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REVIEW ARTICLE

Solar powered operated grass cutter with herbicide spreader

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Abstract

This research paper presents the design and development of a solar-powered electric grass cutter and water sprayer. The aim of the project is to provide a sustainable solution for lawn maintenance and irrigation, while reducing carbon emissions and operating costs. The system is composed of a solar panel, a battery bank, an electric motor, a cutting blade, and a water pump. The solar panel the battery during the day, which powers the electric motor for grass cutting and the water pump attached with the water tank for pesticide. The results show that the system is efficient, reliable, and cost-effective, providing a sustainable solution for lawn maintenance and irrigation. The project has potential for further improvement and application in the field of sustainable agriculture and urban green spaces.

1. Introduction

Lawns and gardens are an integral part of our urban and suburban landscapes, and their maintenance is essential for aesthetic, environmental, and health reasons. However, traditional lawn maintenance methods involve the use of gas-powered mowers and herbicide spreaders, which contribute to carbon emissions, air and noise pollution, and health hazards. In recent years, there has been a growing interest in sustainable lawn care practices that reduce environmental impacts and promote ecological benefits. One of the key solutions for sustainable lawn maintenance is the use of solar-powered electric grass cutters and herbicide spreaders. These systems use renewable energy from the sun to power electric motors that operate cutting blades and herbicide sprayers. Solar-powered lawn maintenance equipment is efficient, cost-effective, and environmentally friendly, as it eliminates the need for fossil fuels and reduces greenhouse gas emissions. The fuel operated grass cutter is harmful in many ways such as, Firstly, they emit harmful pollutants such as carbon monoxide, nitrogen oxides, and volatile organic compounds, which contribute to air pollution and respiratory illnesses. Secondly, gas-powered lawn equipment is noisy, which can be disruptive to residential neighborhoods and wildlife. Thirdly, the cost of fuel and maintenance for gas-powered equipment can be expensive over time, which can deter homeowners and lawn care professionals from investing in sustainable alternatives. In recent years, there have been several innovative designs and developments in solar-powered lawn maintenance equipment. One such design is the solar-powered electric grass cutter and herbicide spreader. One such alternative is solar energy This system uses solar energy to power an electric motor that operates a cutting blade for grass cutting and a herbicide sprayer for weed control. The solar panel charges a battery during the day, which provides power for the electric motor and herbicide sprayer. The solar-powered electric grass cutter and herbicide spreader has several advantages over traditional gas-powered equipment. Firstly, it eliminates the

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need for fossil fuels, which reduces greenhouse gas emissions and air pollution. Secondly, it is quiet and efficient, which reduces noise pollution and disturbance to wildlife. Thirdly, it is cost-effective, as it eliminates the need for fuel and reduces maintenance costs over time. Finally, it promotes ecological benefits by reducing the use of harmful herbicides and pesticides. So, aim of this project is to make a new grass cutting device has been developed which is powered by electricity and includes several components such as a plate, a 12 Volt D.C. battery, a motor, cutting blades, a 12 Volt D.C. pump, a water tank, and wheels. The modified grass cutter features a rotor that is fixed between bearings and attached to the frame of the cutter. The motor is also attached to the rotor and fixed onto the grass cutter frame. To ensure efficient operation, a plate is fixed on the top part of the grass cutter to absorb direct sunlight and is directly connected to the motor. The motor can be rotated in either a clockwise or anticlockwise direction, depending on the wiring or the specific requirement. Additionally, this device can also be used as a pesticide sprayer as it comes with a 12 Volt pump and a sprayer option.

2. Literature review

It includes, the data of the published journal papers related to our projects. We have described the work of respective authorities published in their books. This papers are related to our project topic, which have help us to learn various process, methods and design factors used in respective work. Converging all the ideas and methods used in journal papers, we refined the data required for our project work.

