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## Sustainable horticulture practices: An environmental-friendly approaches

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### Abstract

This review paper gives a general overview of sustainable horticulture methods and emphasizes numerous eco-friendly techniques that are applied in the industry. In order to provide food, green cities, and preserve biodiversity, horticulture is essential. However, traditional horticulture methods frequently have a negative influence on the environment, including soil erosion, water pollution, and greenhouse gas emissions. Adopting sustainable and ecologically friendly practices in gardening has become increasingly important in recent years. In order to reduce environmental impact while boosting production and fostering long-term sustainability, this review will also investigate and assess the efficacy of various strategies. The study analyses a number of significant issues, such as organic farming, integrated pest control, water conservation, management of soil health, and improvement of biodiversity. According to the research, gardening practices that are more environmentally friendly can also result in lower input costs and better ecosystem benefits. But there are also difficulties and potential hindrances to the broad use of these techniques. The analysis finishes with suggestions for additional study as well as useful takeaways for promoting sustainable horticultural practices.

**Keywords:** Sustainable horticulture, ecologically friendly, organic farming, integrated pest management, water conservation, biodiversity

### Introduction

Sustainable horticulture practices are crucial for reducing the environmental effects of conventional horticultural techniques while preserving ecological balance and long-term agricultural yield. Adopting environmentally friendly methods in horticulture is becoming increasingly important as the need for sustainable development and environmental stewardship is recognized on a worldwide scale. In order to achieve sustainable food production systems, this review article seeks to provide a thorough overview of environmentally friendly approaches in sustainable horticulture practices. Conventional horticulture techniques frequently use a lot of pesticides, synthetic fertilizers, and extensive irrigation, which causes soil degradation, water pollution, and biodiversity loss. Sustainable horticulture practices, in contrast, place a higher priority on the preservation of natural resources, the promotion of ecosystem health, and the reduction of harmful environmental effects. In recent years, a number of crucial strategies have evolved to deal with these difficulties. One of the key tenets of sustainable horticulture is organic farming. Organic farming encourages biodiversity, improves soil fertility, and decreases pesticide residues in products by forgoing the use of synthetic pesticides and putting an emphasis on soil health management (Zaller *et al.*, 2019) [1]. The use of biological control agents, crop rotation, and monitoring techniques are all important components of the Integrated Pest Management (IPM) approach, which combines them with other pest control methods to lessen the need for chemical pesticides and reduce any unfavorable effects on non-target organisms (Gontijo *et al.*, 2018) [4]. Given the mounting demands on water resources, water conservation is a crucial component of sustainable horticulture practices. Water wastage is decreased and water use efficiency is increased through efficient irrigation techniques like drip irrigation and precision irrigation (Chaves *et al.*, 2019) [3]. Sustainable water management in horticulture is further aided by the use of reclaimed water, rainwater harvesting, and water-saving devices. For horticulture to be sustainable over the long run, maintaining healthy soil is essential. Long-term production and ecosystem functioning is supported by techniques such as cover cropping, mulching, composting, and vermicomposting. These techniques also increase nutrient availability and decrease soil erosion (Borrelli *et al.*, 2019) [2].

Another crucial component of sustainable horticulture practices is the improvement of biodiversity. Natural pest control, pollination services, and ecosystem resilience are all improved by preserving and establishing habitats for beneficial creatures, implementing agroforestry systems, and encouraging biodiversity protection (Torné-Noguera *et al.*, 2018) [33].

### **Sustainable Horticulture Practices**

These are following practices apply in sustainable horticulture.

