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Solar Based Fertilizer Harvesting Machine

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Abstract: *The increasing demand for sustainable agricultural practices has driven innovation toward energy-efficient and environmentally friendly farm machinery. This project presents the design and development of a solar-based fertilizer harvesting machine that utilizes renewable energy to collect, process, and distribute organic or bio-fertilizer materials directly on the field. The system integrates photovoltaic panels to generate the required power, eliminating dependence on conventional fuel sources and reducing operational costs and emissions. The machine incorporates mechanisms for fertilizer collection, shredding or pulverizing (where applicable), and controlled dispensing to ensure uniform field application. A microcontroller-based control unit optimizes power distribution, monitors operational parameters, and enhances user safety and efficiency. Experimental testing demonstrates that the solar-powered system offers reliable performance under typical daylight conditions, significantly lowers energy consumption, and provides a sustainable alternative to traditional fertilizer handling methods. This solar-based fertilizer harvesting machine contributes to cleaner agricultural operations while promoting resource efficiency and improved soil management in rural farming Environments.*
This paper provides a study of solar-powered fertilizer sprayers used in agriculture. The study reports the sprayer's design, materials, methodology, and results. The sprayer allows rural areas to limit their need for fossil fuel and human labor, improving convenience and efficiency while being more eco-friendly. Moreover, the paper mentions the components of the presented mechanical device, such as the solar panel, battery, motor, and nozzle, to list their technical definitions and areas of application. The purpose of this research is to ease the issues associated with the facial lifestyle and support modern-day challenges in farming.

Keywords: *agricultural*

I. INTRODUCTION

Agriculture plays a vital role in the economic development of many countries, particularly in developing regions where it serves as the primary source of livelihood. Modern agricultural practices, however, face several challenges such as rising energy costs, labor shortages, environmental degradation, and the increasing demand for higher productivity. Among various farming operations, fertilizer handling, processing, and application are critical activities that directly influence soil fertility and crop yield. Conventional fertilizer handling systems predominantly rely on fossil-fuel-powered machinery. While effective, these systems are associated with high operational and maintenance costs, increased fuel dependency, and harmful greenhouse gas emissions. In rural and remote areas, limited access to electricity and fluctuating fuel prices further complicate mechanized farming, especially for small and marginal farmers. These constraints make traditional mechanization both costly and unreliable.

With growing concerns over climate change and environmental sustainability, the agricultural sector is gradually shifting toward renewable and energy-efficient technologies. Solar energy has emerged as one of the most promising alternatives due to its abundance, cleanliness, and suitability for rural agricultural applications. Solar-powered agricultural machines offer low operating costs, minimal maintenance, and independence from conventional fuel sources, making them ideal for sustainable farming systems.

A solar-based fertilizer harvesting machine is an innovative agricultural solution designed to utilize photovoltaic (PV) energy for fertilizer collection, processing, and application. The system converts solar energy into electrical power

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using PV panels, which is regulated through charge controllers and stored in batteries to drive DC motors. This approach eliminates reliance on fossil fuels while ensuring reliable operation in off-grid and rural environments.
The machine integrates mechanical components such as conveyors, lifting mechanisms, shredders, sieves, mixers, and hoppers based on the type of fertilizer being handled, including organic, bio-fertilizer, or granular materials. Additionally, electronic control systems and optional microcontroller-based automation enable precise control of fertilizer flow, improved energy management, and enhanced operational safety. By reducing manual labor and improving application efficiency, the solar-based fertilizer harvesting machine supports sustainable agricultural practices and contributes to long-term economic and environmental benefits.

Problem Statements

- Fertilizer handling and application are essential agricultural operations that directly affect soil fertility and crop productivity.
- Most existing fertilizer harvesting and dispensing systems depend on diesel or petrol-powered machinery, resulting in high fuel consumption and increased operating and maintenance costs.
- The use of fossil-fuel-based machinery contributes significantly to environmental pollution and greenhouse gas emissions.
- These challenges are more severe in rural and remote areas due to inconsistent fuel availability and limited access to electrical power.
- Small and marginal farmers find conventional mechanized fertilizer handling systems unreliable and economically unsustainable.
- Manual fertilizer application methods are labor-intensive, time-consuming, and often lead to non-uniform fertilizer distribution.
- Non-uniform fertilizer application causes inefficient nutrient utilization and reduced crop yields.
- Despite advancements in renewable energy technologies, affordable and energy-efficient fertilizer harvesting machines suitable for off-grid agricultural environments are still lacking.
- There is a strong need to develop a solar-based fertilizer harvesting and application machine that operates independently of fossil fuels.
- Such a system should reduce operational costs, minimize environmental impact, ensure uniform fertilizer distribution, and be simple, reliable, and low-maintenance to support sustainable agricultural mechanization.