2.1 Design & fabrication of multi nozzle spray pump

The populace of India is growing with each passing day, necessitating a modernization of the agricultural sector to meet the increasing demand for food. However, the use of chemical fertilizers has led to a decrease in soil fertility, prompting farmers to shift towards organic farming [1]. This approach not only solves the problem of back pain, which arises from carrying a sprayer on one's back and shoulder, but also provides a convenient adjustment mechanism for crops, preventing excessive use of pesticides and reducing pollution. Moreover, this sprayer is more cost-effective than the conventional spraying pumps available in the market, as it does not require direct fuel or maintenance costs. It is an upgraded version of the manually operated sprayer and weeder, specially designed for small land farmers. This machine saves both time and money when compared to traditional spraying and weeding methods. Since it does not require any fuel or power, the maintenance cost is also minimal.

2.2 Solar powered grass cutter and herbicide sprayer

In previous times, conventional lawn upkeep equipment was the primary preference for householders and lawn care experts. Nevertheless, this equipment that are run by gas, including mowers and herbicide spreaders, come with several downsides. A blade is a component of a machine, weapon, or tool that features an edge created for cutting, thrusting, scraping, or chopping surfaces or materials [2]. In the past, the process of cutting grass involved manual labor with the utilization of hand-held devices such as scissors, which necessitated more human effort and additional time to accomplish the task, often resulting in uneven outcomes. Powered machines that run on fuel tend to increase air pollution and noise levels while demanding regular maintenance [3]. A solar-powered grass cutter, on the other hand, utilizes sliding blades to cut grass at an even length. Its design is straightforward, comprising a DC motor, a switch for managing the motor, and a battery that charges via a solar panel [4]. Solar energy refers to radiant light and heat generated by the sun and captured utilizing a wide range of ever-developing technologies. A solar electric array generates electricity from sunlight with no components that move or wear out. Furthermore, a solar pump efficiently harnesses direct current from the array while accommodating variations in energy production throughout the day. The solar panel generates solar energy, which is stored in a battery, and then converted into electrical energy. The blade, which is connected to the DC motor, can cut all kinds of grass and distribute pesticides on crops.

2.3 Multipurpose pesticides sprayer pump

A pump is a mechanical device that facilitates the movement of fluids by consuming energy to execute mechanical work and propel the fluid [5]. Certain pesticide sprayer pumps are a combination of knapsack and battery-operated mechanisms, which enhance their efficiency. This particular model is a trolley-operated system, enabling the spraying of pesticides in any direction and at any height around the crops, thereby reducing maximum effort required for spraying. It is used for various activities such as weeding and plugging. The purpose of this paper is to suggest a model of a manually operated, multi-nozzle pesticide sprayer pump that can perform spraying at the maximum rate in the shortest possible time. The scope and objective are to decrease operational costs by utilizing new mechanisms, enhance reliability under different working conditions, reduce the cost of the machine, decrease labor costs by advancing the spraying method, design a machine that can perform both operations of spraying and weeding, spray maximum area in minimum time, facilitate proper adjustments with respect to crop size and height, attach multiple nozzles and trolleys, and incorporate other instruments such as pilling, hilling, and plowing. Additionally, this eco-friendly system uses a spray guard to minimize the negative impact of spraying. The equipment is specifically designed for farmers with small farming land, approximately 5-6 acres, who can benefit from its low cost. The equipment is particularly suitable for weeding moist soil, as the weed cutter can easily penetrate and dig out the soil, resulting in more efficient weeding. Furthermore, the equipment performs better on smooth or less uneven surfaces and crops having similar height and spacing between them.

