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Green-houses: Types and Structural Components

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Abstract

A greenhouse is a system for modification and management of environmental factors that allows plants to be grown in suitable climates that may be not well suited for their growth and development. This greenhouse technology gains significance in changing climatic scenario which emphasizes on high quality production along with higher productivity by efficient utilization of available resources. However, the productivity and efficiency of green house technology is fully depends on the types of greenhouse structure used for production. The recent trend in growth of the human population, along with the advancement of consumption patterns, emphasizes the development of innovative greenhouse structures. The type and equipment of greenhouse structure used in any area generally suit the local environment, availability of construction materials and specific crop. In each region, components such as cover materials, climate-control systems, and irrigation and fertilization equipments are regularly evaluated by growers, designers and researchers, to improve their efficiency, lower inputs, and reduce undesired environmental effects. The efficiency and productivity of a greenhouse operation is largely dependent on the type of growing structure used. Since many greenhouse designs are there to select for a particular region, it is very essential to become intimate with the advantages and disadvantages of each green house types and structure. Hence, a brief discussion on different types of greenhouses structure and their components is needed.

Keywords: Greenhouse, structural component, technology, types

1. Introduction

India has made a tremendous progress in agricultural production after green revolution but productivity is quite low due to climate change and intervention of traditional cultivation practices. In order to meet out the food demand in 2050, world production must increase by 70 per cent (FAO 2020). Man has developed technological methods

for year round crop production. In this regard, greenhouse technology can be the only one option to control the local environment for maximizing crop productivity per unit area and enhance the crop production in terms of quantity and quality which is not possible under open field conditions. In this technological development, greenhouse technology has got a lot of popularity over the years. Presently, progressive farmers are adopting commercial protected cultivation of high value vegetables and flowers (Maitra 2020). Greenhouse structures are covered with glass or plastic film, transparent and translucent materials. Now, there are two ways of practice followed; one is a fully controlled environment and the other being a partially controlled one. This technology of using greenhouses to grow plants is of significant importance, especially in areas where the climatic conditions are always on the extreme side and regions of high rainfall. For this various types of greenhouse structures are available for crop production. As there are both advantages and disadvantages in all type of greenhouse structure for a specific application, in common no single type of greenhouse is considered as the best one. Therefore, different types of greenhouse designs based on utility, shape, material and construction are available to meet the specific needs.

2. Types of Greenhouses

2.1 Types of greenhouse based on cost investment

2.1.1 Low technology greenhouses

A very small proportion of the farmers use low technology structures for production. The size of the low technology greenhouses is less than 3 metres in total height. The most common type low technology greenhouses involve tunnel houses provide poor ventilation as they do not have vertical walls. This type of structure is relatively inexpensive due to little or no automation is used. However, this type of structure provides basic advantages for crop production as compared to open field production. Crop potential is still limited by the growing environment and crop management is somewhat difficult. Low technology greenhouses generally provide suboptimal growing environment which results yield reduction and little reduction in the incidence of pests and diseases however, low technology greenhouses offer a cost effective entry to the farming industry.

2.1.2 Medium technology greenhouses

Medium technology greenhouses are typically characterised by vertical walls. The size of the medium technology greenhouses is more than 2m but less than 4 metres tall and a total height usually less than 5.5 metres. These types of green houses facilitate either roof or side wall for better ventilation. They also provide medium automation and usually use clad with either single or double skin plastic film or glass. Medium level greenhouses offer a compromise between cost and productivity

and represent a reasonable economic and environmental basis for the farming industry. Crop production in medium level greenhouses is more efficient than open field production. Hydroponic systems increase the efficiency of water use. There is greater opportunity to use non-chemical pest and disease management strategies but overall the full potential of greenhouse horticulture is difficult to attain.

2.1.3 High level greenhouses

Height of high level greenhouses wall is at least 4 metres and height of roof peak is up to 8 metres above ground level. These structures offer excellent crop production with environmental performance. This structure has proper roof ventilation and also side wall vents. Cladding materials used in high level greenhouse are plastic film (single or double), polycarbonate sheeting or glass. There is automation environmental controls. These structures offer enormous opportunities for economic and environmental sustainability. Use of pesticides also less significantly reduced. High technology structures provide a generally impressive sight and, internationally, are increasingly being involved in agribusiness opportunities. Although these greenhouses are capital intensive, they offer a highly productive, environmentally sustainable opportunity for an advanced fresh produce industry. Investment decisions should, wherever possible, look to install high technology greenhouses.