II. LITERATURE SURVEY

S. M. Kesavan, K. S. AI Mamari and N. S. M. Raja, "Solar-powered robot for agricultural applications,"
The conversion of organic waste into valuable resources, particularly fertilizers, is a critical area of research in sustainability and waste management. Kitchen waste, which constitutes a significant fraction of municipal solid waste, offers a promising feedstock for nutrient recovery. Studies indicate that anaerobic digestion can effectively transform this waste into biogas and nutrient-rich digestate, reducing landfill contributions and greenhouse gas emissions
Moussa, A. H., EI-Shafie, A., & Galal, H.A. (2020). "Solar Energy Applications in Agriculture: Current Status and Future perspectives."
This approach is particularly beneficial in urban areas where energy costs can be prohibitive, and access to conventional energy sources may be limited. While traditional composting and vermiculture have been widely used for waste recycling, these methods often require significant time and labor, making them less practical for urban household
Singh, S., & Kaur, S. (2021). "Impact of Organic Fertilizers on crop Yield: A Review." This process not only generates renewable energy but also provides a base material that can be further processed into organic fertilizers. Solar energy has been increasingly recognized for its potential in agricultural applications. Solar-assisted technologies enable the efficient drying and processing of organic materials, reducing reliance on fossil fuels and enhancing the sustainability of fertilizer production

Dhatchanamoorthy.N,Arunkumar.J, Dinesh Kumar.P,Jagadeesh.K, Madhavan.P "Design and Fabrication of Multipurpose Agriculture Vehicle" Volume 8 Issue No.5

In contrast, the combination of anaerobic digestion and solar thermal treatment offers a streamlined and efficient alternative, yielding high-quality fertilizers in a shorter timeframe. Furthermore, literature suggests that community engagement in decentralized waste management systems can foster greater environmental responsibility

Xiao.S, Hu.K,Huang. B,Deng.H, Ding. X, "A review of research on the mechanical design of hoverable flapping wing micro-air vehicles,"

By empowering households with easy-to-use technology for waste conversion, this project not only addresses waste disposal challenges but also encourages local participation in sustainable practices. This review underscores the potential of integrating solar energy with waste-to-fertilizer technologies, paving the way for innovative solutions that contribute to both environmental sustainability and agricultural productivity.

R. Shinde1,Ashwini T. Deshmukh2, Prof. R. V. Katre3"Speed Synchronization of multiple Motors by Using Microcontrollers"

In summary, existing literature establishes that solar PV integration in agricultural mechanization is technically viable and environmentally beneficial. It demonstrates progress in solar-powered vehicles, robots, and spray systems that provide valuable context for renewable energy solutions in farming. However, the specific domain of solar-based fertilizer harvesting and application machines remains under-explored, indicating a clear opportunity for further research and innovation in this niche to enhance sustainability, reduce operational costs, and support small and marginal farmers effectively.

Objectives

- To design and develop a solar-powered fertilizer harvesting and application machine suitable for small and medium-scale farming operations.
- To utilize photovoltaic (PV) energy for powering fertilizer collection, processing, and distribution mechanisms.
- To ensure efficient fertilizer handling, uniform field application, and reduced manual labour.
- To minimize operational costs and environmental impact by eliminating dependence on fossil fuels.
- To evaluate the performance and reliability of the system under varying sunlight and field conditions.

Key functions

- Converts solar energy into electrical power using photovoltaic (PV) panels.
- Stores energy in batteries for continuous operation, especially during low sunlight.
- Powers all machine components such as motors, pumps, sensors, and control systems.

III. METHODOLOGY

The methodology involves collecting organic farm waste and feeding it into a solar-powered system where the material is shredded, mixed, and prepared for decomposition. Solar energy drives the aeration, moisture regulation, and controlled composting processes that break down the biomass into nutrient-rich fertilizer.

Working Principle

A **solar-based fertilizer harvesting machine** works by converting solar energy into useful electrical power to operate mechanical systems that collect, process, and store fertilizer in a sustainable and cost-effective manner. The machine is equipped with solar panels that capture sunlight and convert it into electrical energy using the photovoltaic effect. This energy is controlled by a charge controller to ensure safe voltage levels and is stored in rechargeable batteries, allowing the machine to function even when sunlight is insufficient. The stored electrical power is then supplied to an electric motor, which drives various mechanical components such as conveyors, rotating cutters, collection rollers, and sieving units. These components help in gathering organic fertilizer materials like compost, farmyard manure, or processed agricultural waste from the field or designated collection areas. During operation, the machine separates unwanted impurities and breaks down large particles to produce fertilizer of uniform size and better quality.