#### **Organic Farming in Horticulture**

Growing fruits, vegetables, flowers, and other horticultural crops using natural methods and materials is emphasized in organic farming, a style of horticulture that is environmentally friendly. Through this method, artificial pesticides, fertilizers, and genetically modified organisms (GMOs) are avoided, supporting sustainable agriculture systems that are good for the environment and human health. An overview of organic horticulture farming, along with arguments in favor of it, are provided in this section. Organic farming prioritizes preserving biodiversity, and soil health, and reducing its negative effects on the environment. Organic farmers use a variety of methods, such as crop rotation, composting, green manure, and the employment of helpful insects for pest management, as opposed to relying on synthetic pesticides. These methods help to boost microbial activity, reduce soil erosion, improve water and nutrient retention, and improve soil fertility (Reganold *et al.*, 2010) [8]. Reducing the use of synthetic pesticides and fertilizers helps to conserve ecosystems and lessen soil and water contamination, which is one of the main advantages of organic farming in horticulture. According to research (Zaller *et al.*, 2019) [1], organic farming practices can dramatically reduce pesticide residues in crops and surrounding surroundings. In comparison to conventionally farmed produce, organic fruits and vegetables have been discovered to have higher concentrations of several essential nutrients and antioxidants (Baranski *et al.*, 2014) [5]. By supplying habitat for beneficial creatures like pollinators and natural adversaries of pests, organic farming in horticulture aids biodiversity preservation. By enabling the presence of various plant species, it strengthens and balances the ecosystem. According to studies (Bommarco *et al.*, 2013; Hole *et al.*, 2005) [6, 7], organic farming has a good effect on birds, beneficial insects, and pollinators. This highlights the potential for organic horticulture to support wildlife conservation.

#### **Integrated Pest Management (IPM)**

Integrated Pest Management (IPM) is a crucial method in horticulture that combines a number of tactics to control pests efficiently while reducing the use of chemical pesticides and their negative effects on the environment. IPM practices combine biological, cultural, physical, and chemical management techniques to keep pest populations below harmful levels while fostering ecological balance and lowering hazards to human health. A summary of IPM techniques used in horticulture, along with arguments in favor of them, are given in this section.

The use of natural enemies including predators, parasitoids, and viruses to manage pest populations is known as biological control, and it is one of the main tenets of IPM in horticulture.

IPM improves natural pest control processes by encouraging the presence and activity of beneficial organisms. A more sustainable and self-regulating pest management system can be developed by releasing or preserving biological control agents through habitat modification, selective planting, and the availability of alternative food sources (Gontijo *et al.*, 2018) [4]. By fostering unfavorable conditions for pests and boosting plant health and resistance, cultural practices play a significant part in IPM. Crop rotation, using resistant types, maintaining good hygiene, and timing of planting are a few cultural practices that break the life cycles of pests and lessen pest load. In IPM, physical exclusion or removal of pests from the crop environment is the goal of physical control approaches. Examples include the use of pest-removal machinery and the use of barriers, traps, netting, and traps. These techniques have the potential to be quite powerful, especially when combined with other IPM tactics. Chemical control is the last line of defense in IPM and is only employed when absolutely necessary. Based on pest monitoring and threshold levels, selected and targeted pesticide treatments are conducted as necessary. IPM encourages the use of low-risk pesticides since they have fewer negative effects on the environment and non-target creatures.

IPM techniques have many advantages for horticulture. They lower the need for pesticides, slow the emergence of pesticide resistance in pests, safeguard natural predators and allies, and lessen adverse effects on unintended creatures and the environment. Research has shown that IPM is successful at lowering pesticide residues in crops, promoting biodiversity, and raising crop yield in general (Gontijo *et al.*, 2018; Parrella *et al.*, 2009) [4, 9].

#### **Water Conservation in Horticulture**

As water shortages and effective water resource management become more crucial, conserving water is a key component of sustainable gardening practices. A summary of water conservation techniques used in horticulture, along with arguments in favor of them, are given in this section.

Drip irrigation is a very effective method of water conservation in horticulture. In contrast to conventional irrigation techniques, it minimizes evaporation and runoff by delivering water directly to the root zone of plants. According to Chaves *et al.* (2019) [3], drip irrigation systems can conserve up to 50% of water while maintaining ideal plant hydration. In addition to reducing weed growth and fungal infections linked to too much moisture on plant foliage, accurate water application control also inhibits the growth of weeds.

Precision irrigation, is another water conservation strategy, which uses cutting-edge technology to deliver water according to the individual requirements of plants. In order to schedule irrigation more effectively and avoid overwatering, weather information, soil moisture sensors, and computerized control systems are used. Precision irrigation maximizes water use efficiency and minimizes water waste by only giving water when and where it is required (Chaves *et al.*, 2019) [3].

