Unit 2

# Types of Protected Structures and their Components

## Introduction


So far, we have learnt that protected cultivation aims to modify the micro climate of the plants by selective control of environment for the protection of the crops from biotic and abiotic stresses for healthy and safe crop production, notably all round the year including the off-season. Greenhouses enable qualitative and quantitative production of ornamental crops of high value especially during the off-season for fetching better prices, that otherwise is not possible through open field cultivation. This is particularly helpful in cold areas with heavy snowfall or chill factors.

Different types of protected structures can be adopted for off-season and round the year cultivation of flowers and ornamental crops. Commonly used protected structures are — low tunnels, walk-in tunnels, net houses, greenhouses and mist chambers. These structures vary in their shape, design, height and size.

## Session 1: Types of Protected Structures

In India, protected cultivation technology for commercial production is hardly three decades old. In a country like ours, where most of the structural designs have been adopted from different countries, the designs

have been amply modified to suit the local conditions and requirements of different agro-climatic areas. The commonly used protected structures are as follows.

## Low Tunnel

Also called 'miniature greenhouses', low tunnels generally cover rows of plants in field and, therefore, they are also known as **row covers**. Clean plastic films or nets are stretched over low wire hoops (arcs up to 1.0 m high) to protect plants against frost, wind, insects and pests. The hoops are made of steel wires or bamboo strips or cane. These hoops are covered by polythene sheets of about 50 microns thickness and are provided with ventilation holes on the side opposite to the solar movement. Total surface area of such ventilation is about 4 per cent. Use of non-woven/spun-bonded fabric material, which is porous and much lighter, is a more recent trend. Low tunnels provide a passive control of plant micro climate, i.e., use of specific plastic material to control radiation and provision of natural ventilation. Plastic mulches and drip irrigation may be used in conjunction with low tunnels. There are several methods of low tunnel formation and operation. The low tunnels permit early yield for spring crops with significantly higher yields. These tunnels are not usually used for growing flowers. The crops which have been generally grown commercially under low tunnel conditions are melons, cucumber, tomato, strawberry, pepper, beans, squash and sweet corn.

*Fig. 2.1: Low tunnel*

A variation of the low tunnel is a plastic covered trench system where polyethylene is stretched over a trench in the ground. The trench may be 20–40 cm deep. The polyethylene is removed from the trenches when the plants start flowering to enable pollination facilitated by insects. Such trenches are showing excellent results under the cold desert conditions of Leh (Jammu and Kashmir) as moisture is also conserved to a great extent.

## Advantages

1. Normally low tunnels are recommended for cultivation during winter season especially for growing early crop of cucurbits.
2. They protect crop against wind, rain, frost and snow.
3. They are suitable for raising a healthy nursery and early vegetable crops.
4. They maintain optimum temperature for plant growth.
5. They help in better nutrient uptake by the plants.

## Walk-in tunnel

It is a temporary structure made by using GI pipes or bamboo, and is covered with different cladding material depending upon the season in which the cultivation is proposed. Walk-in tunnels are used for off-season cultivation of vegetables and flower seedlings. They give an advantage of better prices of the off-season produce, giving more profit per unit area. Optimum size of the walking tunnel is 60–75 sq m, with 2–2.5 m width and up to 30 m length with a 2–2.5 m central height. Overall, the height is enough for the worker to walk comfortably during operation.

*Fig. 2.2: Walk-in tunnels*

## Advantages

1. The worker can easily walk-in to take care of the crop.
2. The cultivators get higher returns from off-season cultivation of vegetables and raising of flower seedlings.
3. These are temporary and low-cost structures, which can be fabricated by the cultivators themselves at the village level with the help of rural artisans.

## Net Houses

Depending upon the cladding (covering) material used, the net houses may be classified as insect-proof net houses and shade net houses.

