Green Technologies in Agriculture

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Abstract

Agricultural systems are presently under pressure from a combination of environmental and resource-related constraints. Irregular rainfall patterns, increasing climatic uncertainty, continuous extraction of natural resources, progressive decline in soil productivity, and accumulation of environmental pollutants have collectively challenged the sustainability of farming. To address these concerns, environmentally responsible technological interventions are required, among which green technologies have emerged as a promising approach for achieving sustainable agricultural development. The concept of green technology evolved as a response to ecological disturbances arising from intensive and non-conservative production systems. Such technologies prioritize conservation of natural resources, reuse and recycling of materials, and prevention of environmental contamination. Adoption of green technologies in agriculture contributes to sustainability by minimizing ecological stress while supporting long-term productive capacity.

Keywords: Green technology, Paddy farming, Sustainability, Resource management

Introduction

Green technology, also referred to as environmentally benign technology, may be described as the deliberate application of scientific principles and available resources to obtain desired agricultural outputs without compromising environmental integrity (Deepika et al., 2022). In farming systems, these technologies emphasize ecological balance and resource conservation rather than immediate yield maximization. Although their benefits may become evident gradually, green technologies ensure long-term environmental stability and resilience of production systems. Most green technologies rely on renewable inputs and environmentally safe practices that help limit greenhouse gas emissions and reduce excessive exploitation of natural resources. Incorporation of such technologies into agricultural systems facilitates a transition towards sustainable production models that integrate productivity with environmental stewardship (Iravani et al., 2017).

Importance of Green technology

The use of green technologies in agriculture and allied sectors plays a significant role in curbing environmental degradation, decreasing reliance on fossil fuel–based inputs, and supporting sustainable agricultural advancement. A wide range of applications fall under green agricultural technologies, including renewable energy utilization, conservation-oriented tillage practices, biotechnology-driven solutions, organic farming approaches, vertical farming systems, improved irrigation methods, integrated pest management strategies, drone-based field assessment, fleet optimization, and sensor-based digital monitoring. Together, these applications enhance resource-use efficiency and promote environmentally sound farming practices

Some of the Green Technologies adopted in Agriculture

A) Renewable Energy Sources

1) Solar-powered irrigation systems

Solar-powered irrigation uses photovoltaic panels to operate water pumps, providing a reliable energy source for irrigation without depending on electricity grids or fossil fuels. This approach is particularly useful in remote areas and helps reduce operational costs and greenhouse gas emissions over time.

2) Biogas generation from farm waste

Biogas plants convert crop residues and animal dung into usable energy through anaerobic digestion. The biogas can be used for cooking or electricity, while the leftover slurry enriches soil fertility as an organic fertilizer, promoting recycling of farm waste.

3) Wind energy in farm operations

Small-scale wind turbines are deployed in areas with sufficient wind availability to pump water or generate electricity. Wind energy offers a renewable alternative to conventional energy, decreasing dependence on non-renewable fuels and supporting sustainable farming practices.

B) Water Conservation Techniques

4) Drip irrigation

Drip irrigation delivers water precisely to plant roots through a network of pipes and emitters, minimizing losses due to evaporation and runoff. This targeted approach improves water-use efficiency and supports healthy crop growth.

5) Rainwater harvesting

Rainwater harvesting involves capturing and storing rainfall in structures such as ponds or tanks. The collected water can supplement irrigation during dry periods and help recharge groundwater, improving overall water availability.

C) Organic Pest Management

6) Biological control methods

Biological control involves the use of natural enemies such as predators, parasitoids, and microbial agents to manage insect pests. These methods help maintain ecological balance and reduce dependency on synthetic pesticides.

7) Botanical pesticides

Plant-derived pesticides, such as neem, garlic, or chilli extracts, offer biodegradable alternatives for pest management. They are environmentally safer and have minimal effects on non-target organisms.

D) Soil Health and Fertility Management

8) Application of organic manures and compost

Organic inputs such as farmyard manure, compost, and green manures improve soil structure and increase organic matter content. These inputs enhance microbial activity and provide nutrients in a sustained manner.

9) Use of biofertilizers

Biofertilizers consist of beneficial microorganisms that enhance nutrient availability to crops. Inoculants such as Rhizobium, Azospirillum, Azotobacter, and phosphate-solubilizing bacteria reduce the requirement for chemical fertilizers and support soil biological health.

10) Conservation tillage practices

Conservation tillage techniques, including minimum and zero tillage, reduce soil disturbance during crop establishment. These practices help conserve soil moisture, prevent erosion, and improve soil organic carbon levels.

E) Waste Reduction and Recycling

11) Management of crop residues

Crop residues are retained on the field as mulch or incorporated into the soil rather than being burned. This practice improves soil organic matter, conserves moisture, and reduces air pollution caused by residue burning.

12) Vermicomposting

Vermicomposting uses earthworms to convert organic farm waste into nutrient-rich compost. The resulting vermicompost enhances soil fertility and supports sustainable nutrient recycling.

F) Energy Efficiency and Precision Resource Use

13) Precision farming technologies

Precision farming employs tools such as GPS, sensors, drones, and decision-support systems to optimize the use of inputs. These technologies enable accurate application of water, fertilizers, and pesticides, reducing wastage and environmental impact.

14) Site-Specific Nutrient Management (SSNM)

SSNM involves applying nutrients based on soil fertility status and crop demand. This approach improves nutrient-use efficiency and minimizes nutrient losses to soil and water systems.

15) Energy-efficient farm machinery

Energy-efficient equipment, including improved irrigation pumps and low-energy farm implements, reduces fuel and electricity consumption. Such machinery supports sustainable mechanization without compromising productivity.

Advantages and disadvantages of green technologies inAgriculture

Green agricultural technologies support sustainable crop production by reducing environmental stress linked with conventional farming. They promote efficient use of natural resources by lowering dependence on synthetic agrochemicals and non-renewable energy. Practices such as biological nutrient management, conservation tillage, renewable energy use, and precision input application improve soil health, conserve water, and reduce emissions. However, adoption is often limited by high initial costs, delayed economic returns, and inadequate technical support. Strengthening extension services and institutional mechanisms is essential for wider adoption and sustainable agricultural development.

Conclusion

Green technologies promote sustainable agriculture by conserving natural resources, improving soil fertility, and optimizing the use of water, nutrients, and energy. Their adoption reduces environmental degradation, enhances system resilience, and supports long-term agricultural productivity while ensuring food security for future generations.

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