Recycled water is becoming more and more popular in horticulture as a sustainable water supply. It is possible to repurpose treated wastewater, gray water, or rainfall collection for irrigation. Recycling water is an important resource for plant nutrition since it reduces the nutrient load in wastewater and conserves freshwater resources. To guarantee

the safety and purity of recycled water for horticultural applications, however, thorough monitoring and the right treatment are required (Chaves *et al.*, 2019) [3]. Covering the soil's surface with organic or synthetic materials is the practice of mulching, which effectively conserves water. Mulch preserves soil moisture levels, inhibits weed development, and lowers soil evaporation. As they decompose over time, organic mulches like straw, wood chips, or compost help enhance the structure and fertility of the soil (Borrelli *et al.*, 2019) [2]. Mulching also aids in regulating soil temperature by reducing excessive swings that could stress plants and raise their water requirements. Another method of water conservation in horticulture is cover cropping. To safeguard and enhance the health of the soil, cover crops are cultivated in between harvest cycles or alongside the primary crops. Cover crops provide a dense layer of protection that lowers evaporation, increases water infiltration, and increases soil moisture retention. In addition, cover crops improve soil structure, nitrogen cycling, and organic matter content, which helps to conserve water over the long run (Borrelli *et al.*, 2019) [2].

### Soil Health Management in Horticulture

The management of soil health is a key component of sustainable horticulture practices since it is essential for sustaining long-term production, encouraging plant development, and assisting ecosystem function. The benefits of soil health management techniques used in horticulture, as well as references proving their efficacy, are described in this section.

For horticulture to improve soil health, cover crops are frequently utilized. For soil protection and enrichment, cover crops like grasses or legumes are cultivated during fallow periods or in conjunction with primary crops. According to Borelli *et al.* (2019) [2], they improve soil structure and water-holding capacity, increase soil organic matter content, encourage nutrient cycling, and minimize soil erosion. Increased crop yields, less nutrient leaching, and improved soil biodiversity are all possible outcomes of incorporating cover crops into horticulture systems. Another successful method of managing soil health in horticulture is mulching. Mulch materials, either organic or inorganic, can be applied to the soil surface to control soil temperature, decrease moisture loss due to evaporation, inhibit weed development, and improve nutrient cycling. Straw, wood chips, or compost are examples of organic mulches that help develop soil organic matter, enhance soil structure, and promote beneficial soil microbial activity (Borrelli *et al.*, 2019) [2].

For recycling organic waste and increasing soil fertility in horticulture, composting and vermicomposting are effective procedures. The process of composting entails the breakdown of organic materials into a nutrient-rich soil supplement, such as plant remains or food scraps. Earthworms are used in vermicomposting to hasten the breakdown of organic matter and create vermicompost of the highest caliber. According to Borrelli *et al.* (2019) [2] and Choudhury *et al.* (2017) [15], both techniques stimulate microbial activity in the soil, improve soil structure, and increase nutrient availability. Crop rotation is a well-known method of managing soil health that entails planting various crop types in a predetermined order. Crop rotation aids in reducing nutrient imbalances, disrupting pest and disease cycles, and enhancing soil structure. Horticultural systems can successfully manage pests, improve soil

biodiversity, and maximize nutrient uptake by diversifying crop species (Borrelli *et al.*, 2019) [2].

Planning for nitrogen management and soil testing are essential parts of managing soil health in horticulture. Regular soil testing enables farmers to evaluate the condition of the soil's nutrients and modify fertilizer treatments accordingly, ensuring that crops have the best possible access to nutrients while reducing nutrient losses and environmental effects.

### Biodiversity Enhancement in Horticulture

Enhancing biodiversity is a crucial component of sustainable horticultural practices since it fosters ecological resilience, improves ecosystem services, and boosts the overall health and productivity of horticultural systems. The strategies for horticultural biodiversity enhancement are discussed in this part, along with the advantages they offer and the evidence for their efficacy.

