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Enhance Crop Productivity through the Implementation of Sustainable Horticulture

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INTRODUCTION

Sustainable horticulture is a system and practice that improves the health of natural resources and ensures food security. The sustainable production of horticultural crops is significantly limited by reductions in plant growth, yield, and quality due to diverse environmental constraints along with climate change. In this chapter, we highlight novel approaches to achieving sustainability in crop production. The advantages of such applications result in higher yields and effective utilization of resources when implemented in greenhouse or field conditions. Focusing on quality control, we examined the effects of the applications of microbial inoculants, NMs, and CEH on horticultural commodities. Furthermore, the genomic editing of plants using CRISPR was reviewed, including its role in modulating gene expression and transcription factors in improving crop production and tolerance.

These challenges have several root causes, including the rapid growth of the global population

- Climate change has increased the negative impact of environmental challenges such as salinity, drought, disease pressure, heavy metal toxicity, etc. due to climate change, which restricts arable land availability and reduces crop yield challenges with resource use efficiency to limit environmental releases of chemicals.
- The increasing use of pesticides, fungicides, bactericides, herbicides, and other chemical-controlling biotic agents, as well as the environmental and health challenges related to their overuse.
- It is imperative to safeguard the integrity of the agricultural resource base, including but not limited to land, water, and biodiversity, in order to sustain production. Nevertheless, owing to the depletion of natural resources over time, there exists a deficiency in catering to the requirements of humans. The desire to avoid this fate is a prime motivation behind the emergence of the idea of sustainable horticulture.

The constituents of a sustainable horticulture.

Here are some of the key components of sustainable agriculture

Soil Health: Soil health is important for sustainable agriculture. Farmers can achieve this by reducing tillage, utilizing cover crops, and rotating crops to enhance soil structure and fertility, as well as minimizing soil erosion.

Water Conservation: Sustainable agriculture practices aim to conserve and protect water resources because they are limited. This can be accomplished by employing water-saving irrigation techniques, enhancing soil retention, and minimizing water contamination.

Biodiversity: Sustainable agriculture aims to enhance biodiversity and ecosystem services through the preservation and restoration of natural habitats, the utilization of agroforestry, and the cultivation of diverse crops and livestock.

Integrated Pest Management: Sustainable agricultural practices employ integrated pest management strategies that minimize the utilization of synthetic pesticides and herbicides, and instead rely on natural pest control techniques such as beneficial insects, crop rotation, and companion planting.

Social and Economic Equity: Sustainable agriculture emphasizes fair labor practices and economic viability for farmers and workers. This requires the promotion of local and regional food systems, improving working conditions, and ensuring that farmers receive a fair price for their products. By incorporating these components, sustainable agriculture can contribute to the development of a resilient and regenerative food system that benefits both individuals and the environment.

The objectives of sustainable horticulture include:

Ensure Food Security: Sustainable agriculture seeks to produce sufficient food to feed the world's growing population in a way that is environmentally, socially, and economically sustainable.

Protect Natural Resources: Sustainable agriculture aims to safeguard and safeguard natural resources such as soil, water, and biodiversity through the implementation of farming practices that minimize soil erosion, mitigate water pollution, and promote biodiversity.

Enhance Soil Health and Fertility: Sustainable farming aims to improve the soil's health and fertility by using natural things like compost and cover crops instead of chemical fertilizers and pesticides.

Resilience to climate change: Sustainable agriculture aims to enhance the resilience of agricultural systems to climate change by implementing practices such as crop diversification and water conservation.

Boost the incomes of farmers and rural communities: Sustainable agriculture aims to enhance the livelihoods of farmers and rural communities by promoting local and regional food systems, ensuring fair prices for agricultural products, and enhancing working conditions.

To ensure the sustainable use of resources: Sustainable agriculture aims to ensure that resources are used sustainably, through promoting the use of renewable resources and reducing waste and pollution. Sustainable agriculture helps to create a food system that is resilient, equitable, and environmentally sustainable by achieving these objectives.

