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# Improving Innovations and Future Prospects in Protected Cultivation of Horticultural Crops

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## INTRODUCTION

Protected cultivation is the practice of growing crops in a closed or partially closed environment, such as greenhouses, shade houses, or high tunnel. The primary objective of protected cultivation is to establish a controlled microclimate that safeguards the crops from adverse weather conditions, pests, and diseases, while simultaneously optimizing environmental factors. The utilization of structures, materials, and technologies serves as a protective barrier and facilitates the manipulation of temperature, humidity, light, and other environmental variables. This technique facilitates year-round or out-of-season cultivation, extends the growing season, enhances crop quality and yield, and reduces dependence on external factors. Various horticultural crops, including vegetables, fruits, flowers, and herbs, are extensively grown under protected conditions. Abiotic and biotic stresses in the current changing climate significantly affect crop production and quality. Horticultural crop production faces challenges such as extreme temperatures, sunlight, water availability, relative humidity, weeds, nutrient deficiencies, wind velocity, carbon dioxide concentration, and diseases and insect pest incidences in North Indian conditions.

This practice enhances the profitability of farmers and reduces transportation duration, thereby guaranteeing the delivery of fresh produce, particularly in peri-urban areas. Greenhouses are structures covered with transparent materials, such as polythene or glass, which serve as selective radiation filters. They allow short-wavelength solar radiation to pass through while trapping long-wavelength radiation inside. This causes a greenhouse effect, which traps solar energy and raises the temperature inside the structure. The greenhouse environment allows for the manipulation of the physiological conditions of the plants. For example, closing the greenhouse at night can increase $CO_2$ levels due to plant respiration.

During the early morning hours of the following day, this elevated $CO_2$ is used for photosynthesis. The increase in temperature, relative humidity, $CO_2$ levels, and improved nutrition within the greenhouse promote rapid growth and increased production. Temperature within a greenhouse can be controlled by incorporating cooling systems such as ventilation, fogging, or fan pad systems. The management practices for protected cultivation differ from open-field production. In Peri-urban areas, multi-storeyed crop cultivation in greenhouses has become imperative in order to meet the demand for fresh vegetables, strawberries, flowers, and fruit tree nurseries. Various techniques, such as naturally-ventilated polyhouses, drip irrigation, fertigation, and mulching, are employed in protected cultivation systems.

❖ **Global and Indian scenarios for protected cultivation of horticultural crops:**

The protected cultivation of horticultural crops involves growing plants in a controlled environment, such as greenhouses, in order to improve yield and quality. This method is used widely all over the world and is especially important in countries with different climates and limited land for farming. Protected cultivation of horticultural crops results in higher yields and better quality produce compared to open field cultivation. For instance, the average yield of tomatoes in protected cultivation is approximately 30-40 kg/m$^2$, whereas the average yield in open field cultivation is approximately 10-15 kg/m$^2$. As of 2023, the global area under protected cultivation for horticultural crops was estimated to be approximately 623,302 hectares. The estimated global production of horticultural crops under protected cultivation is approximately 150 million tonnes annually. China is the leading country for protected cultivation, accounting for 45% of the global area. Other major producer countries include Turkey, Spain, Italy, and Japan. In India, approximately 11 thousand hectares are under protected cultivation. The leading states include Maharashtra, Gujarat, Himachal Pradesh, Karnataka, and Punjab. The primary crops that are grown under protected cultivation include vegetables such as tomatoes, cucumbers, peppers, lettuce, fruits such as strawberries, raspberries, and blueberries, as well as flowers such as roses, gerberas, and carnations. In India, tomatoes, cucumbers, capsicums, strawberries, raspberries, blueberries, roses and gerberas are the main crops grown under protected cultivation.

❖ **Future Prospects for the Protected Cultivation of Horticultural Crops:**

❖ **The global status of protected cultivation is as follows:**

➢ **The widespread adoption:** Protected cultivation techniques, such as greenhouses and high tunnels, have gained popularity across the globe, especially in regions with extreme climates or limited arable land.

➢ **Variety of crops:** It is used to grow a wide variety of horticultural crops, such as vegetables, fruits, flowers, and ornamental plants.

➢ **Technological Advancements:** Many developed nations have made significant investments in modern technologies for controlled environment agriculture, including automated climate control, hydroponics, and vertical farming.

➢ **The implementation of sustainable practices:** There is a growing focus on sustainable and organic practices in protected cultivation to reduce the environmental impact of agriculture.

