Research Article

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Precision farming applications in horticulture

Abstract

Increased food production, higher quality to satisfy the world's ravenous needs, more effective use of natural resources, fewer negative impacts, and environmental protection are the goals of smart agriculture. The adoption of precision agriculture is based on the use of contemporary technologies such as sensors, drones, the Internet of Things (IoT), drones, robotics, and learning machines. Utilizing applications that provide advanced solutions to current agricultural issues and simplify the decision-making process to increase the accuracy and efficiency of agricultural processing. Precision agriculture in horticulture aims to use advanced technologies to maximize crop yield, improve resource use efficiency, enhance productivity, sustain natural resources, preserve the environment, and increased farmers' profitability.

Keywords: crop productivity, drones, fruit quality, robotic

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Introduction

Precision agriculture aims to increase food production, improve food quality to meet the growing demands of food worldwide, enhance the use efficiency of natural resources, minimize adverse effects on crop production, and protect the environment.

Precision agriculture uses modern technologies such as sensors, drones, satellites, the Internet of Things (IoT), and robotics to help farmers adopt smart and sustainable agriculture by using various applications that provide modern solutions to agricultural problems and facilitate decision-making to make agricultural activities more accurate and efficient.[1]

Precision farming in horticulture involves using advanced technologies to optimize crop production, improve resources management, increasing their efficiency. These applications allow for precise monitoring and control of various production factors, such as water, soil, nutrients, and pests, leading to higher yields, reduced costs, and minimal environmental impact.[2]

Precision agriculture applications in horticulture achieve numerous benefits, including enhanced water use efficiency, reduced production costs, and increased crop quality. Adopting smart agriculture in the horticultural sector can meet the growing demand for food while minimizing environmental impact.[3]

For instance, smart irrigation helps farmers respond to increasingly unpredictable weather patterns by adjusting water delivery based on real-time data. This ensures resilience against droughts or excessive rainfall. It is a fundamental technique in dry and semi-dry regions with limited water resources.[4]

Unmanned aerial systems (drones) are used for precision spraying, monitoring climate, and spreading pathogen infection. The precise and efficient application of agrochemicals is an important aspect of precision agriculture. Drones play an important element in smart farming, they can determine the water and nutritional requirements of plants and identify infected areas with plant pathogens, which helps farmers with the accurate and effective use of agricultural chemicals.[5] Traditional methods of spraying agrochemicals are often ineffective, overuse chemicals, have uneven distribution, and are labour-intensive. In smart farming, drones are used to spray various agrochemicals, including pesticides and fertilizers, allowing for precise targeting, variable application rates, more efficiency, and cost reduction in terms of chemicals, water, and labour, as well as reducing soil pollution by agrochemicals.[6]

Applications of precision (smart) farming

Precision agriculture applications provide precise use of natural resources, increased productivity, reduced costs, and environmental protection. Drones contribute to identifying the locations of pathogens and thus combating infection in specific places only and controlling spread in the whole farm, furthermore, they increase the use efficiency of agrochemicals and reduce the quantities, which reduces costs.[5]

Drones are also useful in spraying nutrients, plant protection materials, and fertilizers on fruit trees such as mango, orange, guava, date palm, and various field vegetable crops, to ensure efficient use of agrochemicals without excess or deficiency, thus reducing production costs.

Precision irrigation

Precision irrigation represents a significant advancement in water management for agriculture. Combining advanced technologies such as sensors, automation, and data analytics allows farmers to optimize water use, reduce adverse effects of climate change, reduce costs, improve crop yields, and minimize soil degradation. It is a crucial component of sustainable farming practices, especially in water-scarce regions.[7] Precision irrigation systems aim to enhance efficient water use by using data from other devices, such as weather stations, soil sensors, and crop needs, to schedule irrigation and optimize water usage across the farm. Precision irrigation aims to preserve water and improve water use efficiency. It ensures that water is applied exactly where, when, and the amount needed according to the growth stage. Smart irrigation systems adjust water distribution according to weather patterns, crop type, and growth stage. This conserves water and ensures plants get the required quantity of hydration throughout their growth cycle.

Precision controllers schedule irrigation events, optimizing water delivery based on soil moisture, weather forecasts, and plant requirements. Precision irrigation allows for real-time adjustments, ensuring that water is applied efficiently. These systems often send alerts when water levels are too high or too low, enabling quick interventions.[8]

Precision Fertilization

Precision fertigation systems use sensor readings and data analysis to monitor plant nutrient levels, adjust the nutrient quantity, and ensure that required nutrients are available in the rhizosphere according to the plant's requirements.[9]

Precision agriculture tools improve nutrient use efficiency by monitoring their level in soil and plant tissue by adding adequate quantities according to the plant requirements in each part of the farm, which consequently increases farmers' profits and reduces soil pollution. Precision agriculture tools provide innovative solutions to improve crop production and provide accurate information about the availability of nutrients in the soil and the nutritional status of plants to determine the appropriate time for fertilizing.

