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Mastering Green Polyhouses: Essential Facts and Tips

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Greenhouses are enclosed structures made with transparent materials that enable crop cultivation under controlled environmental conditions. They help establish a suitable micro-climate, allowing for year-round or seasonal production of various crops. This method is particularly advantageous for cultivating high-value fruits, vegetables, and ornamental plants in colder areas where open-field farming is limited. Although regulating temperature—especially providing warmth during colder months—is the primary goal, other factors such as humidity, ventilation, lighting, CO_2 levels, irrigation, nutrient delivery, and pest management are also carefully regulated.

Polyhouse

A polyhouse is a type of protected farming structure, similar to a greenhouse, but it is covered with polyethylene sheets on the roof and walls to allow sunlight to enter. The use of this transparent plastic material helps trap heat and reduces the dependence on artificial lighting by utilizing natural sunlight. This setup enables crops to grow even during colder weather conditions. Compared to traditional greenhouses, polyhouses are generally smaller in size. They are widely preferred due to their lower construction costs, especially when compared to glass-covered greenhouses. Although polyhouses are more affordable initially, greenhouses—particularly those made with durable materials require a higher investment. Both polyhouses and greenhouses can either rely on natural airflow or be equipped with advanced environmental control systems. In naturally ventilated structures, ventilation mechanisms are used to expel warm air and draw in cooler air, helping to maintain optimal internal temperatures. In contrast, environmentally controlled versions include sophisticated systems that manage internal climate conditions such as temperature (similar to air conditioning), humidity, carbon dioxide levels, and more

Classification of Greenhouse/Polyhouse

Classification of greenhouse based on suitability and cost

a) **Low cost or low tech greenhouse**: A low-cost greenhouse is a basic setup built using readily available local materials such as bamboo, timber, and similar resources. It is typically covered with ultraviolet (UV) film, which serves as the cladding material. Unlike standard or high-tech greenhouses, this structure does not include advanced systems to control internal environmental conditions. Instead, simple and manual methods are used to adjust temperature and humidity levels. Light intensity can also be managed by using shading materials like shade nets. During hot seasons, opening the side walls helps lower the internal temperature. This type of structure is also commonly used as a protective shelter for crops during rainfall. When the sidewalls are completely enclosed

with plastic film, the interior becomes warmer, creating a more favorable environment for plant growth in colder conditions. Such greenhouses are best suited for cold climate regions. The construction cost generally falls between Rs. 300 and Rs. 500 per square meter.

b) **Medium-tech greenhouse**: Most greenhouse users prefer manual or semi-automatic control systems due to their low initial cost. This type of greenhouse is generally built using galvanized iron (G.I.) pipes for the frame. The canopy covering is secured to the structure using screws. The entire frame is firmly anchored to the ground to provide stability and resistance against strong winds. To help manage internal temperatures, thermostat-controlled exhaust fans are installed. Additionally, evaporative cooling pads and misting systems are used to maintain adequate humidity levels. Since these systems operate semi-automatically, they demand consistent monitoring and upkeep, making it challenging to sustain uniform conditions throughout the growing season. These greenhouses are most appropriate for regions with dry or mixed climates. The construction cost typically ranges from Rs. 800 to Rs. 1,100 per square meter.

c) **Hi-tech greenhouse**: To overcome some of the difficulties in medium-tech greenhouse, a hi-tech greenhouse where the entire device, controlling the environment parameters, are supported to function automatically. Cost - Rs.2000 to Rs.3500/m^2

Design of Greenhouse /Polyhouse

Greenhouse design should be grounded in scientific concepts to ensure it supports a controlled environment conducive to plant development Around the globe, controlled environment production systems are commonly employed to grow plants in specific conditions, times, or qualities that are not achievable through traditional outdoor cultivation. Compared to open-field farming, controlled environment agriculture demands significantly higher capital investment per unit area, and therefore, it must operate with higher intensity to make the investment economically viable. A greenhouse is an enclosed space clad with transparent materials that allow natural sunlight to reach the plants, aiding their growth. For optimal plant health, key elements such as the structural framework, glazing or cladding, and systems for temperature regulation must be carefully and effectively designed.

Design

The structure has to carry the following loads and is to be designed accordingly:

Dead load: Weight of all permanent structures, including cladding, HVAC systems, water pipes, and all fixed service equipment attached to the frame.

Live load: Loads imposed by usage, including hanging baskets, shelves, and individuals working on the roof. The greenhouse must be designed to support a maximum live load of 15 kg per square meter.

Wind load: The structure must be capable of withstanding wind speeds of 110 kilometers per hour and a minimum wind pressure of 50 kg per square meter.

Snow load: These should be determined based on the average snowfall at the location. The greenhouse must be capable of supporting the dead load, live load, wind load, and half of the live load combined.