Enhancing biodiversity in horticulture starts with planting a variety of plant varieties. Farmers may provide habitat and food sources for a wide range of creatures, including pollinators, beneficial insects, birds, and other wildlife by incorporating a mix of crops, flowers, and native plants into horticultural landscapes. Diverse plant species help create an environment that is more stable and robust, which lowers the danger of pest outbreaks and encourages natural pest control (Bommarco *et al.*, 2013) [13]. For horticulture to improve biodiversity, native plants and ecosystems must be preserved. Native plants offer vital resources for local pollinators and other species and are well-adapted to the local environment. Farmers can construct corridors and stepping stones for biodiversity, allowing for the movement and connectivity of species, by protecting natural areas, and wetlands, or adding native plants in horticultural landscapes (Kremen *et al.*, 2007) [18]. Manipulating habitat is another method for enhancing biodiversity in horticulture. By incorporating various ecosystems into and surrounding horticulture systems, such as hedgerows, wildflower strips, or insectary plants, it is possible to draw predators, pollinators, and beneficial insects. In order to support the presence of beneficial creatures that aid in pest management and pollination, these environments offer refuge, nesting locations, and nectar sources (Landis *et al.*, 2000) [19]. Enhancing biodiversity in horticulture is also supported by using fewer pesticides and implementing integrated pest management (IPM) techniques. Farmers can safeguard beneficial insects, such as pollinators and pest-natural enemies, by using less broad-spectrum insecticides. The use of beneficial species is encouraged by IPM techniques like biological control and cultural management, which lessen the need for chemical interventions and support a healthier and more diverse environment (Gontijo *et al.*, 2018) [4].

### Challenges and Barriers to adaptation

**Knowledge and Awareness Gap:** Lack of understanding of sustainable horticulture techniques can be a major hindrance. According to Bhattarai *et al.* (2015) [21], farmers can be underinformed about the advantages, methods, and economic viability of sustainable practices. To close this knowledge gap and encourage the adoption of sustainable practices, educational programs, training, and extension services are essential.

**Economic Restraints:** Adopting sustainable horticulture practices is frequently complicated by economic concerns.

Farmers may experience financial hardship due to the up-front expenditures associated with switching to sustainable practices, such as organic certification, the adoption of new technology, or infrastructural improvements (Ponisio *et al.*, 2015) <sup>[23]</sup>. Economic limitations are made worse by limited access to financial resources, credit, or government incentives.

**Market Demand and Access:** Farmers may be discouraged from implementing sustainable horticulture practices due to a lack of market demand and restricted access to sustainable markets. Farmers can be hesitant to invest in these changes if the market does not acknowledge and reward the environmental advantages of sustainable practices (Meemken *et al.*, 2013) <sup>[22]</sup>. To encourage the use of sustainable practices, it is crucial to promote sustainable certification programmes, strengthen market ties, and develop market incentives.

**Technical Complexity:** Farmers may find it difficult to implement some sustainable horticulture practices since they may need specialized knowledge, skills, and technical expertise (Bhattarai *et al.*, 2015) <sup>[21]</sup>. Implementing integrated pest management (IPM) practices, for instance, necessitates a grasp of pest dynamics, monitoring procedures, and alternate pest control strategies. Technical difficulties can be overcome with the use of training programmes, extension services, and farmer-to-farmer information exchange.

**Government and Regulatory Factors:** The implementation of sustainable horticultural practices may be hampered by a lack of proper governmental backing, uneven laws, and lax enforcement. According to Meemken *et al.* (2013) <sup>[22]</sup>, farmers require supportive laws, incentives, and policies that encourage environmentally friendly practices and foster a positive economic climate. The best way to deal with these issues is through stakeholder cooperation, policy lobbying, and efficient regulatory execution.

#### Recommendation on for Future Research

Sustainable horticulture techniques have improved agricultural sustainability and encouraged environmental care, but there are still a number of issues that need more study and research. The main suggestions for future horticulture studies are outlined in this part, along with the sources that back them up.

**Long-term Effects of Sustainable Practices:** Future studies should concentrate on evaluating the long-term impacts of sustainable horticulture practices on soil health, biodiversity, water resources, and ecosystem services. The effectiveness and potential advantages of sustainable practices can be better understood through longitudinal studies that track and analyze their effects over protracted time periods (Pretty *et al.*, 2018) <sup>[28]</sup>.

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**Market Demand and Access:** Farmers may be discouraged from implementing sustainable horticulture practices due to a lack of market demand and restricted access to sustainable markets. Farmers can be hesitant to invest in these changes if the market does not acknowledge and reward the environmental advantages of sustainable practices (Meemken *et al.*, 2013) <sup>[22]</sup>. Forcing the adoption of sustainable practices requires bolstering market ties, supporting sustainable certification programs, and developing market incentives.

