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Automated Solid Fertilizer Distribution Machine Using IoT and Sensor Technology

Ankita Nagnath Jadhav[1], Prathamesh Narayan Virape[2], Dnyaneshwar Ganesh Gond[3], Yash Shravan Shelake[4], Satyajeet Dipak Mokashi[5], Vaishnavi Amar Awatade[6]

[1](B.Tech Student, Dept.of Mechanical Engineering, SVERI College of Engineering Pandharpur, Solapur)
[2,3](B.Tech Student, Dept.of Computer Science & Engineering, SVERI College of Engineering Pandharpur)
[4,5](B.Tech Student, Dept.of Electronic & Telecom. Engineering, SVERI College of Engineering Pandharpur)
[6](B.Tech Student, Dept.of Civil Engineering, SVERI College of Engineering Pandharpur)

ABSTRACT

Agriculture plays a crucial role in India's economy, but traditional fertilizer application methods are still manual, time-consuming, and often inaccurate. Farmers frequently face uneven fertilizer distribution, leading to nutrient imbalance and reduced yield. To overcome this, we developed an IoT and Sensor-Based Automated Solid Fertilizer Distribution Machine that provides precise, smart, and uniform fertilizer application. This machine distributes only solid fertilizer based on plant detection using sensors and a microcontroller. The farmer controls the system through a mobile app interface, where they can set fertilizer quantity, operation mode, and movement speed. The sensors detect each plant's position and release the fertilizer accurately near its roots. If crops are not planted in straight lines, the system uses a controlled spreading mechanism to ensure balanced coverage. This machine is suitable for multiple crops like maize, jowar, sugarcane, wheat, and bajra, and its modular and adjustable design allows easy use on different farm sizes. Experimental results show reduced fertilizer wastage, lower labor effort, and increased productivity. The system represents a step toward affordable and smart automation in Indian agriculture.

Keywords: *IoT, Sensors, Automation, Fertilizer Distribution, Smart Farming, Adjustable System.*

1. INTRODUCTION

Fertilizer management is a vital aspect of modern agriculture as it directly influences soil fertility, crop growth, and overall yield. Traditional methods of fertilizer application are mostly manual, which require more labor, time, and often result in uneven distribution. Overuse of fertilizers damages soil health and increases cost, while underuse reduces plant productivity. To overcome these issues, the proposed system introduces an IoT and sensor-based automated solid fertilizer distribution machine that detects plant presence using infrared and proximity sensors and precisely releases fertilizer near the root area. The machine is fully controlled through a mobile application, allowing farmers to monitor and adjust the fertilizer level remotely. It ensures uniform fertilizer distribution for multiple crops like maize, jowar, sugarcane, and bajra, regardless of row pattern. The system is designed with an adjustable frame and dual outlet discs for efficient spreading in various field conditions. This innovation minimizes human effort, reduces fertilizer wastage, saves time, and enhances field efficiency. By integrating mechanical design, electronics, and IoT technology, the project promotes smart and sustainable farming for future agriculture.

2. SYSTEM DESIGN

The machine is designed with several main components:

2.1 Main Control Unit:

Acts as the brain of the system (Arduino) controlling all sensors, motors, and communication functions.

Fig. 01- Microcontroller (Arduino)

2.2 IoT and Mobile Control:

The machine connects to a mobile app via Wi-Fi or Bluetooth. Farmers can select the crop type, fertilizer level, operation speed, and mode. The system status and total fertilizer used are displayed on the app.

