



COCOASSIST AUTO FEDER: AN AUTOMATED COCONUT FERTILIZER APPLICATION SYSTEM

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Abstract - Coconut cultivation remains a vital agricultural activity in tropical regions, yet fertilizer application around coconut trees still depends heavily on manual labor. Traditional practices involving pit digging, fertilizer placement, and soil covering are labor-intensive, time-consuming, and often inconsistent due to human error and workforce shortages. This project addresses these limitations by developing an automated prototype capable of performing all stages of fertilizer application in a controlled and efficient manner. The prototype integrates mechanical hardware, electronic control systems, and embedded programming to automate the digging, dispensing, and covering operations. A high-torque auger creates the pit, a servo-controlled hopper dispenses fertilizer based on user-defined dosage, and a motorized brush completes soil covering. These components are governed by a microcontroller programmed for precise timing and sequential actuation. The model was constructed using lightweight materials, DC motors, a motor driver, a servo motor, and an Arduino controller. Testing of individual subsystems and the fully integrated system demonstrated consistent pit formation, accurate fertilizer release, and effective soil coverage. The outcomes confirm that automating fertilizer application can reduce labor requirements, improve dosage accuracy, and enhance the overall efficiency of coconut plantation management.

Key Words: *Automated Fertilizer Application, Coconut Plantation, Precision Agriculture, Embedded System, Arduino Uno, Auger Mechanism, Servo Motor, Soil Covering, Dosage Control, Agricultural Automation.*

1. INTRODUCTION

Coconut cultivation forms the backbone of plantation agriculture in many tropical regions, particularly in countries like India, Sri Lanka, Indonesia, and the Philippines. The coconut tree, often described as the "tree of life," demands proper agronomic care to maintain its productivity throughout its long lifespan. Among the most important cultural practices associated with coconut farming, fertilizer application stands out as a crucial operation. The coconut palm requires balanced nutrition for vigorous vegetative growth, stable yield, and resistance to environmental stress. Farmers traditionally dig

several small pits around each tree and manually apply fertilizers depending on the age of the tree. However, conventional fertilizer application methods are highly labor-intensive, time-consuming, inconsistent, and inefficient.

Labor shortages in rural agricultural areas have further heightened the difficulty of performing such manual tasks. Increasing wage costs and the physical strain associated with digging and fertilizer placement create substantial challenges, particularly in large coconut fields. Conventional methods also result in inconsistent fertilizer dosages, leading to nutrient imbalances that can negatively impact tree growth and soil health. Moreover, manual operations often depend heavily on the worker's skill and experience, making the process highly variable and prone to human error.

With the growing emphasis on increasing agricultural efficiency and mechanization, there is an urgent need to develop automated systems that improve the precision and consistency of essential agricultural tasks. The prototype developed in this study aims to serve as a conceptual foundation for such innovations by integrating mechanical and electronic technologies to automate fertilizer application for coconut trees. The system includes three essential subsystems: a digging mechanism that prepares the pit, a dispensing mechanism that releases the fertilizer based on a user-defined dosage, and a soil-covering mechanism that restores the soil. All these operations are coordinated through a microcontroller to ensure smooth and predictable workflow.

1.1 Problem Statement

Coconut farmers face persistent difficulties in applying fertilizers because the task requires both physical strength and precision. Manual digging demands considerable effort, especially in fields where multiple trees must be fertilized at regular intervals. The dosage applied to each tree often varies due to inconsistencies in human judgment, leading to inefficient fertilizer usage, increased cost, and decreased productivity. The core problem addressed by this project is the lack of a mechanized system that can automate the delicate and repetitive tasks involved in coconut fertilizer application.

1.2 Objectives

The primary objective of this study is to design and develop a fully functional prototype that automates the major steps of fertilizer application in coconut plantations. Specific objectives include: (i) integrating mechanical and electronic subsystems to perform agricultural tasks in a structured and controlled sequence; (ii) enabling user-defined fertilizer dosage input regulated through a servo-controlled gate mechanism; (iii) achieving consistent pit formation using a high-torque motor and auger bit; and (iv) demonstrating feasibility for future scaling to field-ready machines.

2. OBJECTIVES

The primary objectives of this study are:

- To develop an organic waste-derived plant sunscreen spray using banana stem, fruit peel, tea waste, and aloe vera gel through simple extraction and formulation methods.
- To evaluate the spray's effectiveness in reducing leaf surface temperature and sunburn symptoms under natural field conditions.
- To assess the impact of the protective coating on overall plant growth, foliage quality, and canopy development in tomato and chilli plants.
- To confirm the absence of phytotoxic effects and to determine spray stability and practical field-use suitability.
- To promote a sustainable, low-cost approach to crop protection that utilizes agricultural bio-waste and supports eco-friendly farming.

