



## Smart Broccoli Cultivation under Protected Condition

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**B**roccoli (*Brassica oleracea* var. *italica*) is a highly nutritious cole crop valued for its rich content of vitamins, minerals, antioxidants, and dietary fiber. Increasing consumer awareness regarding healthy foods and the demand for high-quality vegetables have made broccoli cultivation economically attractive. However, open-field cultivation often exposes the crop to unfavorable weather conditions, pests, and diseases, resulting in lower productivity and quality. Protected cultivation integrated with smart technologies offers an effective solution for achieving higher yields, better quality produce, and efficient resource utilization.

### Protected Cultivation of Broccoli

Protected cultivation involves growing crops inside structures such as polyhouses, net houses, or low tunnels, where environmental factors are regulated to provide optimum growing conditions. These structures protect plants from excessive rainfall, frost, high temperatures, and insect infestations.

### Smart Technologies in Broccoli Cultivation

Smart farming combines modern technologies with protected cultivation to optimize crop production and reduce input costs.

#### Climate Monitoring and Control

Environmental sensors continuously monitor:

- Temperature
- Relative humidity
- Light intensity
- Carbon dioxide concentration
- Soil moisture

The collected data help maintain ideal conditions inside the protected structure.

#### Optimal conditions for broccoli:

Parameter	Optimum Range
Temperature	15–22°C
Relative humidity	60–80%
Soil pH	6.0–7.0
Soil moisture	Moderate
Light requirement	Full sunlight

Automatic ventilation systems, cooling pads, exhaust fans, and shade nets help maintain suitable microclimatic conditions.

#### Precision Irrigation

Drip irrigation combined with moisture sensors ensures precise water application according to crop requirements. This technology:

- Saves 30–50% water.
- Prevents water stress.
- Improves nutrient uptake.

- Reduces weed growth.

Fertigation systems supply nutrients directly through irrigation water, enhancing fertilizer use efficiency.

#### **Internet of Things (IoT)-Based Monitoring**

IoT devices transmit real-time information to computers or smartphones, enabling farmers to:

- Monitor crop conditions remotely.
- Receive alerts regarding abnormal temperature or moisture levels.
- Schedule irrigation and fertigation precisely.
- Maintain records for better crop management.

#### **Smart Nutrient Management**

Balanced fertilization is essential for obtaining compact and high-quality heads. Nutrient sensors and fertigation units enable accurate application of nitrogen, phosphorus, potassium, calcium, and micronutrients.

#### **Recommended fertilizer dose per hectare:**

- Farmyard manure: 20–25 tonnes
- Nitrogen: 120–150 kg
- Phosphorus: 60–80 kg
- Potassium: 60–80 kg

Split application through fertigation improves nutrient use efficiency and minimizes losses.

#### **Integrated Pest and Disease Management**

Protected structures reduce pest incidence, but regular monitoring remains necessary. Smart technologies include:

- Sticky traps for insect monitoring.
- Sensor-based warning systems.
- Mobile applications for disease diagnosis.
- Biological control agents and bio-pesticides.

#### **Common pests include:**

- Diamondback moth
- Aphids
- Cabbage caterpillar

#### **Major diseases are:**

- Downy mildew
- Black rot
- Alternaria leaf spot

Integrated pest management practices reduce dependence on chemical pesticides and ensure safer produce.

#### **Automation and Artificial Intelligence**

Artificial intelligence (AI) and automation improve decision-making by analyzing crop data.

Automated systems can control:

- Irrigation scheduling
- Fertigation operations
- Ventilation and cooling
- Lighting systems

AI-based image analysis also assists in early detection of diseases and nutrient deficiencies.

### **Cultivation Practices under Protected Conditions**

#### **Nursery Raising**

- Use disease-free seeds of improved hybrids.
- Raise seedlings in pro-trays filled with cocopeat.
- Maintain adequate moisture and temperature.
- Seedlings become ready for transplanting in 25–30 days.

#### **Transplanting**

- Plant spacing: 45 × 45 cm or 60 × 45 cm.
- Transplant healthy seedlings having 4–5 true leaves.

- Ensure proper ventilation and irrigation after planting.

### **Irrigation and Fertigation**

- Adopt drip irrigation.
- Apply nutrients through fertigation at weekly intervals.
- Maintain uniform soil moisture throughout the crop period.

### **Harvesting**

Broccoli heads are harvested when they become compact, firm, and dark green. Delayed harvesting results in flowering and deterioration of quality. Average harvest period occurs 70–100 days after transplanting, depending on the variety and environmental conditions.

### **Yield and Economic Benefits**

Protected cultivation with smart technologies can produce:

- Yield: 20–35 tonnes per hectare.
- Higher market value due to superior quality.
- Increased income through off-season production.
- Reduced water and fertilizer consumption.
- Enhanced sustainability and profitability.

### **Conclusion**

Smart broccoli cultivation under protected conditions represents a modern approach to sustainable vegetable production. Integration of protected structures with sensors, drip fertigation, IoT, automation, and precision farming techniques helps maintain optimum growing conditions, improve resource-use efficiency, and produce high-quality broccoli throughout the year. Adoption of these technologies can significantly enhance productivity, profitability, and environmental sustainability, making broccoli cultivation a promising enterprise for progressive farmers.