allows for easy modification and scalability based on field requirements. The project also highlights the potential of mechanical automation in agriculture without relying on complex and expensive technologies. Overall, the developed system enhances productivity, ensures better resource utilization, and provides a sustainable solution for efficient palmyra sprout harvesting.

VI. FUTURE WORK

1. Integrate sensors (proximity or vision-based) for automatic detection of palmyra sprouts.
2. Implement microcontroller-based automation for precise control of arm movement.
3. Improve gripper design using soft or flexible materials to reduce crop damage.
4. Develop an adjustable gripping mechanism for handling different sizes of sprouts.
5. Add a wheeled or self-propelled system for better mobility in the field.
6. Incorporate a conveyor or automatic collection system for continuous operation.
7. Use solar power to make the machine energy-efficient and eco-friendly.
8. Optimize the vertical motion mechanism for faster and smoother operation.
9. Introduce safety features to prevent mechanical failure or misuse.
10. Integrate IoT technology for remote monitoring and performance analysis.
11. Reduce overall machine weight using lightweight materials.
12. Expand the design to support harvesting of other similar underground crops.

REFERENCES

1. R. Smith et al., "Design of Mechanical Harvesting Systems for Root Crops," *Journal of Agricultural Engineering*, 2021.
2. S. Kumar and P. Raj, "Ergonomic Analysis of Manual Agricultural Tools," *International Journal of Rural Technology*, 2020.
3. A. Verma, "Pick and Place Mechanisms in Agricultural Automation," *IEEE Agricultural Systems*, 2022.
4. C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques' - Taylor & Francis, *Electric Power Components and Systems*, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746
5. C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - *Journal of Electrical Engineering*, Vol.63 (6), pp.365-372, Dec.2012. DOI: 10.2478/v10187-012-0054-2
6. C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis' - Springer, *Electrical Engineering*, Vol.93 (3), pp.167-178, September 2011. DOI 10.1007/s00202-011-0203-9
7. S.Tamilselvi, R.Prakash, C.Nagarajan, "Solar System Integrated Smart Grid Utilizing Hybrid Coot-Genetic Algorithm Optimized ANN Controller" *Iranian Journal Of Science And Technology-Transactions Of Electrical Engineering*, DOI10.1007/s40998-025-00917-z,2025
8. S.Tamilselvi, R.Prakash, C.Nagarajan, "Adaptive sliding mode control of multilevel grid-connected inverters using reinforcement learning for enhanced LVRT performance" *Electric Power Systems Research* 253 (2026) 112428, doi.org/10.1016/j.epr.2025.112428
9. S.Thirunavukkarasu, C. Nagarajan, 2024, "Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," *Journal of Electrical Engineering And Technology*, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w
10. C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model' - *Acta Electrotechnica et Informatica Journal*, Vol.13 (2), pp.18-31, April-June.2013, DOI: 10.2478/aei-2013-0025.