## Insect-proof Net House

*Fig. 2.3: Insect-proof Net House*

An insect-proof net house can be fabricated as a temporary or permanent structure in different designs. It can be in a walk-in tunnel design and shape, with double door facility at one end of the structure. It is covered with UV-stabilised insect-proof net of 40–50 mesh for effective control of pests and diseases. The minimum size of insect-proof net house is 100 sq m. The permanent structure can be fabricated in two designs — flat roof design having 3.5–4 m height and dome shape with a height of 4.5–5 m and the other in dome shape in a popular type of greenhouse design. Usually, the quality production as well as growing seedlings are possible under these net houses with proper selection of varieties without application of harmful chemicals in their production.

### Advantages

1. Off-season cultivation
2. Production of quality seedlings is possible.
3. Restrict the growth of pests and diseases.

## Shade Net House

*Fig. 2.4: Shade Net House*

It is primarily constructed to protect plants from highly intense solar radiation. The structure is made of wood, stone, bamboo or GI pipes. When wood or bamboo are used, the poles are treated with turpentine and tar on one side before inserting them in the ground. Cladding material used on the top and sides of the structure is generally a shade net. The shade nets are available in different colours with different percentages of shade factor. Suitability of colour and shade factor is location and season-specific. Generally, shade nets are used for hardening of fruit orchard planting material raised under greenhouses.

## Advantages

1. They control high intensity solar radiation.
2. They protect plants from frost.
3. They also protect plants from large insects.

### Greenhouse

It is a framed or covered structure with a transparent or translucent material which permits ample sunlight for crop production and has provisions for at least partial control of plant environment.

*Fig. 2.5: Greenhouse*

A greenhouse, depending upon the transparency of the glazing material, admits sunlight which is absorbed by the crop, equipment, structure and the floor. These objects in turn emit thermal radiation which is only partially transmitted out of the greenhouse. As a result of this, a part of the solar energy is continually retained in the greenhouse, leading to a temperature increase. This natural temperature rise in the greenhouse is utilised during winters to grow crops with or without supplementary heat. During summers, the greenhouses are cooled as per the crop requirement.

The closed side container of the greenhouse during the night results in trapping the air rich with carbon dioxide, which would improve photosynthetic activity during the early hours of the day. Air humidity in the greenhouse can also be increased or lowered. In addition, favourable light conditions for crops, in terms of quality and quantity, can be created by providing supplementary lighting and shading systems. In general, crops in greenhouses are either grown on beds or in pots irrigated by micro-irrigation systems. Off-season vegetables, flowers and ornamental/grow-bags, plants and nursery raising are fairly remunerative practices in protected cultivation.

## Advantages

1. Off-season cultivation of crops is possible round the year.
2. Crop cultivation is possible under harsh environmental conditions.

3. They provide excellent opportunities to produce export-quality crops.
4. Early production of quality seedlings and planting materials is possible.
5. More production per unit area in comparison to open field cultivation.
6. Greenhouses can also be used for growing flower plants, strawberries and propagation of quality fruit plants.
7. Insect, pest and weed management is easier in greenhouses than in open fields.
8. Greenhouses can provide substantial income for cultivators having small land holdings.

## Mist Chamber

The main purpose of such a structure is to create high humidity and droplet-free presence of water for propagating delicate soft wood cuttings, vegetable crops, root plants and shrubs, etc. Cuttings are misted intermittently in place of continuous water application or drenching. The intermittent water misting is done using a high pressure pump, pipeline system and a timer switch. The mist nozzles are connected to the main pipelines for misting the plant material growing inside the growth chambers or structures. A mist chamber of 15–25 sq m is sufficient for a nursery. The frequency of misting depends upon ambient temperature and type of plant material being propagated.

### Advantages

1. Assured supply of plant material throughout the year, which is not possible in open field cultivation.
2. Mist chambers reduce the rate of moisture loss from the plants, thereby helping in survival of root-cuttings as well as for hardening of tissue cultured plants. Thus, the main advantage of mist chambers is to avoid the desiccation or drying out of the plant material.
3. Planting material remains devoid of any susceptibility to pathogen, insect and pests attack.

## Practical Exercises

**Activity 1: Prepare a low tunnel with locally available materials.**

*Material required:* peg, rope, measuring tape, bamboo stick/ 6 mm GI rod, insect proof net.