Pest and disease monitoring

Remote sensing and IoT (Internet of Things) devices, such as cameras, drones, or satellite imaging, can detect early infection or disease outbreaks in horticultural crops in wide areas. Artificial Intelligence (AI) can analyze these data to identify potential threats, allowing farmers to intervene early with targeted treatments and reducing the use of pesticides.[10]

Fungicide and pesticide management

Precision application systems monitor the effectiveness of treatments and optimize application schedules based on current crop conditions and disease threats. In addition to utilizing natural organisms or substances to control diseases, reduce chemical inputs, and promote sustainability.

Precision farms in horticulture

Horticulture precision farms involve utilizing various tools and technologies to monitor and automate all aspects of the farm.

Smart farming systems, including weather stations, provide data about temperature, rainfall, wind speed, and solar radiation. This information helps in planning planting schedules, irrigation, and harvesting activities. The key tools used for smart farms in horticulture include:

Sensors

Various sensors are used in smart agriculture to measure soil humidity and precisely deliver water to plant roots based on soil moisture, and available nutrients in the rhizosphere, allowing for the precise control of the growing environment, like soil moisture sensors, nutrients sensors, environmental sensors, and weather sensors.

Microclimate sensors track changes in temperature and humidity, which provide insights into specific areas that may need attention, such as disease prevention or adjusting irrigation.

Drones and aerial imaging

Drones capture detailed images of crops, identifying plant stress, irrigation requirements, or early pathogen infestation. Drone-based aerial spraying system are used for precision spraying of pesticides and foliar nutrients, ensuring even coverage and minimizing the use of agrochemicals.[6]

Automated greenhouses

Sensors monitor temperature, humidity, light levels, and CO2 concentrations in precision greenhouses; automated systems adjust ventilation, heating, and shading according to plant growth stage, which allows farmers to manage the greenhouse environment through remote monitoring that improves water and nutrient efficiency and reducing the need for manual labor.

Pest and disease management tools

Controlling diseases in Precision Horticulture involves integrating advanced technologies and practices to monitor, detect, and manage plant diseases effectively. By leveraging data-driven insights and automation, farmers can minimize the impact of diseases on crops and reduce the use of pesticides.

Tools like drones and camera systems can detect early signs of pest infestations or disease outbreaks in crops in their early stages and provide early intervention recommendations.

Biocontrol systems

Releasing beneficial insects or biological agents to control pests, which reduces the need for chemical interventions. Controlling diseases in smart horticulture allows using a proactive approach, protects crops, promotes sustainable farming practices, and reduces the reliance on pesticides, benefiting both the environment and productivity. It effectively approaches allowing monitoring and managing plant diseases, ensuring the crops and improved yields.[11]

Soil health monitoring

Precision application of horticulture provides real-time insights regarding soil health by measuring various parameters like pH, salinity, and nutrient levels, consequently helping farmers to prevent soil degradation and optimize crop yields.

Automated planting and harvesting

Robotic planting machines precisely plant seeds or seedlings in the soil, ensuring uniformity and optimal spacing in the correct location and depth with high precision, ensuring uniform crop establishment, detecting and removing weeds without damaging the crops, and reducing the use of herbicides.[1]

Automated harvesting machines identify and pick ripe fruits and vegetables, improving the speed and efficiency of harvesting, and reducing labor costs.

Crop health monitoring

Precision applications provide insights into plant health by detecting abiotic stress, nutrient deficiencies, or pathogen infection. It helps farmers forecast crop yields, pest outbreaks, and optimal harvest times, enabling better planning and decision-making.

Precision spraying technologies

Precision sprayers apply fungicides or pesticides precisely where needed, minimizing chemical use and reducing environmental impact.

Variable Rate Application (VRA): Allows farmers to apply treatments at varying rates based on specific areas that require more attention, ensuring targeted disease management.

Conclusion

Precision farming in horticulture relies on a range of advanced tools and technologies to enhance efficiency, productivity, and sustainability. These tools, from sensors and drones to AI platforms and automated systems, help farmers optimize every aspect of their operations, from planting, irrigation, and fertilization to pest control and climate management. By leveraging these technologies, farmers can improve crop yields, reduce resource usage, and achieve more production, and high fruit quality.

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None

Conflicts of interest

There is no conflict of interest.

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