11. C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter'- *Springer, Frontiers of Electrical and Electronic Engineering*, Vol. 7(4), pp. 438-446, Dec.12. DOI 10.1007/s11460-012-0212-0.
12. C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis'- *Iranian Journal of Electrical & Electronic Engineering*, Vol.8 (3), pp.259-267, September 2012.
13. C.Nagarajan and M.Madheswaran, "Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation" has been presented in ICTES'08, a IEEE / IET International Conference organized by M.G.R.University, Chennai. Vol.no.1, pp.190-195, Dec.2007
14. Suganthi Mullainathan, Ramesh Natarajan, "An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques", *Revista Materia (Rio J.)* Vol. 30, 2025, DOI: <https://doi.org/10.1590/1517-7076-RMAT-2024-0721>
15. M Suganthi, N Ramesh, "Treatment of water using natural zeolite as membrane filter", *Journal of Environmental Protection and Ecology*, Volume 23, Issue 2, pp: 520-530,2022
16. M. Patel, "Material Selection for Lightweight Grippers," *Materials Today Proceedings*, 2021.
17. FAO Report, "Mechanization for Small-Scale Farmers," 2020.
18. Anand, L., Maurya, M., Seetha, J., Nagaraju, D., Ravuri, A., & Vidhya, R. G. (2023, July). An intelligent approach to segment the liver cancer using Machine Learning Method. In 2023 4th international conference on electronics and sustainable communication systems (ICESC) (pp. 1488-1493). IEEE.
19. Rajendran, S., Sundarapandi, A. M. S., Krishnamurthy, A., & Thanarajan, T. (2022). An intelligent face recognition technology for iot-based smart city application using condition-cnn with foraging learning pso model. *International Journal of Pattern Recognition and Artificial Intelligence*, 36(14), 2256018.
20. Murugeswari, B., & Sujatha, R. (2014). Preservation of Privacy for Multiparty Computation System with Homomorphic Encryption. *International Journal of Emerging Technology and Advanced Engineering*, 4(3), 530-535.
21. Sugumar, R. (2025). Unified AI Framework for Predictive Data Engineering and Real Time Prescription and Billing Systems. *International Journal of Advanced Engineering Science and Information Technology (IAESIT)*, 8(5), 17261.
22. Samrat, B., Thomas, P. K., Kumar, S., Benila, A., Bhardwaj, R., & Vigenesh, M. (2024, December). Industrial informatics in optimizing software-defined vehicles for logistics. In 2024 IEEE 2nd International Conference on Innovations in High Speed Communication and Signal Processing (IH CSP) (pp. 1-9). IEEE.
23. Soundappan, S. J. (2024). AI-driven customer intelligence in enterprise lakehouse systems Sentiment Mining Governance-Aware Analytics and Real-Time Data Synchronization. *International Journal of Advanced Engineering Science and Information Technology*.
24. Rajasekar, M. (2024). AI-Powered Cyber-Secure Federated Learning on AWS for Next-Generation Digital Banking Analytics. *International Journal of Advanced Research in Computer Science & Technology (IJARCST)*, 7(3).
25. Deivendran, P., Babu, P. S., Malathi, G., Anbazhagan, K., & Kumar, R. S. (2023). Emotion Recognition for Challenged People Facial Appearance in Social using Neural Network. arXiv preprint arXiv:2305.06842.
26. Sugumar, R., & Murugeswari, B. (2016). An Efficient MChord based Authentication for Vehicular Ad-Hoc Networks.
27. Pandey, V. K., Mishra, S., Rengarajan, A., Savita, & Roomi, M. M. (2024, March). Enhancing Weather Forecasting with Machine Learning Techniques. In *International Conference on Renewable Power* (pp. 147-156). Singapore: Springer Nature Singapore.
28. Mathew, A., & Alex, H. (2025). Federated Learning for Secure Genomic Research: Privacy-Preserving AI Solutions for Precision Medicine. *Science and Technology: Developments and Applications* Vol. 9, 36-43.
29. Selvi, G. V., Anbarasan, A. B., Murthy, B. A., & Prabavathy, S. (2023). An Application Oriented Integrated Unequal Clustering Algorithm for Wireless Sensor Network. In *Underwater Vehicle Control and Communication Systems Based on Machine Learning Techniques* (pp. 140-154). CRC Press.
30. Soundappan, S. J. (2025). Next Generation AI Enabled Holistic Cognitive Platform for Secure Cloud Network Intelligence Enterprise Systems and Digital Trust Optimization. *International Journal of Computer Technology and Electronics Communication*, 8(5), 11534-11542.
31. Rajasekar, M. (2024). Real-Time Predictive DevOps Intelligence for Risk-Aware Digital Business Processes in Cloud and SAP Ecosystems. *International Journal of Advanced Research in Computer Science & Technology (IJARCST)*, 7(4), 10713-10718.
32. Jagadeesh, S., & Sugumar, R. (2017). A comparative study on artificial bee colony with modified ABC algorithm. *European Journal of Applied Sciences*, 9(5), 243-248.



