

Recent Advances in Polyhouse and Net-House Vegetable Cultivation

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INTRODUCTION

Protected cultivation using polyhouses, greenhouses, and net houses has transformed modern vegetable production. Rapid climate changes, increasing pest issues, limited land resources, and higher demand for quality vegetables have made controlled environment agriculture essential. Unlike open-field farming, these structures provide a controlled microclimate that optimizes temperature, humidity, light intensity, and ventilation. This ensures stable and predictable crop growth.

Polyhouse and net-house cultivation have become popular for supporting off-season production, reducing crop losses, improving resource efficiency, and boosting market competitiveness. With technological advancements and strong policy backing, protected vegetable cultivation is now a vital part of climate-smart and sustainable horticulture.



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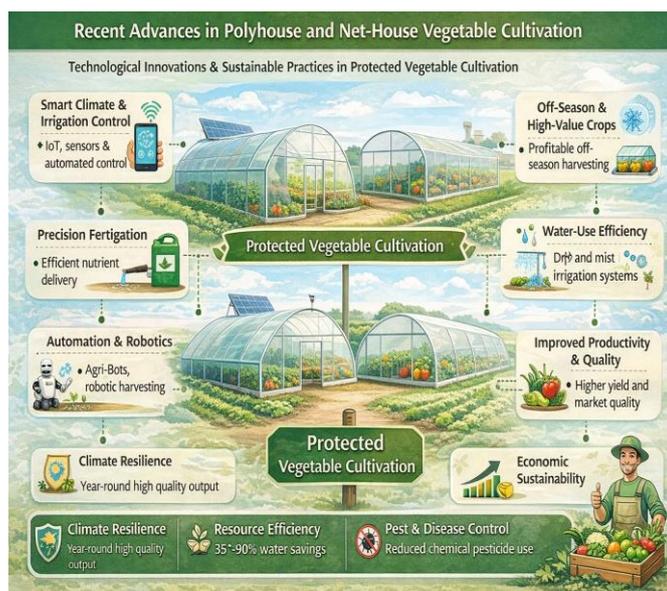
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2. Evolution of Protected Structures

2.1 Polyhouse and Greenhouse Systems

Polyhouses are usually framed structures covered with UV-stabilized polyethylene films, whereas greenhouses often use rigid materials like glass or polycarbonate sheets. These setups allow for partial or total control over environmental factors such as temperature, humidity, carbon dioxide levels, and light exposure. Modern polyhouses feature side and roof ventilation, fogging systems, shade nets, and thermal screens to maintain optimal growth conditions.

Vegetable crops like tomatoes, capsicums, cucumbers, cherry tomatoes, lettuce, and exotic greens thrive in polyhouse environments, demonstrating improved growth, consistency, yield, and quality. Developments in affordable and naturally ventilated polyhouses have made them more accessible for small and marginal farmers.

2.2 Net Houses

Net houses, also known as shade or insect-proof net structures, are covered with nets of different mesh sizes. They protect against insect pests, birds, hail, excessive sunlight, and moderate temperature extremes. Net houses are relatively inexpensive and require little energy, making them ideal for tropical and subtropical regions.

Crops like capsicum, brinjal, chili, cucumber, leafy vegetables, and nursery seedlings are commonly grown under net houses. By reducing pest problems, net houses lower pesticide use and production costs while also improving the quality of the produce.

3. Technological Advancements in Protected Cultivation

3.1 Smart Climate and Irrigation Control

The use of the Internet of Things (IoT), sensors, and automation has transformed protected vegetable cultivation. Sensors monitor temperature, humidity, light levels, soil moisture, and nutrient content. Automated systems adjust irrigation, ventilation, fogging, and shading in real-time, ensuring ideal growing conditions.

Modern greenhouses now include artificial intelligence (AI) for disease detection and stress monitoring through image analysis and

machine learning. These technologies allow for early detection of nutrient deficiencies, pest problems, and diseases, reducing yield losses and the need for chemicals.