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**Policy and Regulation Factors:** Adoption of sustainable horticulture methods may be hindered by a lack of enforcement, inconsistent legislation, and inadequate governmental support. In order to encourage sustainable practices and foster a positive economic climate, farmers require supportive policies, incentives, and regulations (Meemken *et al.*, 2013) <sup>[22]</sup>. To overcome these issues, stakeholders must work together, advocate for policy changes, and ensure that legislation is implemented correctly.

#### Practical Implications for Promoting Sustainable Horticulture

Promoting sustainable horticulture practices is essential for achieving environmental sustainability and guaranteeing the agriculture sector's long-term survival. This section discusses the sources that support the practical implications for improving sustainable horticulture, including methods, methodologies, and policies. Knowledge transfer and capacity building: It's crucial to provide farmers with information and training on sustainable horticultural methods. In order to spread knowledge and increase farmers' capacity to adopt sustainable practices, extension services, training programs, and farmer-to-farmer knowledge exchange platforms can all be extremely helpful (Dong *et al.*, 2020) <sup>[29]</sup>. Increased awareness, comprehension, and implementation of sustainable practices result from effective knowledge transfer.

**Financial and Policy Support:** To encourage sustainable horticulture practices, governments, politicians, and funding organizations should offer both financial and policy support. To help farmers make the switch to sustainable practices involves providing financial incentives, grants, and subsidies (Seyyedi *et al.*, 2020) <sup>[31]</sup>. In addition, it is essential to create supportive policies that prioritize sustainable agriculture, such as restrictions on the use of pesticides, organic certification, and market access.

**Market Development and Consumer Awareness:** According to Kaufman *et al.* (2019) <sup>[30]</sup>, increasing consumer knowledge of the advantages of sustainably produced horticulture products for the environment and health is a crucial motivator for promoting sustainable practices. Demand for sustainably

grown horticulture products can be increased through promoting certification programs, eco-labeling, and direct marketing channels.

**Collaboration and Stakeholder Engagement:** It is essential for promoting sustainable horticulture practices to foster collaboration among stakeholders, including farmers, researchers, government organizations, NGOs, and industry representatives. Multi-stakeholder platforms, networks, and partnerships can make it easier for people to share knowledge, collaborate on research, and work together to overcome obstacles to adoption (Cameron *et al.*, 2020) <sup>[32]</sup>. The engagement of stakeholders makes ensuring that all viewpoints and areas of expertise are taken into account while promoting sustainable practices.

**Technology Adoption:** Adopting sustainable gardening practices can be facilitated by embracing technological advances and advancements. It is possible to maximize resource consumption, minimize environmental consequences, and boost output by promoting the use of precision agriculture technology, sensor-based irrigation systems, and digital platforms for monitoring and decision-making (Kang *et al.*, 2017) <sup>[26]</sup>. For sustainable technology to be applied successfully in horticulture systems, it is essential to support research and development in these fields.

## Conclusion

Sustainable horticulture techniques are essential for reducing negative environmental effects, fostering resource efficiency, and preserving the long-term viability of the horticultural industry. In this assessment, we've emphasized a number of eco-friendly practices that support long-term horticulture. Horticultural systems can be improved to become more sustainable and resilient through the use of organic farming, integrated pest management, water conservation, soil health management, biodiversity improvement, and evaluation of environmental results. These environmentally friendly methods provide a number of advantages, including better soil health, fewer chemical inputs, increased water efficiency, biodiversity preservation, and decreased environmental contamination. In addition, they support sustainable livelihoods for farmers and the provision of safer, healthier food. They also boost ecosystem services. However, overcoming obstacles and hurdles like knowledge gaps, financial restrictions, market dynamics, technological complexity, and policy assistance is necessary for the effective adoption of sustainable horticulture practices. The introduction of supportive legislation and financial incentives, as well as the participation of numerous stakeholders, including farmers, academics, policymakers, and consumers, are required to address these difficulties. To better understand the long-term effects of sustainable practices, increase climate change resilience, take advantage of technological advancements, address socioeconomic issues, and develop scaling-up strategies, more study is required. We can speed up the adoption of sustainable horticulture practices, support environmental sustainability, and make sure that the horticultural industry has a more resilient and profitable future by improving our understanding of these areas and putting their practical consequences into action.

In summary, environmentally friendly agriculture cannot be accomplished without using sustainable horticulture techniques. Adopting these strategies offers not just a moral obligation but also a chance to develop a more resilient and sustainable horticulture industry that benefits the environment and society at large.

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