2.4 Solar based grass cutter machine

The grass cutting principle involves imparting high-speed rotational motion to the blade, which aids in cutting the grass with precision and smoothness. For the upkeep and enhancement of the aesthetics of lawns and gardens, grass cutting machines serve as a highly efficient option. A lawn mower, equipped with revolving blades, helps people effortlessly maintain their lawns and gardens, ensuring even lengths of grass. In modern times, there are numerous options available, ranging from the most basic push-along mowers to the highly advanced electric grass cutting machines. As per the World Energy Report, conventional fossil fuels such as oil (36%), natural gas (21%), and coal (23%) account for approximately 80% of the energy we use. However, it is widely known that these sources are finite and will eventually be depleted. Therefore, it is crucial to explore alternative energy sources to avoid an energy crisis in the near future. Incorporating solar energy into the functioning of grass cutting machines can help mitigate this issue [6]. The use of solar energy as a source of power to drive a lawn mower is increasingly necessary due to the rising cost of fuel and the harmful emissions generated by the combustion of these fuels, which pollute the environment. This project outlines a design methodology for a solar-powered grass cutter, which operates based on the Law of Conservation of Energy. The grass cutter has solar panels arranged at an angle of 45 degrees to receive high-intensity solar radiation easily, which the panels then convert into electrical energy [7].

3. Working

Direct conversion of solar radiation into electricity is made possible by utilizing photovoltaic (PV) cells, which function as semiconductor devices. When the solar cell is exposed to sunlight, it absorbs a portion of the energy and transforms it into electrical energy. This electrical energy is then stored in a lead-acid battery. The battery is connected to a 12V DC motor, which then converts the electrical energy into mechanical energy. The solar-powered agro sprayer comprises three primary components, namely the solar panel unit, battery storage unit, and solar-powered pump. In the solar agro sprayer pump, the two-stroke petrol engine has been substituted with a combination of a storage battery and solar pump. To recharge the storage battery, a solar panel arrangement is placed at the top of the unit. To allow the maximum amount of solar radiation to fall on the panels, the solar panels are arranged at a 45-degree angle to the vertical. This permits the unit to receive the maximum amount of solar energy from the sun while it is in use in the field. The output of the panel is linked in parallel with a 12V storage battery to store the electrical energy generated by the panel. The 12V solar panel is then linked to the 12V battery. The operation of the solar pump is controlled by a switch and regulator. The stored electrical energy is converted into mechanical energy by rotating the motor, eliminating the need for traditional fuels such as gasoline for mechanical operations.

3.1 DC motors

An electric motor that converts direct current electrical energy into mechanical energy is well known as DC Motor. It consists of a rotor, a stator, and a commutator that provides the motor with the ability to change the direction of the current flow. A motor driver is an electronic device that controls the speed and direction of a motor by regulating the current flow. It can be used to drive DC motors and is essential for applications where precise control of motor speed and direction is required.
In a solar power operated grass cutter, a DC motor and motor driver commands the blade speed and direction. Motor, powered by the solar panel which generates direct current from the sun's energy. The motor driver receives input from a controller and adjusts the motor's speed and direction accordingly. This enables the grass cutter to operate efficiently and effectively while using renewable energy sources.

Figure 1: DC Motor

3.2 Operation of DC Motor

In modem industrial applications, the DC motor you will find operates very similarly to the simple DC motor mentioned earlier in this chapter. An electrical diagram of a simple DC motor is shown in the figure [8]. The DC motor in a solar power operated grass cutter is powered by the direct current generated by the solar panel. When a voltage is applied to the motor's terminals, it generates an attractive field that interacts with the magnetic influence of its environment can be detected stator. This interaction causes the rotor to rotate, which in turn drives the blade of the grass cutter. By adjusting the voltage applied to the motor, the speed of the blade can be controlled. The motor driver regulates the voltage and current flowing to the motor, ensuring that it operates efficiently and avoids damage. The combination of the DC motor and the motor driver enables the grass cutter to operate effectively using renewable solar energy.

3.3 Solar Panel

Photovoltaic cells, also known as solar cells, are electronic devices that convert the energy of photons from sunlight into electrical energy. A solar panel comprises of three essential components. Firstly, a material known as a semiconductor generates electron-hole pairs through the absorption of solar energy. Secondly, there is a zone that contains a drift field responsible for the separation of charges. Lastly, front and back electrodes are used to collect charges [9].

