Automated sensor based solid fertilizer dispenser for various crops

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Abstract— The Solar Solid Pesticide Dispenser, a ground-breaking invention intended to transform pesticide application in agriculture, is shown in this project. The dispenser combines cutting-edge technologies with solar energy to provide precise and environmentally friendly insect control. High-efficiency solar panels, energy storage, and a sophisticated control system that ensures autonomous operation are important parts. Targeted and data-driven pesticide discharge is made possible by environmental sensors, a dispensing mechanism, and a communication module, which maximizes resource use. Farmers are empowered to efficiently control the system thanks to the dispenser's user-friendly interface. Eco-friendly materials and safety features promote environmental stewardship and are in line with the worldwide trend towards sustainable agriculture. Different pesticides may be accommodated by the modular design, and sturdy structural elements provide endurance in a range of agricultural conditions. The initiative intends to lessen environmental effect, promote ethical agricultural methods

Keywords—Agriculture, Fertilizer, dispensing, sustainability, solar, system, Technology

I. INTRODUCTION

Maintaining crop health and productivity while reducing environmental effect is major challenge for agriculture. Conventional Fertilizer application techniques can lead to misuse ,which contaminates the environment and breeds resistance in pest populations .In order to solve these problems, The Solar Fertilizer Dispenser provides cutting-edge, environmentally friendly pest control method. This project creates a small, user-friendly device by combining precise dispensing mechanisms, environmental sensors, and solar energy harvesting. The dispenser uses solar power to run on its own without the need for other energy sources, which encourages sustainability. The environmental sensors provide real-time data to improve pesticide application by continuously monitoring weather patterns, pest activity, and soil conditions. This focused strategy minimizes damage to non-target creatures and the environment while reducing the use of pesticides and their associated expenses.

Where we can eliminate the problems like nan uniform quantity of application and also man power isn't needed .Many of the small farmers as well as landlords will be benefited because there is no need to pay for the extra wages where the labourers are demanding now a days which is leading for the farmers loss on this fertilizer application thing. This focused strategy minimizes damage to non-target creatures and the environment, cuts expenses, and allows for remote management of operations to improve responsiveness and efficiency. Its versatile design ensures broad applicability by accommodating a variety of solid insecticides and allowing customization for diverse crops and pest circumstances.

II. RELATED WORKS

A. Dispensing mechanism

The Solar Fertilizer Dispenser's dispensing system is made to minimize waste and its negative effects on the environment while precisely and effectively delivering solid Fertilizers to specific regions. This mechanism makes use of precision engineering and cutting-edge technology to guarantee the best possible Fertilizer application based on current environmental data.

The solid Fertilizer pellets or granules are kept in the storage container. Its purpose is to shield the Fertilizer from contamination and moisture. The Fertilizer e flow from the storage container to the dispensing equipment is managed by the feeder system. It guarantees a steady and regulated Fertilizer discharge. The nozzle is designed to equally disperse the insecticide throughout the intended region. Both the dispersion pattern and rate are controllable.
The motorized part that powers the dispenser nozzle and feeder system is called an actuator. The central processing unit regulates it to guarantee exact dosing and timing.

Workflow for Operations:
1.Data Collection: The dispenser's built-in sensors gather environmental data in real time, including temperature, humidity, and insect activity.
2.Data analysis: To decide whether to apply Fertilizer, the central processing unit examines the sensor data. Algorithms consider variables such as crop type, nutrition levels and insect population density.
3.Command Execution: The processing unit instructs the actuator to start the dispensing operation based on the analysis.
4.Feeding and Dispensing: The Fertilizer is dispensed uniformly across the area by the dispenser nozzle, which is driven by the actuator that powers the feeder mechanism.

5.Variable Dispensing Rate: The mechanism enables the dispensing rates to be changed to meet particular Nutrition control requirements. This guarantees that the precise amount of Fertilizer is applied.
6.Targeted treatment: The system can target particular areas with high pest activity by assessing environmental data, avoiding a general treatment and using fewer pesticides.
7.Real-Time Modifications: Based on continuous sensor data, the system is able to make real-time modifications to the dispensing rate and pattern, guaranteeing optimal application all through the operation.