3. LITERATURE REVIEW

The literature concerning automated fertilizer application, mechanized digging systems, soil nutrient delivery mechanisms, and agricultural automation reveals significant progress in the integration of mechanical design, electronics, and intelligent control systems in modern farming. Several researchers have emphasized the importance of replacing manual labor with automated systems to improve consistency, efficiency, and productivity in plantation-based agriculture.

Manivannan, Raut, and Prasad (2022) examined the growing need for mechanized fertilizer application in perennial crops such as coconut and oil palm. Their semi-automated unit consisting of a motorized auger, a controlled dispenser, and a soil covering mechanism demonstrated that mechanized systems improve work speed by over 40% and enhance dosage accuracy by up to 30%. The study validates the technical choice of incorporating microcontroller-based prototypes integrating drilling, dispensing, and soil covering.

Nandakumar and Suresh (2020) explored the application of auger-driven mechanisms for improving the efficiency of pit excavation in plantation-based agriculture. Through extensive field trials, they reported that auger systems exhibit superior digging speed and depth consistency compared to conventional methods. The study emphasized that higher torque motors facilitate better penetration into resistant soils and validated the engineering rationale behind adopting an auger-based design.

Prakash and Udhayakumar (2021) investigated controlled fertilizer dispensing technologies. The study reveals that servo motors are highly effective for precision dispensing, achieving over 95% accuracy in fertilizer measurement compared to manual techniques. The insights reinforce the suitability of incorporating a servo-controlled hopper and Arduino-based control system for accurate fertilizer delivery.

Harikrishnan and Lokeswari (2021) demonstrated that integrating controlled dispensing units, such as servo-operated gates, enhances precision in agricultural fertilizer management. Their prototype showed improved uniformity in fertilizer placement and reduced wastage in comparison to traditional broadcasting methods.

Thilakar and Kumaravel (2019) discussed the rapid technological transition in plantation agriculture through the adoption of mechatronic systems. The study provides examples of existing automation techniques used in coconut and rubber plantations, reinforcing the multidisciplinary approach used in the present project.

3. METHODOLOGY

3.1 Design Approach

The design approach originated from a detailed analysis of traditional fertilizer application practices. The manual process involves digging pits at a specified distance from the tree trunk, dispensing fertilizers based on the age and nutritional requirement of the tree, and covering the soil afterward. The design was segmented into three core functional units: (i) the digging unit using an auger-driven system; (ii) the fertilizer dispensing unit with a servo-controlled gate hopper; and (iii) the soil-covering unit with a motor-driven brush mechanism. An Arduino microcontroller was chosen as the control center due to its reliability, ease of programming, and ability to interface with motors and sensors.

3.2 Fabrication and Assembly

The fabrication process involved constructing each mechanical subsystem and assembling them into a unified working prototype. The frame was constructed using plywood and mild steel to provide structural strength and stability. The digging motor was mounted vertically with the auger bit aligned perpendicular to the base for consistent pit formation. The

fertilizer hopper was installed above the drilling area with the servo motor controlling the gate calibrated for smooth operation. The electronic assembly required meticulous wiring with insulated wires to ensure safety, while the microcontroller was placed on a vibration-free mount.

3.3 Software Development

The software was developed using the Arduino IDE in a structured manner. The program initialized all motors, servos, and input interfaces, then awaited user input for fertilizer dosage. The dosage determined the duration for which the servo-operated gate would remain open. After receiving dosage input, the program activated the digging mechanism for a calibrated period, then triggered the dispensing subsystem, and finally activated the soil covering mechanism. Additional features such as servo angle calibration, delay functions, and safety constraints were incorporated to ensure operational reliability.

3.4 Testing Procedures

Testing began with individual subsystem testing. The digging mechanism was evaluated by running the auger in soil under different conditions to test penetration ability, depth consistency, and stability. The fertilizer dispensing mechanism was tested using a weighing scale beneath the hopper outlet for repeated calibration. The soil covering mechanism was tested by manually creating pits and observing how effectively the rotating brush returned soil. Final integrated tests confirmed smooth sequential operation.