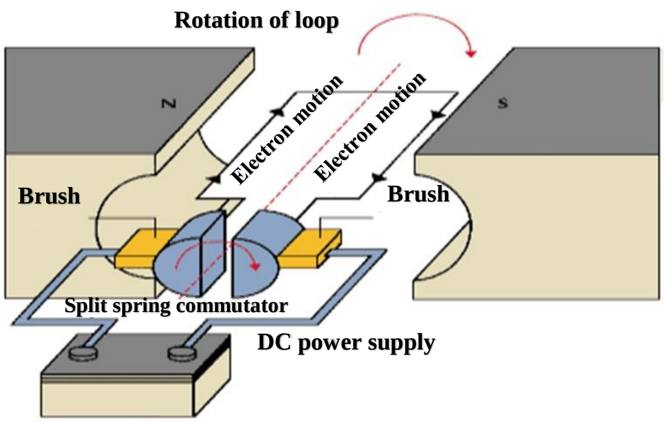

Figure 2: Operation of A DC Motor

Electrons are collected by a network of electrodes and conductive wires, which can be used to power devices or stored in batteries for later use. Photovoltaic cells have become a popular technology for producing clean, renewable energy, with applications ranging from powering small electronic devices to providing electricity for entire communities. A schematic diagram of solar panel and its working mechanism is shown below.

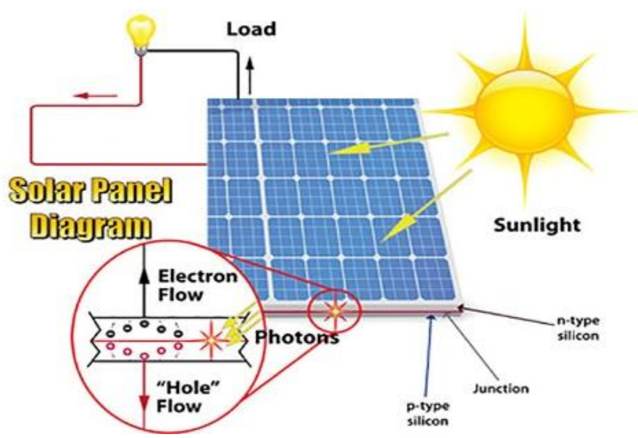

Figure 3: Solar panel

Solar panels have the ability to convert sunlight into electricity through a process called the photovoltaic effect. There are different kinds of solar panels that offer unique features and benefits.

- The most efficient but expensive type is the monocrystalline solar panel, which is made from a single silicon crystal and has a uniform black appearance.
- On the other hand, polycrystalline solar panels, made from multiple silicon crystals, are less efficient but more affordable, often appearing blue due to the manufacturing process.
- Meanwhile, thin film solar panels have a photovoltaic material layer on a flexible substrate, making them less efficient but more adaptable for various uses due to their lightweight and flexibility.
- Building-Integrated Photovoltaic or BIPV panels can serve as both energy generators and building materials when incorporated into the design of a building, such as windows or roofs.
- Finally, concentrated solar panels utilize lenses or mirrors to focus sunlight onto a smaller area, producing more electricity per unit of surface area.

Ultimately, the choice of solar panel will depend on cost, efficiency, space availability, and intended use, with each type having its own advantages and disadvantages.

3.4 Solar Energy

Solar energy refers to the energy that is harnessed from the sun's radiation. It is a renewable and abundant source of energy that can be converted into electricity or used directly for heating or lighting purposes (as shown in below –fig 4.1b)
There are two main ways to harness solar energy:
Photovoltaic (PV) technology: Photovoltaic (PV) technology is a form of renewable energy that transforms solar energy into electrical power. The fundamental component of a PV system is the PV cell, which can be arranged into arrays or panels. The electrical output of a PV device can be utilized to operate small loads like DC motors and lighting systems without the need for additional components. This is made possible by the voltage and current produced at the terminals of the PV device. [10]. These cells are typically combined into solar panels and arrays to provide power for homes, businesses, and other applications. Solar thermal technology: This technology harnesses the energy from sun to heat water or air, which is used for many applications. Solar thermal systems can be used for residential, commercial, and industrial purposes.
Solar power is an eco-friendly and sustainable form of energy that offers numerous benefits over traditional energy sources like oil, coal, and natural gas. It generates no harmful air pollutants or greenhouse gas emissions, making it a clean option for the environment. Additionally, once the installation is complete, solar energy has exceptionally low operational costs. As awareness of the necessity to reduce carbon footprint and transition to more sustainable energy sources increases worldwide, the use of solar energy is rapidly expanding.