Novel approaches to sustainable horticulture have been developed:

The utilization of microbiological inoculants: Microbial inoculants are becoming increasingly important for attaining sustainable agricultural production systems. The nutrient supply capacity of soil is continuously decreasing as a result of soil erosion, degradation, the accumulation of salts, undesirable elements and metals, water scarcity, or an excess and imbalanced nutrient supply system. Biological inoculation combinations have a significant impact on the management of plant nutrients through the process of fixation, solubilization, or

transformation in soil. As a result, biodegradable materials and microbe-inoculants can be utilized to meet future nutrient requirements.

The utilization of Nanomaterial's: Nano-particles are solid colloidal particles that comprise macromolecular components. The nanoparticles contain active ingredients, such as bioactive substances or pharmaceutical compounds. Nanofertilizers are environmentally friendly and cost-effective inputs that promote highly efficient plant nutrition and ultimately increase the yield of crop plants. Their release is targeted, gradual, and effective for the plants. In agriculture, nanoparticles are used to make plants grow, pollinate flowers, and make them fertile. This makes fruit trees produce more fruits and have better quality.

Examples:

- ✓ Under saline stress conditions, exogenous supplementation with nano-Ca results in increased vegetative growth and increased chlorophyll content in the leaf.
- ✓ The spraying of mango trees with nano-zinc also results in an increase in fruit weight, fruit number, and yield, and in the contents of leaf chlorophyll and carotene.
- ✓ The application of nano-boron and nano-zinc fertilizers improves the quality of fruits, increases the number of fruits, increases the ratio of total soluble sugars (TSS) and maturity index, and increases the total sugars and total phenols in pomegranates.

Controlled Environment Horticulture

Controlled environment horticulture is the production of plants and their products, such as vegetables and flowers, inside controlled environments structures such as greenhouses, vertical farms, and growth chambers. By utilizing CEA, we can cultivate high-value crops with maximum productivity in a cost-effective and sustainable manner. Within the realm of CEA, there exist two growing techniques that are driven by technology, namely hydroponics and aeroponics.

- **Hydroponic farming**: Hydroponic farming means plants are grown in water rather than soil. Nutrients are added to the water to ensure healthy plants with maximum output.
- **Aeroponic farming:** Aeroponic farming growing means plants are grown with their roots exposed to the air. The roots are then regularly misted with water and vitamin solutions, which they can then absorb.

The advantages of pursuing sustainable agriculture.

Sustainable farming has many benefits for the environment, farmers, and society as a whole. These are some important advantages:

Environmental Protection: Sustainable agriculture aims to reduce the negative environmental impacts of conventional farming, such as soil erosion, water pollution, and biodiversity loss. It promotes the preservation of natural resources and employs farming practices that minimize environmental impact.

Enhanced Soil Health and Fertility: Sustainable agriculture practices emphasize the use of organic matter and natural fertilizers, which improve soil health and fertility. This leads to improved crop yields, better quality food, and improved resilience to drought and other climate-related stresses.

Food Security: Sustainable agriculture can improve food security by improving local and regional food systems and reducing dependence on global food markets. This will ensure that people have access to nutritious food, even in times of crisis.

Financial Benefits: Sustainable agriculture has the potential to offer economic advantages to farmers, rural communities, and consumers. Sustainability agriculture can help to create new jobs and stimulate economic growth by reducing the cost of inputs, increasing crop yields, and promoting local food systems.

Improved Public Health: Sustainable farming can make people healthier by reducing exposure to harmful chemicals like pesticides and other chemicals, and by encouraging people to eat healthy, organic food.

Biodiversity Conservation: Biodiversity preservation is promoted through the protection and restoration of natural environments, the planting of diverse crops, and the reduction of harmful chemicals that can harm animals.

CONCLUSION

Horticulture is an important and important industry with a great impact on the lives of many small and large farmers and especially on world poverty. The advancements in horticulture hold significant significance in enhancing protection, productivity, and food quality and safety, particularly in the context of changing environmental conditions. In this review, many affordable, fast, eco-friendly, and effective approaches were discussed that could make a successful horticultural crop production. Particularly, the utilization of beneficial microbial inoculants and nanoparticles holds significant potential to substitute certain agrochemicals and serve as a safe and natural component of biofertilizers and plant protection formulations, thereby enhancing plant resilience, crop productivity, and quality.