4. MATERIALS AND METHODS

4.1 Mechanical Components

The mechanical components formed the physical backbone of the automated fertilizer applicator. The auger drill bit was selected for its proven ability to penetrate soil efficiently while maintaining a consistent hole diameter. A high-torque DC gear motor was used to drive the auger with torque rating carefully evaluated for coconut plantation soil conditions. The prototype hopper was fabricated from PVC or acrylic material for its lightweight and moisture-resistant properties, with a servo motor-controlled gate at the outlet for controlled fertilizer release. The soil covering mechanism utilized a motor-driven brush assembly simulating the manual action of pushing soil back into the pit.

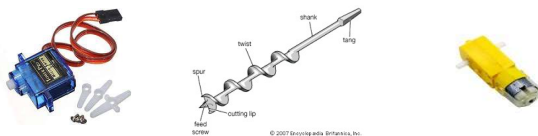
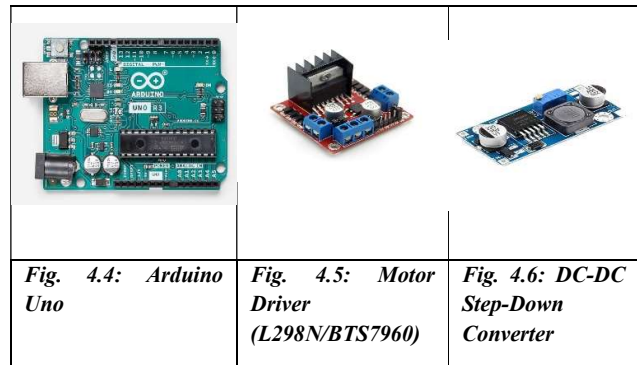


Fig. 4.1: Servo Motor *Fig. 4.2: Auger Drill Bit* *Fig. 4.3: DC Gear Motor*

4.2 Electronic Components

The electronic components served as the control center of the entire prototype, ensuring precise coordination between mechanical actions. The Arduino Uno microcontroller was selected for its ease of programming and compatibility with a variety of input and output modules. The motor driver regulated power distribution to the auger motor and the soil covering motor. A 12-volt DC power source was used to drive the motors, while voltage regulators ensured stable operation of the microcontroller and servo motor. A DC-DC step-down converter maintained appropriate voltage levels across the system.



4.3 Product Design and Physical Implementation

The developed automatic coconut fertilizer mechanism is engineered as a compact, robust, and efficient system capable of automating the complete fertilizer application process with minimal human intervention. The structural framework is fabricated using durable materials such as mild steel or reinforced plywood, ensuring mechanical strength and stability during field operation. The digging mechanism consists of a vertically mounted auger driven by a high-torque DC motor, ensuring efficient penetration and consistent pit formation. An enlarged fertilizer hopper is mounted above the auger assembly with a conical base to facilitate smooth material flow and prevent clogging. The soil covering mechanism is positioned at the rear end of the system, consisting of a rotating brush or blade arrangement powered by a DC motor.

4.4 Three-Dimensional Conceptual Design

The three-dimensional conceptual design provides a detailed representation of the system architecture, illustrating the spatial arrangement and integration of various components. The auger mechanism is centrally aligned for accurate pit formation. The fertilizer hopper is positioned directly above the auger to enable gravity-assisted flow. The soil covering mechanism is

strategically placed behind the dispensing unit to complete the operation in a continuous sequence.



Fig 5.1: 3D Conceptual Design



Fig 5.2: Working Model in Field

Fig. 4.7: Three-Dimensional Conceptual Design of the COCOASSIST AUTO FEDER System

4.5 Cost of Production

Table 1 presents the estimated cost of production for the prototype. The estimated cost per unit ranges from ₹7,500 to ₹8,500.

The proposed selling price of the system, considering production cost, operational expenses, and market demand, is recommended at ₹11,000 to ₹13,000. Reduced fertilizer wastage and lower labor requirements indicate favorable long-term financial benefits for farmers.

S.No	Component	Quantity	Cost (INR)
1	Arduino Uno Microcontroller	1	600
2	High Torque DC Motor (Auger)	1	1,200
3	Servo Motor (Gate Control)	1	300
4	DC Motor (Soil Covering)	1	500
5	Motor Driver Module	1	350
6	Auger Drill Bit	1	800
7	Hopper (PVC/Acrylic)	1	400
8	Structural Frame (Metal/Plywood)	1	1,500
9	Power Supply & Battery	1	700
10	Wiring, Connectors, Miscellaneous	-	500
11	Assembly & Fabrication	-	800
Total Estimated Cost per Unit:			₹7,500 – ₹8,500