3.5 Irrigation

The agriculture sector's heavy water consumption, accounting for 85% of available freshwater resources worldwide, necessitates the development of more efficient irrigation technologies. This need is particularly urgent due to population growth and increasing food demand. Manual irrigation methods based on soil water measurement have given way to automatic irrigation scheduling techniques. Autonomous irrigation machines consider plant evapotranspiration, which depends on atmospheric parameters like humidity, wind speed, solar radiation, as well as crop-specific factors such as growth stage, plant density, soil properties, and pest presence. By integrating these factors, autonomous irrigation systems aim to optimize water usage and improve irrigation efficiency. Implementing autonomous irrigation technologies can help reduce water waste, conserve resources, and enhance crop yields. By accurately tailoring irrigation based on real-time data, these systems ensure that plants receive the appropriate amount of water at the right time, promoting sustainable water management in agriculture.

Various irrigation methods are explored with the objective of developing a system that reduces resource usage and enhances efficiency [11]. The research highlights the use of devices such as fertility meters and pH meters, which are deployed in the field to assess soil fertility by measuring the concentration of key soil nutrients like potassium, phosphorus, and nitrogen. To facilitate efficient irrigation, automatic plant irrigators are strategically positioned in the field using wireless technology, particularly for drip irrigation. This approach not only promotes soil fertility but also ensures the optimal utilization of water resources. By providing water directly to the roots of plants in controlled quantities, drip irrigation minimizes water loss due to evaporation or runoff, thereby maximizing water efficiency. By combining advanced sensor technology, wireless communication, and precision irrigation techniques, the proposed system aims to optimize crop growth while minimizing resource waste. The integration of these technologies allows for real-time monitoring and adaptive irrigation practices, ultimately resulting in improved crop productivity and sustainable water management. Savitha and UmaMaheshwari (2018) proposed an efficient and automated irrigation system by utilizing remote sensors developed using Arduino technology. These sensors play a crucial role in increasing crop production by up to 40%. By incorporating remote sensing capabilities, the system enables real-time monitoring and control of irrigation parameters [12]. Varatharajalu and Ramprabu (2018) also presented an automated irrigation system. Their approach involved the development of different sensors for specific purposes. These sensors included a soil moisture sensor for detecting soil moisture content, a temperature sensor for monitoring temperature, a pressure regulator sensor for maintaining optimal pressure levels, and a molecular sensor for promoting improved crop growth [13]. Furthermore, the integration of digital cameras into the system allows for visual monitoring and analysis of crop conditions. The collected data from these sensors and cameras are converted into digital signals, which are then transmitted to a multiplexer via wireless networks like Zigbee and hotspot. By combining sensor technology, wireless communication, and data analysis, these proposed systems aim to optimize irrigation practices and enhance crop productivity. The real-time monitoring and control capabilities provided by these systems facilitate efficient water usage and ensure better crop growth.