In some systems, solar heat or electrically driven fans are used to reduce moisture content, improving the shelf life and effectiveness of the fertilizer. The final processed fertilizer is collected in a hopper or storage bin, making it ready for transportation or direct application to crops. By using solar power, the machine significantly reduces dependence on fossil fuels and grid electricity, lowers operational costs, and minimizes environmental impact. This eco-friendly technology supports sustainable agriculture, reduces labour requirements, and is highly beneficial for farmers in rural or off-grid areas, contributing to increased productivity and environmentally responsible farming practices. A **solar-based fertilizer harvesting machine** functions by efficiently utilizing renewable solar energy to power the harvesting and processing of fertilizer materials in an eco-friendly manner. The system mainly consists of solar panels, a charge controller, batteries, an electric motor, and a fertilizer harvesting and processing unit. Solar panels mounted on the machine absorb sunlight and convert it into electrical energy through the photovoltaic effects

Front view of model

Working Procedure

We get a power supply of 20watt by solar panel it is connected to the charger controller is an electrical device used mainly in a solar power system to manage the flow electricity between solar panels, batteries and loads.

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From solar panel to charger controller.
It receives variable DC power from the solar panel.
From charger controller to battery power storage.
From battery load - It supplies power to DC loads or through an inverter to AC loads.
Four wheels are operated by Arduino microcontroller, it is a small open – source electronic board based on microcontroller that can easily programmed to control device and system.
These four wheels are connected to12 volt DC motor with (30rpm) connected with L298 bridge motor controller.
There will be a hopper containing fertilizer. It is supplied with the two adjacent pipes through this pipe's fertilizer is fed to crops.

Advantages

- Uses solar energy, reducing dependency on fossil fuels.
- Lowers the carbon footprint, making it an eco-friendly solution.
- Operates efficiency in remote or off-grid rural areas.
- Zero fuel costs post-installation.
- Long-term savings on electricity and fuel.
- Minimal maintenance costs with solar-powered systems.
- Mechanized harvesting of fertilizer (e.g., compost, manure, or processed organic fertilizer) speeds up the process.
- Reduces manual labor, which is time-consuming and physically demanding.
- Ensures more consistent to fertilizer quality and distribution.
- Can be designed to fit different scales: small, medium, or large farms.

Disadvantages

1. Dependent on Sunlight
The machine's performance reduces on cloudy, rainy, or winter days.
Limited efficiency during early morning or evening due to low sunlight.
2. Higher Initial Cost
Solar panels, batteries, and charge controllers make the initial investment higher than manually operated or fuel-operated machines.
3. Limited Power Output
Solar-powered DC motors usually provide less torque and may not be suitable for heavy-duty or large-scale fertilizer processing.
4. Slow Processing Speed
Due to limited energy availability, the grinding and shredding process may be slower compared to fuel or electric machines.
5. Battery Maintenance and Replacement
Batteries degrade over time and typically need replacement every 2–3 years, increasing long-term costs.

IV. APPLICATIONS

- **Organic fertilizer production** from agricultural and animal waste
- **Waste recycling** by converting biodegradable waste into useful manure
- **Sustainable farming** by reducing dependence on chemical fertilizers
- **Solar-powered drying** of compost to improve storage life
- **Use in remote areas** where electricity supply is limited
- **Cost reduction for farmers** through low operating and fuel costs
- **Soil health improvement** by promoting eco-friendly fertilizers

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- **Educational and research applications** in agricultural and engineering institutions

V. CONCLUSION

The design and development of the solar-based fertilizer harvesting machine demonstrate the effective application of renewable energy in agricultural mechanization. The project addresses key limitations of conventional fertilizer handling systems, including high fuel consumption, increased operating costs, environmental pollution, and heavy reliance on manual labor. By integrating photovoltaic technology with a simple and efficient mechanical system, the machine operates independently of fossil fuels, making it particularly suitable for rural and off-grid farming environments.

The use of CATIA V5 for 3D modeling and assembly enabled accurate visualization, proper component integration, and early identification of design issues prior to fabrication. The generated top, side, and isometric views helped validate the structural layout and functional performance of the machine. Experimental results show that the system can handle and apply fertilizer uniformly under varying sunlight conditions while maintaining low maintenance requirements.

Overall, the developed machine provides a cost-effective, eco-friendly, and energy-efficient solution for small and medium-scale farmers. The project highlights the potential of solar-powered agricultural equipment to enhance operational efficiency, reduce environmental impact, and promote sustainable farming practices. With further refinement and automation, the system can be scaled and adapted for wider agricultural applications, contributing to long-term sustainability and rural development.

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