Table 1: Cost of Production Estimation

5. RESULTS AND DISCUSSION

5.1 Field Testing and Data Collection

The developed automatic coconut fertilizer mechanism was subjected to extensive field testing in a real coconut plantation environment to evaluate its operational performance, reliability, and adaptability under practical agricultural conditions. The testing was systematically conducted on multiple coconut trees at varying distances from the trunk to ensure that the system could perform consistently across different locations within the field. The experimental setup was carefully designed to simulate real-world usage by exposing the mechanism to a range of soil conditions including dry, moderately moist, and wet soil, thereby enabling a comprehensive assessment of its performance under diverse environmental scenarios. The system was pre-programmed to dispense a fixed and agronomically recommended quantity of fertilizer of 500 grams per cycle, ensuring that nutrient delivery remained consistent and measurable throughout all test runs. Key performance parameters such as pit formation time, fertilizer dispensing

duration, uniformity of distribution, and system response time were meticulously recorded across five independent trials to establish reliable performance benchmarks. Additional environmental factors including ambient temperature, soil texture, and surface moisture levels were also monitored during each trial, as these variables directly influence both soil penetration efficiency and the rate of fertilizer absorption into the root zone. Each trial was repeated multiple times under identical conditions to minimize observational error and to validate the repeatability and accuracy of the collected data, ensuring that the performance trends identified were statistically meaningful and practically relevant.

5.2 Observed Performance Data

Table 2: Observed Performance Data During Field Testing

Trial	Soil Condition	Fertilizer Dispensed (g)	Time (sec)	Observation
1	Dry Soil	500	35	Uniform distribution
2	Moderate Moisture	500	32	Efficient absorption
3	Wet Soil	500	30	Slight delay in penetration
4	Dry Soil	500	34	Consistent output
5	Moderate Moisture	500	31	Optimal performance

5.3 Result Analysis

The analysis of the experimental data reveals that the system performs effectively under varying field conditions. The fertilizer dispensing mechanism maintained a consistent output of 500 grams in all trials, indicating precise control over the dispensing process. The time taken for operation showed minor variations depending on soil conditions. In dry soil, higher resistance to auger penetration resulted in slightly increased operation time (35 seconds), while moderately moist soil provided optimal conditions with a mean operation time of 31.5 seconds. The results confirm that the automated mechanism significantly improves efficiency compared to manual methods.

5.4 System Performance Discussion

The overall system performance during testing was stable and reliable. The auger mechanism operated smoothly without any mechanical failure or excessive vibration. The fertilizer dispensing unit functioned effectively with the servo-controlled gate regulating fertilizer flow accurately and no clogging observed during the trials. The microcontroller-based control system responded accurately to programmed instructions, ensuring proper synchronization between digging, dispensing, and soil covering operations. However, soil hardness had a

direct impact on operation time, and extremely wet conditions affected soil handling efficiency. These observations suggest the need for adaptive control systems in future iterations.

5.5 Phase I and Phase II Summary

We concentrated on prototype development, subsystem integration, and controlled laboratory evaluation. Fabrication of the structural frame and installation of the auger drilling assembly were completed. Repeated trials confirmed uniform pits with consistent depth and diameter. The fertilizer dispensing mechanism demonstrated accurate release of fertilizer quantities corresponding to programmed timing intervals. We focused on performance assessment in simulated field environments. Calibration improvements enhanced dosage accuracy, and the hopper design supported uninterrupted material flow. An economic evaluation confirmed the system's estimated production cost positions as an affordable alternative to labor-intensive methods.

6. CONCLUSION

The automatic coconut fertilizer mechanism developed in this project presents an effective and practical solution to enhance fertilizer application in coconut cultivation. The proposed system successfully addresses the challenges of manual fertilizer application by incorporating automation into the fertilizer application process. The integration of mechanical and electronic components enables the system to perform critical operations such as pit formation, controlled fertilizer dispensing, and soil covering in a sequential and synchronized manner, ensuring that each coconut tree receives an accurate and consistent quantity of fertilizer.

One of the key advantages of the developed mechanism is its ability to minimize fertilizer wastage. Precise dispensing ensures that only the required amount of fertilizer is applied, preventing excessive usage that can lead to soil degradation and environmental pollution. Another significant benefit is the reduction in labor dependency, enabling farmers to cover larger areas within a shorter duration while maintaining uniformity in application.

The field testing demonstrated that the system performs reliably across different soil conditions. Future developments may include the integration of sensor-based nutrient monitoring, adaptive control systems for varying soil conditions, and compatibility with mobile or autonomous platforms. The developed system contributes to the advancement of precision agriculture by promoting efficient resource utilization and reducing operational constraints, representing a significant step toward modernizing agricultural operations in coconut farming.

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