3.6 Centrifugal Energy Sprayer

The Centrifugal Energy Sprayer utilizes a high-speed rotating device, such as a disc, concave or convex plate, wire mesh cage, bucket, puncture strainer, or brush. At the center of this device, the spray liquid is fed under low pressure, and as it exits the periphery of the atomizer, it is further atomized by centrifugal force. The atomized liquid forms droplets that are then carried by the air stream generated either by the sprayer's blower or by natural wind if the sprayer does not have a fan. The centrifugal force helps to disperse the droplets in a wide pattern, ensuring effective coverage over a larger area. This type of sprayer is commonly used in agricultural applications for crop protection, where the atomized liquid needs to be evenly distributed over the plants. The centrifugal energy sprayer provides efficient and uniform application, allowing the spray to reach the target area effectively. By harnessing the centrifugal force, this sprayer design provides a reliable and versatile solution for dispersing liquid sprays, contributing to efficient and effective agricultural practices. The hydraulic energy sprayer, the gaseous energy sprayer, the centrifugal energy sprayer and the kinetic energy sprayer (Fig. 4).

3.7 Hydraulic energy sprayer

In a Hydraulic Energy Sprayer, the material intended for spraying is pressurized to a range of 40-1000 psi (pounds per square inch) using one of two methods. The first method involves directly pressurizing the material using a positive displacement pump. Alternatively, a vacuum pump can be employed to create a lower air pressure above the material in a sealed container, resulting in pressurization. The pressurized material is then expelled through a spray nozzle. In this process, the pump supplies the energy required to transport the material to the plant foliage. The spray nozzle allows for controlled dispersion of the pressurized material, ensuring effective coverage and distribution onto the plants. The Hydraulic Energy Sprayer provides a means to apply materials such as pesticides, fertilizers, or other agricultural substances to the desired plants or crops. The pressurized spraying mechanism facilitates efficient application, reducing waste and ensuring the targeted plants receive the necessary substances for growth and protection.

3.8 Gaseous Energy Sprayer

In a Gaseous Energy Sprayer, the spraying process relies on a high-speed air stream generated by a blower. This air stream is directed through a pipe towards the end where the spray liquid is located. The liquid is allowed to flow through a diffuser plate under the influence of gravity. To deliver the liquid or powder to the target area, it is introduced into the air stream. The high-speed air stream carries the liquid or powder particles along with it, propelling them towards the intended target. This spraying method is commonly used for applications such as dust control, pest control, or applying coatings. The high-speed air stream ensures effective distribution of the sprayed material, allowing for broad coverage and efficient application. The Gaseous Energy Sprayer offers a versatile and efficient solution for delivering liquids or powders to specific areas, providing an effective means of achieving desired results in various industrial and agricultural applications

3.9 Kinetic Energy Sprayer

In the Kinetic Energy Sprayer, the spray liquid flows downward by gravity to a vibrating or swaying spout, which produces a coarse fan-like spray pattern. This type of sprayer is specifically designed for the application of herbicides. To assess the spray effectiveness of any of the aforementioned sprayers, the following equation can be utilized:

$$\text{Spray Effectiveness} = \frac{\text{Sprayed amount}}{\text{Applied amount}} \times 100\ \%$$

The "Sprayed Amount" refers to the actual amount of the spray material that reaches the target area, while the "Applied Amount" represents the intended amount of spray material applied. By calculating the spray effectiveness using this equation, one can evaluate the efficiency and accuracy of the spray application, ensuring that the desired amount of spray material is delivered to the target surface. This helps in optimizing the use of herbicides or other spraying substances and achieving effective control or treatment.