➢ **Market Expansion:** The expansion of the market for protected cultivation equipment, technology, and services has presented numerous opportunities for enterprises.

❖ **Indian status as a protected cultivation:**

❖ **Rapid Growth:** In recent years, the adoption of protected cultivation methods in India has been steadily increasing, driven by the growing demand for fresh and off-season produce. This trend is supported by

advancements in technology, government initiatives, and the imperative for sustainable farming practices.

- **Favourable Climate:** India's varied climate, characterized by dangerous temperatures and monsoon patterns, makes it well-suited for protected cultivation. These methods are used to extend growing seasons and protect crops from adverse weather conditions. Furthermore, the adoption of these practices improves crop yields and quality, and contributes to sustainable agricultural development.
- **Horticultural Diversity:** In India, a wide variety of horticultural crops is cultivated using advanced protected cultivation techniques, including vegetables, floricultural species, and exotic fruit cultivars. These scientific-driven methods not only enhance yield and quality, but also enable the year-round production of high-value crops, meeting the demands of both domestic and international markets.
- **Government Initiatives:** The Indian government has implemented various schemes and incentives aimed at promoting protected cultivation, encouraging farmers to adopt greenhouse and polyhouse technologies. These initiatives aim to enhance agricultural productivity, enhance crop quality, and ensure sustainable farming practices.
- **Challenges:** Despite the expansion of protected cultivation, obstacles remain, including the substantial initial expenditures, the lack of technical expertise among small-scale farmers, and concerns regarding sustainability. The resolution of these issues is imperative for a wider acceptance and sustained success in this industry.
- **Research and Innovation:** Indian agricultural institutions and research organizations are engaged in the development of technologies for protected cultivation and enhancing crop productivity. These efforts include improvements in climate control systems, pest and disease management, and the development of high-yield, resilient crop varieties to make agricultural sustainability and profitability better.
- **Export Opportunities:** Protected cultivation has also helped India's horticultural exports, with certain crops being successfully exported to international markets. This expansion not only boosts the country's agricultural economy, but also strengthens its global trade relationships. Moreover, the consistent quality and accessibility of produce grown under protected cultivation methods enhance India's competitiveness in the global marke
- **Future Prospects of Protected Cultivation:**

The prospects for protected cultivation in India appear promising, with the potential for significant expansion and innovation. The advancements in technology, including automated climate control systems, precision farming, and integrated pest management, are anticipated to further enhance productivity and sustainability. As the population increases and the available arable land decreases, protected cultivation presents a viable solution to meet the increasing demand for horticultural crops. Furthermore, increasing awareness and education among farmers about the benefits of protected cultivation will encourage wider adoption. Government assistance through subsidies, training programs, and research initiatives will continue to play a pivotal role in expanding this sector. The integration of protected cultivation with digital agriculture and smart farming techniques holds the potential to transform India's agricultural landscape, guarantee food security, and enhance the country's position in global agricultural markets.

- **Emerging Technologies in Protected Cultivation:** Several emerging technologies in protected cultivation

include the use of drones for crop monitoring, robotics for harvesting, precision agriculture techniques, and the integration of Internet of Things (IoT) solutions for data collection and analysis.

- **Expanding Role in Meeting Global Food Demands:** Protected cultivation is essential for meeting global food demand. It facilitates the production of high-quality crops in regions with unfavourable climate conditions, reduces post-harvest losses, enhances crop productivity, and ensures a consistent supply of fresh produce throughout the year.
- **Challenges and Opportunities:** Although protected cultivation presents numerous opportunities, it also encounters challenges such as high initial setup expenses, energy consumption, appropriate maintenance, and ensuring optimal environmental conditions for crop growth. Nonetheless, the advancements in technology and heightened awareness regarding sustainable farming practices present prospects for surmounting these obstacles and broadening the application of protected cultivation.

## CONCLUSION

Protected cultivation is a method of growing crops in a controlled environment, which allows for the regulation of factors such as temperature, humidity, and light, depending on the specific requirements of the crop. This controlled environment facilitates the growth of healthier plants and enhances the overall yield. There are numerous types of protected cultivation practices, including forced ventilated greenhouses, naturally ventilated polyhouses, insect-proof net houses, shade net houses, plastic tunnels, and techniques such as mulching, raised beds, trellising, and drip irrigation. These practices can be used independently or in combination to create a favourable growing environment, shielding plants from harsh climates, extending the cultivation period, or enabling off-season crop production. The use of drip irrigation in conjunction with raised beds and mulch films offers benefits such as weed control and improved soil moisture retention by reducing evaporation losses.