B. Building a control system

The Solar Fertilizer Dispenser's control system is its brain. It processes environmental data, decides how much Fertilizer to apply, and oversees the device's general performance. It combines software and hardware components to guarantee dependable, accurate, and efficient performance.

The central component of the control system is the central processing unit. It transmits commands to the actuator and other parts, processes data from sensors, and runs algorithms.
Microcontroller: Real-time tasks like reading sensor inputs and managing the actuator are handled by microcontrollers. It guarantees quick and effective performance.
Sensors: The system is equipped with a number of sensors to keep an eye on the surrounding circumstances. These include sensors for temperature, humidity, soil moisture, and pest activity.

Actuator: The actuator is responsible for controlling the dispensing mechanism by following commands from the Control system. The Power Management Unit is in charge of managing the power from the solar panels and battery storage to ensure a steady and dependable power supply to all components. The Communication Module allows for remote control and monitoring via a mobile application or web platform, utilizing wireless communication technologies like Wi-Fi, Bluetooth, or cellular networks. The User Interface comprises a display and control panel for manual adjustments and local monitoring, as well as real-time feedback and alerts for the user.

The Optimization algorithms analyze environmental data to pinpoint the precise amount and time of pesticide application required to control pests. Over time, the system may adjust to changing environmental circumstances and pest behaviors by utilizing machine learning techniques to make better decisions. Users can set up settings in software for various pest and crop situations. To improve workflow, users have the ability to store and retrieve particular configurations.

By leveraging advanced control system technologies, the Solar Fertilizer Dispenser offers a sophisticated, efficient, and user-friendly solution for sustainable Nutrition management in agriculture.

C. Communication module

The communication module plays a crucial role in the Solar Fertilizer Dispenser by facilitating data transmission, remote control, and monitoring between the user and the dispenser. It guarantees uninterrupted communication and improves the usability and functionality of the system.

Wi-Fi Module: Facilitates remote access and real-time data transmission by connecting to nearby wireless networks.
Bluetooth Module: Enables short-range connectivity for setup and troubleshooting at first.
Cellular Module: Uses mobile networks (e.g., 4G/LTE) to provide access in places lacking Wi-Fi coverage.
RFID/NFC: Enables configuration and identification at close range.
GPS Module: Enables geofencing and position tracking for the dispenser.

III. METHODOLOGY

A. Solar fertilizer Dispenser Project Methodology

1. Project Planning and Feasibility Study:

   Clearly we have stated the goals of the project, such as integrating sustainable practices, lowering the environmental effect, and increasing the efficiency of pesticide application.

   Feasibility Analysis: Assessed the project's technical, financial, and environmental viability by conducting a feasibility study.

2. Design and Development:
   i)Hardware Design: Created the control unit, communication module, sensor array, solar power system, and dispensing mechanism.
   Software Design: We have created software for the user interface (mobile application and web platform), control algorithms, and data processing.
   ii)Selection of Components:
   Selection of Solar Panels and Batteries: for the design we chosen the high energy-storing solar panels with maximum efficiency and appropriate batteries.
   Sensors: the environmentally useful sensors like Image processing sensors for temperature, humidity, soil moisture, and insect activity.
   iii)Dispensing Mechanism: The dispensing mechanism which we integrated will help us for the precision application of the fertilizer from plant to plant
   iv)Microcontroller: Microcontroller we used here for the control over the system and also the work beneficiary.
   v)Communication Module: Communication module works as an mediator between the dispenser and control unit which helps for the further instructions to be clear and also functionable.
3. Prototyping:
   Integration: We have integrated each and every part to form into this device where it can function for the requirements.
4. Validation and Testing:
   Functionality Testing: Before integration of the components we have analysed and tested the functionality of each and every component based on its working and then we integrated it.

Environmental Testing: We have tested sensor accuracy and system resilience, in different environmental scenarios for the perfection.

Dispensing Accuracy: In the time of field trials, we have tested the precision in the dispensing and also the dispensing accuracy of the dispensing mechanism.