*Procedure*

1. Mark the area as per layout.
2. Insert peg as per demarcation.
3. Fix bamboo stick/GI rod.
4. Covering with cladding material.

## Check Your Progress

**A. Fill in the blanks**

1. Low tunnel is also called as _____ greenhouse.
2. Height of low tunnel is _____ meter.
3. Polyfilm of _____ micron thickness is used in greenhouse.
4. Centre height of walk-in tunnel is generally _____ metre.
5. Commonly used mesh size of insect-proof net house is _____ mesh.

**B. Mark the correct choice**

1. Protected structures commonly used for hardening of plants is
   (a) walk-in tunnel (b) shade nethouse
   (c) greenhouse (d) low tunnel
2. Protected structures commonly used for early rooting of cuttings is
   (a) walk-in tunnel (b) shade net house
   (c) greenhouse (d) mist chamber
3. The suitable structure for propagated plant materials is
   (a) polyhouse (b) mist chamber
   (c) shade net house (d) plastic low-tunnels

**C. Descriptive questions**

1. Describe the types of protected structures.

_____

_____

_____

2. Write short notes on the following.
   (a) Low tunnel

   (b) Shade net house

   (c) Greenhouse

   (d) Mist chamber

   (e) Walk-in tunnel

**D. Match the columns**

| A | B |
|---|---|
| 1. Low tunnel cladding | a. Plants protect against solar radiation |
| 2. Protected cultivation | b. Maintain humidity |
| 3. Mist chamber | c. 50 micron polythene sheet |
| 4. Shade net houses | d. Off-season cultivation |

## SESSION 2: CLASSIFICATION OF GREENHOUSES

Greenhouses can be classified according to the material used in their construction, the shape of their structure and the climate control methods adopted. Their classification is sometimes done on the basis of the cost of fabrication per unit area.

### Classification of Greenhouses based on Cost

#### Low-cost Greenhouse

It is fabricated mainly using local and low-cost available material like wooden logs or bamboos. The protection

of wooden structures from insects and termites is a major challenge. These structures are small in size and have a short life-span. Since the height of the structure is lesser as compared to those with steel frames, maintaining proper temperatures in summer becomes difficult. Therefore, they are recommended mostly in cold climatic zones and low wind speed regions. The approximate cost of establishing such greenhouse units ranges between Rs. 450–620 per sq m.

*Fig. 2.6: Low-cost Greenhouse*

## Medium-cost Greenhouse

It is generally fabricated using galvanised iron (GI) square or rectangular or round pipes or lipped channel or their combinations. The whole structure is firmly fixed in the ground to withstand high speed wind up to 140 km/hr. Such greenhouses are suitable for dry and composite climatic zones. The normal height of these structures ranges between 6.5–7 m and these are mostly naturally ventilated. The climate inside the structure is regulated by opening and closing of side curtains (which are rolled above permanently fixed insect-proof net on windows). Thus, air circulation can be regulated. Humidity is maintained through operation of foggers/misters. Light intensity can be controlled with the use of internal collapsible shading nets. The approximate cost of establishing such naturally ventilated polyhouse unit ranges between Rs. 900–1000 per sq m depending upon the size of the structure.

*Fig. 2.7: Medium-cost Greenhouse*

## High-cost Greenhouse

For the production of sensitive, off-season, exotic or quality crops, sometimes medium-cost greenhouses cannot deliver the requisite quality. Therefore, high-cost greenhouse structures, which can precisely regulate climatic and nutritional needs of the plants,

*Fig. 2.8: High-cost Greenhouse*

are required. The greenhouse climate parameters are regulated through passive cooling by operating fan and pad systems and sensor-based controlled systems. The approximate cost of establishing such greenhouse units ranges between Rs.1500–2500 per sq m depending upon the size of the structure.