Orientation

Greenhouse orientation should balance wind direction, latitude, and temperature control needs. For single greenhouses above 40°N, the ridge should run east–west to allow low-angle sunlight to enter from the sides. Below 40°N, a north–south ridge is preferred due to the higher sun angle, which helps move gutter shadows across the structure. To minimize shading between adjacent greenhouses, they should be aligned east–west, while also considering local wind patterns and latitude.

Wind effects - For naturally ventilated greenhouses, align the structure to maximize natural wind flow ideally with the length set perpendicular to summer wind direction. In fan-and-pad systems, the natural wind should align with the direction of airflow from the fans.

Size of the greenhouse - The dimension of greenhouse should not be more than 10m x 30m. The length of evaporatively cooled greenhouse should not be more than 60m.

Spacing between greenhouses - Greenhouses should be spaced 10 to 15 meters apart to prevent exhaust air from one entering the next.

Height of greenhouse - A 50m × 50m greenhouse can have a maximum height of up to 5m, which can be reduced for smaller structures. Greater height increases wind load on the frame and glazing. Side ventilation should be 2m wide, and roof ventilation 1m wide

Cladding Material Polythene - Plastic proves to be an economical, durable, unbreakable, and lightweight cladding option. UV-stabilized clear fiberglass and polycarbonate roofing panels are now widely available. In tropical and subtropical regions, plastics are preferred over glass or fiberglass due to cost-effectiveness. They help create enclosed ecosystems for plant growth. UV-stabilized LDPE/LLDPE lasts 3–4 years, unlike regular polythene.

Environmental Factors Influencing Greenhouse Cultivation

Plants require optimal temperatures for best yield and quality. Greenhouses in plains and coastal India need cooling, often achieved through natural ventilation in mild climates. Hot northern plains greenhouses use evaporative cooling or fan-and-pad systems. Depending on the crop, these greenhouses may also need both heating and cooling.

Natural ventilation

The greenhouse must be well-ventilated to maintain temperature control. Year-round, the temperature inside should not exceed 20°C, and during hot months, it should match the outside ambient temperature

Heating of greenhouse

In cold climates like North India's winters or high-altitude Himalayan regions, heating greenhouses improves crop yield. Using double glazing with an air cushion significantly reduces heating requirements.

Heating systems

These can be of the following types

Boiler

Heating Systems for Large Greenhouses: Centralized heating uses a boiler fueled by coal or oil, producing hot water (85°C) or steam (102°C) circulated through pipes above crop beds and along walls. Steam systems are generally cheaper. Multiple coils and blowers help distribute heat efficiently.

Unit Heaters: These localized heaters are installed about 3 meters high, combusting fuel at the base. Hot fumes heat exchanger tubes, warming the greenhouse evenly

Infra-red Heaters: LPG burns to produce fumes at 480°C, passed through overhead pipes about 1.5m above plants with reflectors directing heat onto plants and soil, not the air. Pipes are spaced 6–10 meters apart, with exhaust fans maintaining fume flow

Solar Heating: Flat plate solar heaters warm water during the day, stored in insulated tanks, and circulated through pipes at night. Supplementary heating is used during cloudy or rainy day.

Temperature control: A thermostat can control the water pump or exhaust fan to regulate greenhouse temperature. However, the temperature in a fan-and-pad system cannot drop below the wet bulb temperature. This system is commonly used for cooling.

Relative humidity control: A humidistat controls the water pump or exhaust fan to manage relative humidity in fan-and-pad greenhouses, reaching up to 90%. In non-ventilated greenhouses, foggers are used to increase humidity.

Light intensity control: In low-light areas, artificial lighting supports plant growth. Incandescent bulbs produce too much heat and are usually unsuitable. Fluorescent tubes work well for low-light plants like African violets and gloxinias. While light is essential for chlorophyll synthesis, excessive light can damage it. Chrysanthemums, a classic short-day plant, require warm night temperatures for flowering and can bloom year-round by controlling day length and temperature.

Fan and pad polyhouse: Demand for fresh produce year-round has grown, especially in dry areas where greenhouse seasons are extended. However, high solar radiation raises internal temperatures, which can harm plant growth and quality, causing wilting or death. Even with good air circulation, leaf temperatures can be 5–10°C higher than air temperature. Crops shouldn't be exposed to 30–35°C for long. If natural ventilation and shading can't keep temperatures below 28°C, artificial cooling is recommended. Common methods include fogging, misting, and fan-pad systems, with fan-pad cooling being most effective for hot, dry climates A fan-pad system includes cellulose pads, exhaust fans, a water pump, and pipes. Pads and fans are placed on opposite walls to cool plants in between. The corrugated cellulose pads allow water and air to pass through. As air moves through the wet pads, water evaporates, using sensible heat in an adiabatic process where enthalpy stays constant without heat loss or gain.

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