B. *System Architecture*

In order to accomplish effective and long-lasting nutrition management, the Solar Fertilizer Dispenser's system architecture is built to smoothly combine a variety of hardware and software components. A microprocessor and control system at the center process data in real time from a variety of environmental sensors that track temperature, humidity, soil moisture, and insect activity. The exact amount and time of pesticide spraying are determined by optimization algorithms that are executed by the control system.

A solar power system ensures independence from external power sources by supplying the necessary energy for operation through the combination of high-efficiency solar panels and a battery storage unit. The control system instructs the microcontroller-controlled precision dispensing system to precisely release solid fertilizers.

Additionally, the system has a communication module that permits users to access real-time data and make changes via a mobile app or web platform. This allows for remote monitoring and control via Wi-Fi, Bluetooth, or cellular networks. Robust performance, flexibility to changing climatic circumstances, and user-friendly remote management capabilities are guaranteed by this architecture.

Figure 1 Explains about design flow and also system architecture in simple form where the flow of works is demonstrated one by one in a detailed manner showing the steps the system follows when dispensing the fertilizer

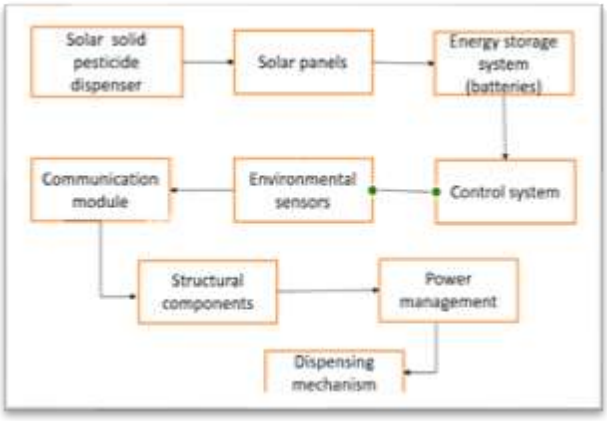

Figure:1

C. *Activity Diagram*

In this study we have incorporated our different perspective ideas into one product to solve the particular problem statement we have chosen to solve. We have taken two major issues like lack of laborers in the field of agriculture and to cut off the unwanted expenses for the farmers and make them aware about the technological inventions which helps them more than the same traditional practices.

We have incorporated control system as well as dispensing mechanism in a single device which helps farmers for the precision application and also the plant identification can also be done using the sensors.

Where our project works with solar energy and remote controller to be controlled in the field lanes to move front and back for our convenient use in the field only one man is enough to control our equipment.

IV. Results and Discussions

A. *Product interface*

Our product is composed of wheels for the conveniency in moving and also it contains a container to store fertilizer its of the capacity of the max.6kg which can be enough for the two lanes in the field the wheels are controlled using a remote for the ease in the use of the vehicle in the specified direction to apply the fertilizer.

The environmental sensors which are installed on the both sides of the equipment will be able to identify the plant and apply the selected amount of the fertilizer to the selected plant.

We have an advantage over here while the product is working in the field it is instantly charged due to the sun rays

B. *Product Testing and Modifications*

a) Testing and Modifiactions:

We have tested our product in the field lanes for the accuracy and required functionality of the product.we have got many gliches in the intial stges of the product testing we have done amny modifications to the design as well as architecture to get the optimal results.

After so many trials we have done we developed the accurate precision dispensing system which worked as we expected

The modifications included change in the wheel design, Container quantity and battery storage capacity and also solar panel measurements. The change in the placement of the sensors have played a key role for the precision application of the fertilizer. The results we got are more accurate in the days where we completed all the modifications of the project.