## Classification of Greenhouses based on shape

(a) Gothic Roof
(b) Slant Roof
(c) Saw Tooth
(d) Flat Roof

*Fig. 2.9: Types of Greenhouse based on shape*
*(a) Gothic Roof (b) Slant Roof (c) Saw Tooth (d) Flat Roof*

## Classification of Greenhouses based on cladding material used

(a) Transparent glass
(b) Fiberglass reinforced plastic/polycarbonate
(c) UV-stabilised low density polyethylene film

## Classification of Greenhouses based on climate control mechanisms

### Naturally Ventilated Greenhouse

The climatic parameters such as temperature, humidity, carbon dioxide in these polyhouses are maintained and/or controlled through natural air convection without using any additional systems, and are mostly operated manually.

### Forced Ventilated Greenhouse

The climatic parameters such as temperature, humidity, carbon dioxide in these polyhouses are maintained and/or controlled through forced air circulation using fan and pad systems (for hot regions)/heaters (for temperate regions), foggers, curtain actuators (mechanism that makes the system work) that are controlled with automatic sensors. These systems are mostly operated automatically, however, these can be operated manually as well. These structures require continuous power supply and backup.

## Factors Responsible for Selection of Specific Design of a Greenhouse

The following factors are kept into consideration while selecting a specific design.

(a) Type of crop to be grown
(b) Easy availability of raw material
(c) Local climatic conditions
(d) Investing capacity of the farmer
(e) Market demand of the produce
(f) Appreciation to the produce

## Practical Exercises

**Activity 1: Identify types of protected structures**

*Material required*: pen, pencil, notebook, etc.

*Procedure*

Visit any institution and note down the following information.

1. Identify types of structures.
2. Enlist kinds of material used in different structure.
3. Write down utility of each structure observed.
4. Draw sketch of protected structure.

## Check Your Progress

**A. Fill in the blanks**

1. Climatic parameters are mainly maintained in _____.
2. In low cost naturally ventilated polyhouses _____ or _____ material are generally used.
3. In forced ventilated greenhouses the temperature inside the structure is maintained with the help of _____.
4. The normal height of medium cost greenhouses ranges between ____ and ____ m.
5. The sensor based controlled system used in _____ greenhouse.

**B. Mark the correct choice**

1. A greenhouse does not comes under the classification based on shape
   (a) Quonset type
   (b) Curved roof type
   (c) Gable roof type
   (d) Forced ventilated
2. An approximate cost of establishing low cost greenhouse is Rs./sq.m.
   (a) 900–1000
   (b) 1200–1500
   (c) 450–620
   (d) 200–250

**C. Descriptive questions**

1. Classify greenhouses on the basis of cost.

_____

_____

_____

2. Describe in brief
   (a) Naturally ventilated greenhouse
   (b) Forced ventilated greenhouse
   (c) Criteria for selection of specific design

**D. Match the columns**

| A | B |
|---|---|
| 1. High cost greenhouse | a. Manually operated |
| 2. Cladding material | b. Short life span |
| 3. Naturally ventilated greenhouse | c. Precisely regulated climatic |
| 4. Low cost greenhouse | d. Poly ethylene film |

## Session 3: Major Components of a Greenhouse

A greenhouse is constructed with different material and their components. In this session, the major components used in greenhouse construction and their features and functions are described.

### Different Greenhouse Components with their Features and Functions

#### Cladding Material

Polythenes or other transparent material used for walls and roof of a greenhouse for protection as well as transparency, which simulates climatic conditions inside the greenhouse is called cladding material. The material could be made of polycarbonate, glass or poly sheets. The polycarbonate and glass houses are temporary structures and mostly used for research or academic purposes. The polythene sheet as a cladding material is most commonly used and these films are normally UV-stabilised, 200 micron thick and fixed with aluminum profiles using zigzag springs.

It is important to select a proper film for the polyhouse, which has direct relation with the quality of the crop as well as the quantity of the produce. Polythene should be properly UV-stabilised and a minimum life span of at least three years. With 1 kg polyfilm, a maximum area of 5.4 sq m can be accommodated.