3.2 Automation and Robotics

Automation and robotics are changing the landscape of protected cultivation. Autonomous greenhouse robots (Agri-Bots) can monitor crop health, run ventilation and irrigation systems, and assist with tasks like spraying, harvesting, and data collection. These advancements reduce reliance on labor, improve efficiency, and enable uniform crop management. Robotic systems are especially helpful in large-scale and commercial polyhouses where consistent labor availability is a concern.

3.3 Precision Fertigation Systems

Precision fertigation combines drip irrigation with controlled nutrient delivery, tailored to crop growth stages and real-time sensor feedback. This method supplies fertilizers directly to the roots in soluble form, improving nutrient use efficiency and reducing waste.

These systems cut down fertilizer use, prevent nutrient leaching, and boost crop yield and quality. Precision fertigation has become standard in modern polyhouses and net houses, particularly for high-value vegetables.

4. Crop Production and Yield Impact

4.1 Off-Season and High-Value Vegetable Production

A major benefit of protected cultivation is the ability to produce vegetables out of season. Polyhouses allow farmers to grow crops during less favorable weather, giving them access to premium markets and better prices. In hilly and peri-urban areas, low-cost portable polyhouses have been effectively used to grow vegetables during winter and rainy seasons. Protected cultivation has also encouraged diversification into high-value and exotic vegetables, increasing farm income and profitability.

4.2 Increased Productivity and Quality

Vegetables grown in polyhouses and net houses consistently yield more, have better size uniformity, improved color, and longer shelf life. Fewer pests and diseases lead to lower pesticide

residues, making the produce safer for domestic and export markets. Studies show yields can increase by 2 to 5 times compared to open-field farming, depending on the crop and management practices.

5. Water and Resource Use Efficiency

Protected cultivation employs advanced irrigation technologies like drip systems, micro-sprinklers, and misting systems. These methods can cut water usage by 35 to 90% compared to traditional irrigation. Controlled water and nutrient delivery promote optimal plant growth while saving valuable water resources. Efficient resource management in protected environments also results in reduced fertilizer use, lower energy consumption, and improved overall production effectiveness.

6. Sustainability and Environmental Impact

Protected vegetable cultivation strongly supports sustainability goals. Key environmental advantages include:

- ✓ Reduced chemical pesticide use through improved Integrated Pest Management (IPM)
- ✓ Lower water and fertilizer runoff, minimizing soil and water pollution
- ✓ Opportunities to integrate solar energy for irrigation and sensor systems
- ✓ Decreased carbon footprint due to more efficient inputs and higher productivity per area
- ✓ Enhanced soil health through minimal disturbance and precise nutrient management

7. Training, Policy Support, and Adoption

In India, protected cultivation is actively encouraged through government schemes and agricultural universities. Subsidies of 50 to 80% are available for building polyhouses and net houses, as well as for irrigation systems and planting materials. Training programs, demonstrations, and capacity-building efforts help farmers adopt scientific farming practices.

These initiatives have boosted adoption, particularly among progressive farmers, farmer producer organizations (FPOs), and agri-entrepreneurs.

8. Challenges and Future Directions

Despite quick advancements, protected cultivation faces challenges like high startup

costs, the need for skilled management, and reliance on stable electricity and water supply. Pest resistance, disease outbreaks in enclosed environments, and limited access to crop varieties designed for protected conditions are constraints.

Future research will focus on:

- ✓ AI-based crop monitoring and decision-support systems
- ✓ Nanotechnology for controlled-release fertilizers and plant enhancers
- ✓ Integrating renewable energy sources
- ✓ Vertical farming and multi-layer cultivation in protected spaces
- ✓ Developing stress-tolerant vegetable varieties for protected cultivation

CONCLUSION

Protected cultivation with polyhouses and net houses is changing vegetable production by offering climate resilience, higher yield, better resource use, and economic viability. Ongoing technological advancements combined with supportive policies, farmer training, and sustainable practices will strengthen the role of protected cultivation in achieving future food and nutrition goals. As agriculture shifts toward precision and sustainability, polyhouse and net-house cultivation will remain key to the evolution of modern horticulture.

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