Protected Cultivation Technologies Status in India vis-à-vis World

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The history of protected cultivation programme in India is not very long. The Department of Chemicals & Petrochemicals, Ministry of Chemicals and Fertilizers, first considered the promotion and development of use of plastics in agriculture and irrigation for improving agricultural yields, quality of produce and improving input use efficiency in 1977. National Committee on use of Plastics in Agriculture (NCPA) was set up in 1981 to identify areas for use of plastics in agriculture, R&D programmes and to suggest plan for implementation. Plasticulture Development Centres (PDCs) were started in 1985-86. NCPA was transferred to the Ministry of Agriculture and Farmers' Welfare in 1993 and was renamed as National Committee on Plasticulture Applications in Horticulture (NCPAH) and the PDC was renamed as PFDC (Precision Farming Development Centre). ICAR initiated All India Coordinated Research Project (AICRP) on Application of Plastics in Agriculture in 1988 which was later renamed to AICRP on Plastic Engineering in Agricultural Structures and Environment Management (PEASEM) in 2021. The first polyhouse was designed and set up in 1985 at Leh located in

the Union Territory of Ladakh, India. The greenhouse cultivation started in India during VIII plan with total area of 3211 ha. The total area under protected cultivation in 2018 was 2.51 lakh ha. On an average 80% area of protected cultivation is covered under plastic mulching and remaining under greenhouse, tunnel, shade-net and anti-hail net. ICAR AICRP PEASEM has promoted extensive research to provide cultivation strategies, irrigation and fertigation scheduling, indigenized tools and machinery for various unit operations within polyhouse, shade-net house, low-tunnels etc. The benefits of plastic mulching have also been demonstrated.

Protected cultivation in India is not only a concept but has witnessed significant growth, expanding to more than **2.75 million hectares** as of 2023. However, this still represents a meagre percentage of the country's total gross cropped area, starkly contrasting with global leaders like **China**, which manages over **4 million hectares** of controlled environment agriculture. While the global industry moves toward fully automated glasshouses and vertical farming, India's landscape is dominated by low-to-medium-cost structures like **naturally ventilated polyhouses** and **shade net houses**.

CURRENT STATUS: INDIA VS. THE WORLD

The adoption of protected cultivation is a response to the dual challenges of climate change and rising food demand. While the technology is mature in many parts of the world, it still is considered as an emerging sector in India, though here too all relevant technologies and design are available. In addition, most of the people engaged herein consider it as a specialized job of horticulturists, while

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Table 1. Status of level of technologies being majorly adopted vis-à-vis global advancement

Feature	Indian Status	Global Advanced Status
Primary Structure	Naturally ventilated polyhouses, shade nets.	Fully automated glasshouses with CO_2 enrichment.
Cooling Systems	Mostly passive (ventilation); some fan-and-pad.	Precision HVAC and liquid cooling systems.
Cultivation Method	Soil-based with drip irrigation; rising hydroponics.	Soilless (Aeroponics/Hydroponics) and Vertical Farming.
Automation	Basic timers for irrigation/fertigation.	AI-driven climate control and robotic harvesting.

major work is of design of structures, environment control and automation etc. It is a highly specialized first engineering job and then cultivation practices.

Current coverage in India is estimated between 50,000 and 70,000 hectares. Distribution of area is primarily concentrated mostly in states like Maharashtra, Karnataka, and Himachal Pradesh. China leads with over 4 million hectares, followed by Japan and European nations like the Netherlands, which uses roughly 10,500 hectares of high-tech glasshouses to become the world's second-largest agricultural exporter. Protected cultivation in India typically increases yields by 3 to 5 times over open-field farming, whereas high-tech systems globally can achieve even higher efficiencies through precise climate control and precision nutrient management. There is a significant difference in the status of technologies being adopted in India and at global level (Table 1).

KEY TECHNOLOGIES IN INDIA

Indian farmers primarily adopt technologies that balance cost with environmental protection. **Polyhouses** mostly made of tubular structures covered with UV-stabilized polyethylene for cultivation of mostly high-value vegetables like **capsicum and cherry tomatoes**, while **Shade Net Houses** are crucial for tropical regions to reduce light intensity and temperature for nurseries and leafy greens. **Plastic Low Tunnel** is an inexpensive solution used in Northern India for off-season vegetable production. **Emerging Technologies** such as **hydroponics** is growing in urban peripherals to serve luxury markets, and **drone technology** is increasingly used for precision spraying in protected environments. High tech fully controlled environment and nutritional management system are also getting momentum.

GOVERNMENT INITIATIVES AND SUPPORT

The Indian government provides substantial financial backing to bridge the gap with global standards.

MIDH & NHB: The Mission for Integrated Development of Horticulture (MIDH) and National Horticulture Board (NHB) offer **50% subsidies** for constructing

Fig. 1. Modern automated greenhouse in India (photo: ICAR-AICRP PEASEM)

greenhouses and polyhouses, while **NHM** (National Horticulture Mission) provides locally additional grants, often capping to some amount per project for commercial units. **Clean Plant Programme is the most recent**: **Rs.1,765.67 crore** initiative aimed at providing virus-free, high-quality planting material, essential for the success of protected cultivations

CHALLENGES AND FUTURE OUTLOOK

Despite the growth, following barriers limit faster expansion of protected cultivation technologies in India to reach global scales:

- **High Initial Cost**: Setting up a basic polyhouse requires significant capital, often exceeding **Rs.1,000 per square meter**.
- **Technical Knowledge**: There is a critical gap in farmer training regarding micro-climate management and pest control inside structures. Trained manpower for constructing high tech and engineering designed structures are also lacking.
- **Lack of standards**: Standard for construction of protected cultivation structures was lacking till now. The bureau of Indian Standards has recently developed the standard and Indian Council of Agricultural Research published a book with region-specific standards. These two should be implemented throughout India.
- **Market Linkages**: While production increases, many farmers lack direct access to high-value retail chains, leading to price volatility.

The future of protected cultivation in India lies in **localized low-cost automation** and the expansion of **vertical farming** in urban areas to ensure food security for a population by 2050.