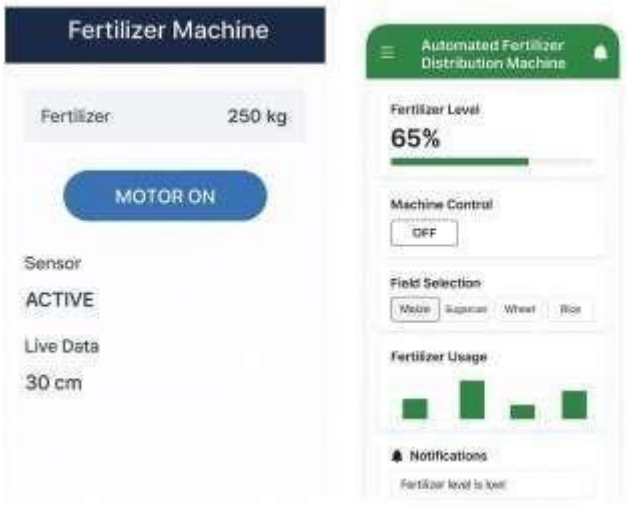

Fig. 02- User Interface

2.3 Sensor Module:

Detects the presence and position of plants. Once a plant is detected, it sends a signal to release fertilizer.

IR Sensor – Detects the presence of a plant.

Proximity Sensor – Measures the exact position of the plant.

Fig. 03- Sensor Technology (IR & Proximity Sensor)

2.4 Fertilizer Storage Hopper:

A specially designed storage container that holds the solid fertilizer and releases it evenly when triggered by the controller.

Fig. 04- Fertilizer Storage Hopper

2.5 Motorized Distribution Mechanism:

When sensors detect a plant, the motor activates and rotates the fertilizer dispensing unit, dropping a fixed quantity near the root zone. For irregular crop patterns, a spreading attachment ensures even coverage across the area.

The motor activates and rotates the spreading discs. Fertilizer is accurately released near the plant roots

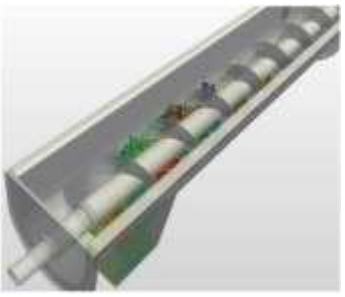

Fig. 05- Conveyor & DC Motor

2.6 Mechanical Frame:

The frame is height and width adjustable, making it compatible with different crop heights and field types. Its modular structure allows easy assembly and transport.

Fig. 06- Main Machine Mechanical Frame

3. WORKING PRINCIPLE

The working of the Automated Solid Fertilizer Distribution Machine is based on the principle of sensor-based detection and controlled mechanical distribution. The system operates automatically once it is set up in the field and connected to the mobile application.

At the center of the machine lies a hopper, designed to store the required amount of solid fertilizer. The fertilizer gradually moves downward due to gravity and is guided toward the two outlet pipes positioned at an angle on either side of the hopper. These outlets are connected to rotating distribution discs, which ensure uniform spreading of the fertilizer near the root zone of each plant.

When the machine moves forward in the field, infrared (IR) or proximity sensors continuously monitor the ground to detect the presence and spacing of plants. Upon detecting a plant, the sensor sends a signal to the microcontroller, which in turn activates the DC motor attached to the distribution disc. The motor rotates for a specific duration, releasing the exact quantity of fertilizer required for that plant.

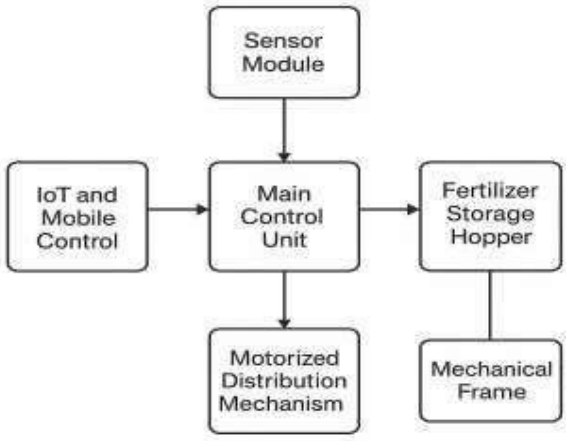

Fig. 07- Flow Chart

If the plants are arranged in irregular rows, the spreading discs disperse fertilizer in a wider pattern to maintain even coverage across the area. Conversely, when crops are planted in straight rows, the system dispenses fertilizer directly beside each plant, minimizing wastage.

