

# Engineering and Technologies for Protected Cultivation: Pathway to Blueberry Cultivation in India

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## BLUEBERRIES UNDER COVER: HOW PRECISION CULTIVATION IS REWRITING INDIA'S HORTICULTURE STORY

Blueberries have become one of the fastest-growing fruit crops globally, with production crossing 2 million tonnes. Countries like China, the United States, and Peru dominate, with Peru leading exports through highly efficient production systems. Yields in advanced regions range between 10–20 tonnes per hectare, supported by improved varieties and organised supply chains. Rising global demand, driven by the fruit's strong health appeal, has made blueberries a year-round, high-value commodity.

In India, blueberries remain a nascent but rapidly evolving crop. Cultivation is expanding across Maharashtra, Karnataka, Himachal Pradesh, and Uttarakhand, largely under protected and soilless systems. Domestic production is estimated at 2,000–3,000 tonnes annually, far below demand. Imports exceed 20,000 tonnes each year, primarily from Peru, Chile and the United States, making India a strongly import-dependent market.

1. **Agricultural Transition:** India's



agricultural transition is quietly but decisively moving away from a singular focus on volume. The new direction is shaped by precision, quality and value. Among the crops symbolising this shift, blueberries stand out, not just for their premium market appeal, but for the way they are pushing farmers and agri-entrepreneurs to rethink how crops are grown. At the centre of this transformation lies protected cultivation, where engineering meets biology to create controlled, high-performance growing systems.

2. **Crop Sensitivity:** Blueberries are not a conventional Indian crop.

They demand specific conditions eg acidic soil, controlled moisture, mild temperatures and protection from excessive rainfall. In open field conditions, these requirements are difficult to meet consistently. Protected cultivation, however, changes the equation. By creating a microclimate around the plant, it allows growers to manage variables that were once left to chance.

3. **Structural Systems:** Structures such as polyhouses and polytunnels form the physical backbone of this system. Built using metal frames and UV stabilised plastic films, they trap solar radiation and maintain a stable internal environment. This does not merely shield the crops from extreme weather, it actively shapes the conditions in which plants grow. Ventilation systems, insect-proof nets and fogging units ensure that temperature, humidity & airflow remain within optimal ranges. For a crop as sensitive as blueberry, such stability is essential.
4. **Root Zone Engineering:** Equally important is what happens below the plant. Traditional soil often becomes a limiting factor in blueberry cultivation due to its

pH and structure. The solution has come in the form of substrate-based systems. Instead of relying on native soil, plants are grown in engineered media such as cocopeat, perlite or peat moss. These substrates allow precise control over root conditions especially pH and nutrient availability while ensuring excellent drainage and aeration. The result is uniform root development and healthier plants.

5. **Container Innovation:** Containers such as grow bags and air pots further enhance this system. They prevent root circling and improve oxygen availability, both of which directly influence plant vigour and productivity. In many ways, the root zone becomes a designed environment, much like the structure above it.
6. **Water & Nutrient Precision:** Water and nutrient management represent another critical layer of precision. Drip irrigation systems deliver water directly to the root zone in measured quantities, reducing wastage and ensuring consistency. When combined with fertigation where soluble nutrients are supplied through irrigation lines, this system becomes highly responsive. Growers can adjust nutrient composition in real time, aligning it with the plant's growth stage. This level of control has a visible impact on fruit quality, influencing size, sweetness, firmness and shelf life.
7. **Weed Management:** Weed management, often overlooked, also benefits from simple yet effective engineering solutions. Weed mats and plastic mulches suppress unwanted growth without the need for chemical herbicides. At the same time, they help retain soil moisture and regulate temperature, contributing to overall crop health. For high-value crops like blueberries, where cleanliness and uniformity matter, these small interventions make a significant difference.
8. **Data-Driven Farming:** What truly distinguishes modern protected cultivation, however, is its growing reliance on data. Sensors placed within the growing environment continuously monitor temperature, humidity, light intensity and root-zone parameters such as moisture, electrical conductivity and pH. This information feeds into digital dashboards, allowing growers to track conditions in real time. Instead of reacting to problems after they occur, decisions can be made proactively.
9. **Emerging Technologies:** Emerging technologies are taking this a step further. Automated irrigation systems, integrated with sensor data, can adjust water delivery without manual intervention. Early-stage tools using artificial intelligence are beginning to detect signs of plant stress, nutrient deficiencies or disease before they become visible to the human eye. While still evolving, these tools point towards a future where cultivation is increasingly guided by predictive insights rather than experience alone.
10. **Expanding Geography:** The success of blueberries in such systems illustrates the broader potential of protected cultivation in India. Once considered limited to temperate regions, blueberries are now being grown across diverse agro-climatic zones, thanks to the availability of low-chill and zero-chill varieties. Combined with controlled environments, these varieties are expanding the geographical scope of the crop.

## CHALLENGES & CONSTRAINTS

Yet, the path forward is not without challenges. The initial investment required for structures, irrigation systems and monitoring equipment can be substantial. Technical knowledge remains a barrier, particularly for first-generation adopters. Access to quality planting material and reliable inputs is still uneven. Without adequate training and support, the risk of failure can discourage potential growers.

## WAY FORWARD

Addressing these constraints requires a coordinated approach. Capacity building must move beyond one-time training sessions to continuous, field-level support. Financing mechanisms need to be more accessible and aligned with the realities of neo-entrepreneurs. Local manufacturing of equipment can help reduce costs, while digital advisory platforms can bridge knowledge gaps in real time.

## CONCLUSION

Despite these hurdles, the direction is clear. Protected cultivation is not just a technology it represents a shift in mindset. Blueberries, with their demanding nature and high returns, are simply the most visible expression of this shift. In the coming years, the lessons learned from blueberry cultivation are likely to influence a wider range of crops, shaping a more resilient and value-driven future for Indian horticulture.