#### Polyhouse Film

(i) *Compulsory properties*: UV stabilisation, diffusion/ clear (light transmission)

(ii) *Optional properties*: UV blocking/antivirus, sulphur resistant, thermic, anti-drip, anti-mist, anti-dust, three-layer/five-layer films

## Crop-wise Recommendations

(i) *Dutch roses*: Cladding—200 micron thick, UV-stabilised, anti-dust, anti-sulphur, with cooling effect, light diffusion

(ii) *Gerbera, Bell pepper, Anthurium and Orchids*: Cladding—200 micron thick, UV-stabilised, anti-dust, with cooling effect, light diffusion

(iii) *Carnation*: Cladding—200 micron thick, UV-stabilised, anti-dust, with cooling effect for IR protection polythene at high altitudes

## Gutter

It is used for collecting rainwater from the roof of the greenhouses and are placed at an elevated level (at least 4–4.5 m from ground level) between two spans.

Gutters are made of galvanised sheet of 2 mm thickness in trapezoidal shape (preferably of single length without joint). It should be leak-proof.

Minimum of 1 per cent slope is required for the gutter. Gutter orientation is in North–South direction in multi-span greenhouse and may change according to the direction of the wind.

**Indian Standards for construction of Greenhouse/Polyhouse**

The Bureau of Indian Standards (BIS) has formulated following standards with respect to Polyhouse/Greenhouses.

1. IS 14462:1997: Recommendation for layout, design and construction of greenhouse.
2. IS 14485:1998: Recommendations for heating, ventilating and cooling of greenhouse.
3. IS 15827:2009: Plastics films for Greenhouse

## Foundation Pipe

It connects the structure and the ground.

## Tubular Structural Members, Foundation and Labelling

These are the galvanised iron tubular/square pipe and angles. These items are used to erect a stable frame to support the cladding material and other systems in the greenhouse. These items include horizontal and vertical structure members in any polyhouse.

(i) *Purlin*: It is a member that connects cladding supporting bars to the columns.

(ii) *Ridge*: It is the highest horizontal section on top of the roof.

(iii) *Girder*: It is a horizontal structural member, connecting columns on gutter height.
(iv) *Bracings*: These support the structures against wind.
(v) *Arches*: These support covering or cladding materials.

## Polyhouse Length and Width, Orientation

*gable: transparent wall of a greenhouse*

(i) Polyhouse length is the dimension of the polyhouse in the direction of gable. (Length is side along the gable or side along the truss lines)
(ii) Polyhouse width is the dimension of the polyhouse along the gutter.
(iii) Orientation of polyhouse for single-span structures, should be East–West. For multi-span structures, the orientation should be North–South. The distance of trees adjacent to the greenhouse should be about 2.5 times the height of the greenhouse, to avoid shade.

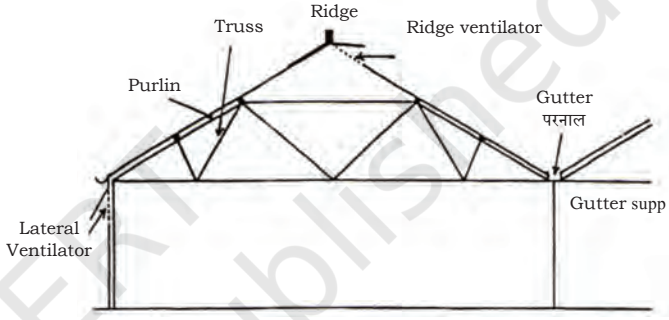
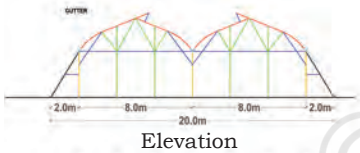