Table 1 shows the results of the product before and after modifications done

Test no.	Storage capacity	Discharge time	Time taken for one lane application
1	3Kg	4 hrs.	12 min
2	8Kg	3hrs	15min
3	4Kg	4 hrs.	10min
4	6 kg	5 hrs.	8 min

Table:1 results after field trials

C. *Prototype*

The figure 2 shows the developed prototype model

Figure 2: prototype image

D. *User Acceptance Testing*

We also included a community partner for our project to enhance the communication with the local farmers and to know their view on this particular innovation. During the testing phase we interacted with many local farmers and collected their feedback and also, we asked for the rating on our product, besides we also conducted a survey among all those whom we visited in the time of testing. Keeping all their views in mind we done many modifications for this project

We also did a survey with the villagers about the situation of the workers of the field and also about their wages.

Figure 3 represents about the views of the farmers on this project.

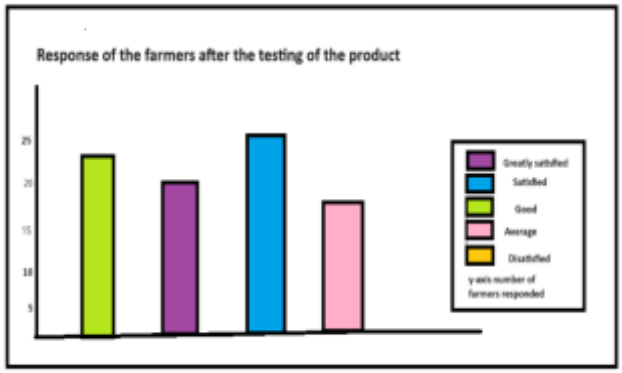

Figure 3: Feedback from the Users

V. Conclusion and Recomendation

A. *Conclusion*

The Solar Fertilizer Dispenser, which combines cutting-edge technology with environmental responsibility, is a major breakthrough in sustainable agriculture. This system successfully solves the inefficiencies and environmental issues related to conventional fertilizer delivery techniques because to its creative design, which combines solar power, precision dispensing, and real-time environmental data collecting. A communication module gives farmers the ability to remotely monitor and manage their pest control operations, giving them real-time information and control. Field testing has shown the system's efficacy and dependability, as well as its potential to boost environmental sustainability and agricultural output. Because of this, the Solar Fertilizer Dispenser is a viable answer to today's farming problems, bringing with it financial advantages as well as support for international efforts to promote sustainable development.

The Solar Fertilizer Dispenser, which combines cutting-edge technology with useful farming requirements, is a major breakthrough in sustainable agriculture. The system promotes environmental sustainability by operating independently of conventional energy sources through the utilization of solar electricity. By combining cutting-edge sensors with data analytics, fertilizer is applied precisely and effectively, limiting the need for chemicals and their negative effects on the environment. Real-time monitoring and control are made possible by the communication module, giving farmers the freedom and knowledge they need to improve their pest management strategies. The dispenser has proven that it has the ability to increase farming production, boost resource efficiency, and encourage environmentally friendly farming methods. In addition to addressing the problems with pest control now, this research lays the groundwork for future developments in precision agriculture, which will ultimately lead to more resilient and sustainable food systems.

B. *Recommendations*

It is advised to improve the Solar Fertilizer Dispenser's uptake and efficacy by honing its data analytics skills. The accuracy of nutrition detection and prediction models may be increased by implementing sophisticated machine learning algorithms, allowing for even more accurate fertilizer administration. By foreseeing growth outbreaks under varied climatic circumstances, integrating weather forecasting data might also aid in optimizing the usage of fertilizers. Furthermore, creating a comprehensive user education and assistance program will be necessary to guarantee farmers are able to operate and maintain the system efficiently. Having thorough user manuals, instructional videos, and a helpful customer care team may assist optimize the system's functionality and dependability in various farming environments.

In order to accommodate a wider variety of crops and pest control techniques, the system's capabilities should be expanded to enable numerous fertilizer kinds and variable application schedules. Working together with extension services and agricultural research organizations may confirm the system's effectiveness in various crop systems and geographical areas, offering insightful input for ongoing improvement. In addition, investigating collaborations with governmental and non-governmental entities can expedite broader dissemination and acceptance, especially in environments with limited resources where sustainable farming methods are most exigent. The Solar Fertilizer Dispenser has the potential to make a substantial impact on the advancement of sustainable agriculture and the improvement of global food security by implementing these recommendations.

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