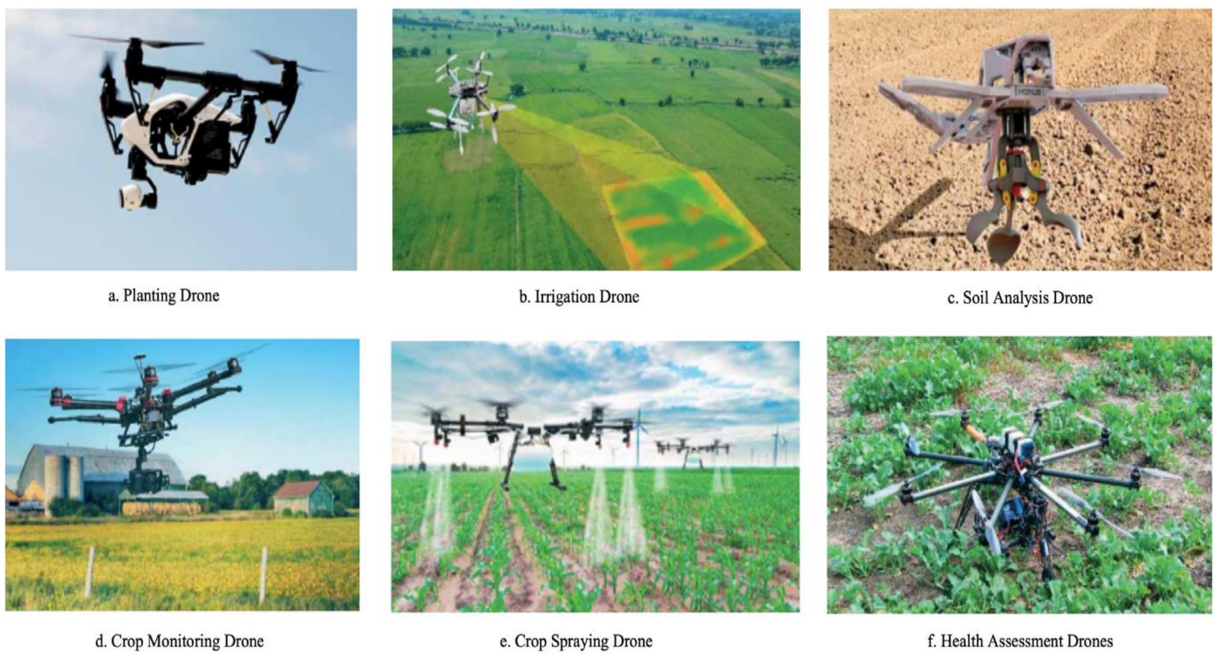

Figure 4: Types of agricultural drones. Source: modern agriculture drones [14].

4. Crop Monitoring

The advancement in sensors and imaging technology has revolutionized farming practices by offering farmers new ways to enhance crop yields and reduce crop damage (refer to Table 5). In recent years, unmanned aerial vehicles (UAVs) have gained popularity for practical applications in agriculture. Equipped with cutting-edge sensors and high-tech cameras, UAVs act as aerial assistants, providing farmers with valuable visual data and enabling them to implement optimal surveying, data acquisition, and analysis techniques. Although aerial surveys have been used in agriculture for some time, UAVs have brought a new level of precision and flexibility to the field. Unlike satellite-based systems, UAV flights are not dependent on satellite positioning or specific weather conditions. Additionally, UAVs capture images from a relatively low altitude of 400-500 feet, resulting in higher-quality and more precise data. This integration of advanced sensors, imaging capabilities, and UAV technology has empowered farmers to make informed decisions based on real-time data, leading to improved agricultural practices, increased productivity, and better resource management.

5. Conclusions

The solar-powered operated grass cutter with herbicide spreader offers several advantages in the field of agriculture and lawn maintenance. By utilizing solar power as its energy source, it provides a sustainable and environmentally-friendly solution, reducing reliance on fossil fuels and minimizing carbon emissions. The integration of a grass cutter and herbicide spreader into a single system allows for efficient and effective weed control. The automated operation eliminates the need for manual labor and reduces human effort and time required for mowing and applying herbicides. The use of advanced technologies such as remote sensors, imaging capabilities, and automated irrigation systems further enhances the performance and productivity of the grass cutter with herbicide spreader. These technologies enable precise monitoring and control, leading to optimized use of resources, increased crop yields, and reduced crop damage. Overall, the solar-powered operated grass cutter with herbicide spreader offers a sustainable, efficient, and cost-effective solution for maintaining lawns, fields, and agricultural areas. Its implementation can contribute to water conservation, improved weed control, and enhanced agricultural productivity, benefiting both the environment and the farming community.

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