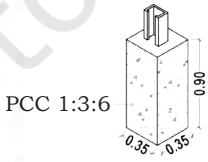

*Fig. 2.10*

**Polyhouse 20m × 28m**

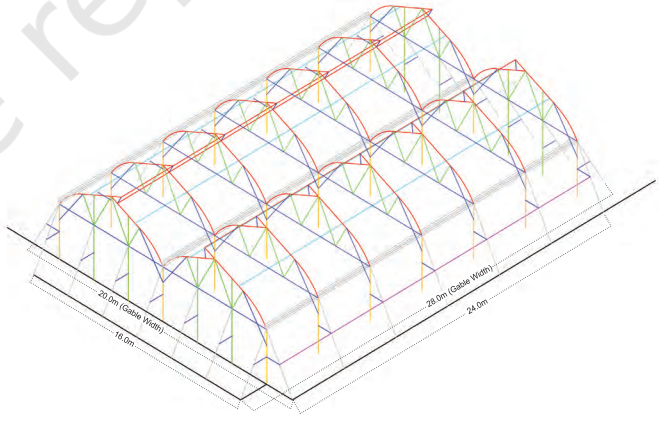



Elevation


Plan




Foundation Plan




Isometric View

Note:
Gable Width–20m
Gable Length–28m
The Greenhouse measurements are measured by Gable dimension as a Width and Gutter side dimension as a Length (As shown in Drawing)

## Micro Irrigation System

Micro irrigation system is the best way for watering plants in a polyhouse as per the daily needs and the stage of the crop. Besides this, care should be taken that water does not trickle directly on the leaves or the flower, which may lead to disease and scorching of leaves or flowers.

## Fertigation Equipment

For providing fertilisers to the plants as per their daily needs, water-soluble or liquid fertilisers are injected in the irrigation mainlines feeding the greenhouse crops. Fertiliser dosers and tanks are used for injecting soluble fertilisers. They can also be connected to automatic mixing and dispensing unit. The fertilisers are dissolved in different tanks as per compatibility and are mixed in discrete proportions for supply to the plants through drip irrigation systems.

## Spraying System

This system is used for spraying required chemicals on the crop to control pests and diseases, if any. The spraying machines are normally portable but may be equipped with high pressure motorised piston pumps and nozzles.

## Exhaust Fan and Cooling Pads

For removing hot air from the greenhouses in forced ventilated greenhouses, cooling pads are used for cooling the air entering into the greenhouses.

These systems are operated as and when the climatic parameters like temperature, humidity, etc., inside the greenhouse need manipulation as per crop growth requirement.

## Shading Net

These are used for controlling light intensity falling on the crops inside the greenhouse. Various shading nets with shading capacities like 35 per cent, 50 per cent, 75 per cent are used for different crops and seasons.

## Sensors and Controllers

They are used for controlling climatic parameters automatically inside hi-tech greenhouses. These systems are generally used for very high-value crops and sensitive activities like soil-less cultivation, tissue culture plant and hardening activities.

## Practical Exercises

**Activity 1: Enlist the different components of a greenhouse structure**

*Materials required*: notebook, pen, etc.
*Procedure*

- Visit the nearby greenhouse.
- Observe different components of the greenhouse.
- Note down the components and their use.
- Draw figures of different components.

## Check Your Progress

**A. Fill in the blanks**

1. Transparent material mounted on the walls and roof of a greenhouse is known as _____.
2. Gutters are used for _____ the rain water from the roof of greenhouse.
3. In polyhouse _____ polyfilm as cladding material is generally used.

**B. Multiple choice questions**

1. The distance of trees near to the greenhouse should be about ____ times the height of the greenhouse
   (a) 1.5 (b) 2.5
   (c) 3.5 (d) 4.5
2. One kilogram weight of polyfilm can be accommodated in _____.
   (a) 5.4 sq. (b) 3.4 sq.
   (c) 2.4 sq. (d) 1.4 sq.

**C. Descriptive questions**

1. What are the different components of the greenhouse?

_____

_____

_____

2. Write short notes on
   (i) Shading net
   (ii) Micro irrigation system
   (iii) Fertigation equipment

**D. Match the columns**

| A | B |
|---|---|
| 1. Connects cladding supporting bars to columns | (a) Foundation pipe |
| 2. Highest horizontal section in top of the roof | (b) Purlin |
| 3. To support the structure against wind | (c) Ridge |
| 4. Connection between the structure and ground | (d) Bracings |