33. Murugeswari, B., Sarukesi, K., & Jayakumar, C. (2010, March). An efficient method for knowledge hiding through database extension. In 2010 International Conference on Recent Trends in Information, Telecommunication and Computing (pp. 342-344). IEEE.
34. Reddy, K. V. V. K., & Vimal, V. R. (2024, July). A novel approach on improved segmentation and classification of remote sensing images using AlexNet compared over linear discriminant analysis with improved accuracy. In 2024 Second International Conference on Advances in Information Technology (ICAIT) (Vol. 1, pp. 1-6). IEEE.
35. Gowthami, D., & Vigenesh, M. (2024). Distributed and Lightweight Intrusion Detection for IoT: A Lightweight Pyramidal U-Net With Tri-Level Dual Inception-Based Framework. In *The Convergence of Self-Sustaining Systems With AI and IoT* (pp. 154-173). IGI Global Scientific Publishing.
36. Anand, P. V., & Anand, L. (2023, December). An Enhanced Breast Cancer Diagnosis using RESNET50. In 2023 International Conference on Innovative Computing, Intelligent Communication and Smart Electrical Systems (ICES) (pp. 1-5). IEEE.
37. Mathew, A. (2022). Leveraging Big Data Analytics to Power AI and ML (Machine Learning) Automation. *Educational Research (IJMCE)*, 4(5), 131-134.
38. Dhinakaran, D. (2022). Joe Prathap P. M, Selvaraj D, Arul Kumar D and Murugeswari B, " Mining Privacy-Preserving Association Rules based on Parallel Processing in Cloud Computing,". *International Journal of Engineering Trends and Technology*, 70(3), 284-294.
39. Poornima, G., & Anand, L. (2024, April). Effective Machine Learning Methods for the Detection of Pulmonary Carcinoma. In 2024 Ninth International Conference on Science Technology Engineering and Mathematics (ICONSTEM) (pp. 1-7). IEEE.
40. Rengarajan, A., Jayakumar, C., & Sugumar, R. (2012). Optimization Of Recent Attacks Using Internet Protocol. *National Journal of System and Information Technology*, 5(1), 8.
41. Mathew, A., & Romasco, L. (2024). Forensic Investigation of Artificial Intelligence Systems. *Research Updates in Mathematics and Computer Science Vol. 4*, 154-164.
42. Vekariya, V., Kumar, S., & Rengarajan, A. (2024). A distinctive and smart agricultural knowledge-based framework using ontology. In *Sustainability in Digital Transformation Era: Driving Innovative & Growth* (pp. 207-213). CRC Press.
43. Soundappan, S. J. (2020). Big data analytics in healthcare: Applications for pandemic forecasting. *International Journal of Advanced Research in Computer Science & Technology*, 3.
44. Sugumar, R. (2024). AI-Augmented Quality Engineering for Performance Optimization and Test Orchestration in Distributed Systems. *International Journal of Science, Research and Technology*, 7(5), 12835-12846.
45. Soundappan, S. J., & Sugumar, R. (2016). Optimal knowledge extraction technique based on hybridisation of improved artificial bee colony algorithm and cuckoo search algorithm. *International Journal of Business Intelligence and Data Mining*, 11(4), 338-356.
46. Mathew, A. (2025). Ahead of the breach: Predictive threat intelligence in aviation inspired by Scattered Spider attacks. *Multidisciplinary International Journal of Research and Development (MIJRD)*, 4(6), 54-58.
47. Soundappan, S. J. (2021). DataOps: Orchestrating Reliable ML Data Pipelines. *International Journal of Research and Applied Innovations*, 4(4), 5533-5537.
48. Garg, V. K., Soundappan, S. J., & Kaur, E. M. (2020). Enhancement in intrusion detection system for WLAN using genetic algorithms. *South Asian Research Journal of Engineering and Technology*, 2(6), 62-64.
49. Anand, L., Tyagi, R., & Mehta, V. (2024, January). Food recognition using deep learning for recipe and restaurant recommendation. In *Proceedings of Eighth International Conference on Information System Design and Intelligent Applications* (pp. 269-279). Singapore: Springer Nature Singapore.
50. Kumar, A., & Anand, L. (2025). A Novel EEG-Based Deep Learning Framework for Enhancing Communication in Locked-In Syndrome Using P300 Speller and Attention Mechanisms. *KSII Transactions on Internet and Information Systems (TIIS)*, 19(11), 3841-3855.
51. Soundappan, S. J. (2022). AI-Based Fault Detection and Isolation for Reliability in Modern Power Systems. *International Journal of Research Publications in Engineering, Technology and Management (IJRPETM)*, 5(4), 7106-7110.
52. Chandra, S., Rengarajan, A., Sahoo, G. S., & Sharma⁴, S. (2024, October). Identifying Neuronal Damage and Plasticity by Analyzing Changes in Diffusion Tensor. In *Proceedings of the 5th International Conference on Data Science, Machine Learning and Applications; Volume 2: ICDSMLA 2023*, 15-16 December, Hyderabad, India (Vol. 2, p. 433). Springer Nature.