The entire process is controlled through a mobile app that allows the farmer to:

- ➢ Set the fertilizer quantity per plant or per area,
- ➢ Adjust motor speed and movement rate,
- ➢ Start or stop the machine remotely, and
- ➢ Monitor total fertilizer used in real-time.

As the machine progresses through the farm, sensors ensure that fertilizer is released only when necessary, avoiding continuous flow or over-distribution. Once the set quantity is dispensed, the motor automatically stops, conserving fertilizer.

The support wheels provide stability and smooth motion, while the adjustable frame allows the system to adapt to different crop heights and row widths.

4. RESULT

After extensive field testing of the automated fertilizer distribution machine across multiple crop types such as maize, sugarcane, and jowar, several significant outcomes were recorded. The system demonstrated a reduction in fertilizer usage by 30–40%, due to precise delivery of nutrients only when and where required. The operational time decreased by approximately 50%, as the machine covered a larger field area in less time compared to manual spreading. The fertilizer application was found to be highly accurate and uniform, eliminating overuse and minimizing wastage.

The overall crop yield improved by nearly 25%, owing to balanced nutrient supply and optimized soil health. Additionally, labor cost was reduced drastically, since a single operator could control and monitor the machine remotely via mobile connectivity. The sensors responded effectively to variations in crop spacing, ensuring correct fertilizer release only near plant roots. Field trials confirmed that the machine performs reliably on different soil conditions and terrains, making it a cost-effective and scalable solution for modern farming practices.

5. DISCUSSION

The results clearly indicate that the Automated Fertilizer Distribution Machine using IoT and Sensor Technology successfully addresses the major challenges faced in traditional fertilizer management. The system's ability to detect plant position and dispense fertilizer precisely near the root zone ensures targeted and efficient application, which directly improves soil health and crop productivity. The reduction in fertilizer consumption by 30–40% not only lowers farming costs but also minimizes environmental impact caused by excess chemical usage.

The integration of IoT-based remote control and monitoring provides farmers with real-time access to operational data, enabling them to make quick and accurate adjustments during field operation. This feature is especially beneficial for large-scale farms where manual supervision is difficult. The machine's adjustable mechanical design allows it to be used for multiple crops and varying row patterns, ensuring high versatility.

Furthermore, the system significantly contributes to environmental sustainability by reducing excessive fertilizer runoff into soil and water bodies, thereby preventing pollution and maintaining ecological balance. It also proves to be highly cost-effective, as it minimizes labor requirements and optimizes fertilizer utilization — helping small and medium-scale farmers achieve better productivity at lower operational costs.

Moreover, the system demonstrates strong potential for scalability; additional sensors such as moisture and pH detectors can be integrated in the future to further enhance automation. The positive increase in crop yield (up to 25%) highlights the effectiveness of precise fertilizer placement in improving nutrient absorption. Overall, the discussion concludes that the proposed system offers a smart, reliable, and eco-friendly solution that can transform traditional farming into a more data- driven and sustainable process.

6. CONCLUSION

The Automated Solid Fertilizer Distribution Machine is an innovative step toward smart and precise agriculture. It eliminates manual effort, reduces fertilizer waste, and enhances productivity. The machine can easily adapt to different crops and field conditions through its adjustable design.

By combining IoT, sensors, and automation, this system makes fertilizer application simple, accurate, and affordable. In the future, features like AI-based plant detection, automatic navigation, and cloud-based data analytics can be added to make the system more advanced. Overall, this project represents a technological revolution in farming, helping farmers save time, reduce cost, and increase yield a perfect example of modern engineering meeting traditional agriculture.

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