2.2 Greenhouse type based on shape

2.2.1 Lean-to type greenhouse

A lean-to types of greenhouse is applicable when it placed against the side of an existing greenhouse structure for one or more of its sides. The roof of the existing greenhouse structure is extended with covering material and the exposed area is properly covered. The whole structure should faced south side which is the best direction for adequate sun exposure. This type of greenhouse is limited to single or double-row plant benches with a total width of 7 to 12 feet and length can be as the building it is attached to the structure. The advantages of the lean-to type greenhouse are, usually it is a least expensive structure which close to available electricity, water and heat source. This types of greenhouse makes the best use of sunlight and minimizes the requirement of roof supports. Whereas limited space, limited light, limited ventilation and temperature control are the following disadvantages.

2.2.2 Even span type greenhouse

The even span is the common type of greenhouse constructed fully on ground level with the two equal width and pitch of roof slopes. This type of greenhouse structure is used when the size of greenhouse is a small size and attached to a house at one gable end. This type of greenhouse is restricted to 2 or 3 rows of plant benches. The price of an even-span greenhouse structure is more as compared to the cost of a lean-to type, but it has eminent plasticity in design and suitable for more plants. Because the size of greenhouse structure and substantial amount of uncover glass

area, it will cost more to heat. The design has better shape as compared to a lean-to type for air movement inside the structure to maintain uniform temperatures during the winter season. It accommodates two side benches, two walks and a wide centre bench. There are different types of single and multiple span structures available in various regions of India. For single span type the span in general, varies from 5 to 9 m, whereas the length is around 24 m and the height varies from 2.5 to 4.3 m.

2.2.3 Uneven span type greenhouse

This uneven span type of greenhouse is suitable for hilly or undulating terrains. The roofs of the structure are differ in width; which resembles the name of the structure and make the structures adaptable to the side slopes of hill. This type of greenhouses is rarely used as it is not adaptable for automation.

2.2.4 Ridge and furrow type greenhouse

This type of greenhouse designs use two or more A-frame greenhouse structure connected to one another along the length of the eave. The eave represent as gutter or furrow to handle rain water and melted snow. The side wall is eradicate between the greenhouses, seems structure with a single large interior, The interior space in greenhouse structure reduces labour, minimize the price of automation, upgrade personal management and less consumption of fuel as there is less uncovered wall area through which heat escapes. The snow stuffs must be taken into the frame specifications of these greenhouses since the snow cannot slide off the roofs as in case of individual free standing greenhouses, but melts away. In spite of snow loads, ridge and furrow greenhouses are effectively used in northern countries of Europe and in Canada and are well.

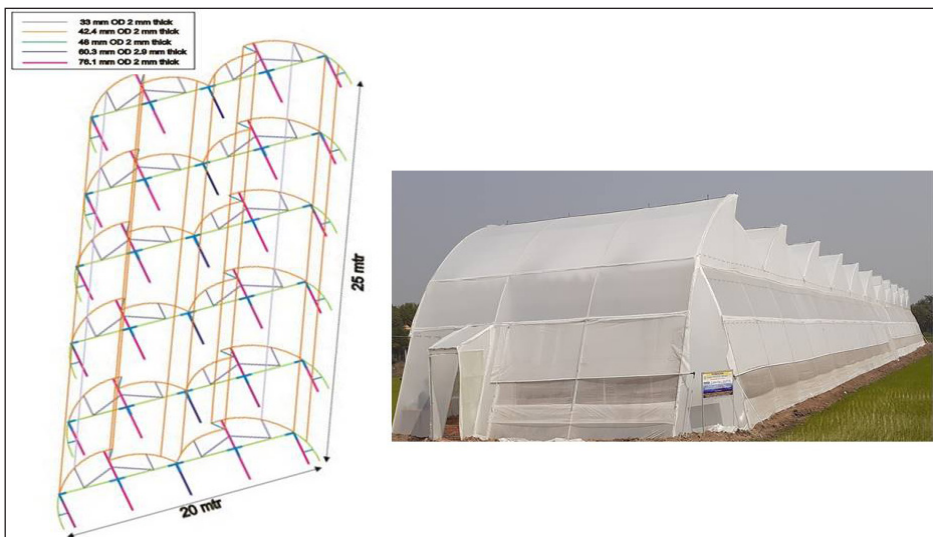


Fig. 1: Saw-tooth greenhouse

2.2.5 Saw tooth type greenhouse

This type of greenhouses is similar to ridge and furrow types, except that this type provides natural ventilation from saw-tooth form of the greenhouse (Fig. 1). When open the saw tooth vent allows a continuous airflow to reduce the inside temperature or can be closed to optimise the climate control of the growing area. The roof ventilation alone provides 25% of the total ventilation of the covered area, in addition to the side ventilation. The shape of the arches allows excellent light transmission.

2.2.6 Quonset greenhouse

Pipe arches are used to provide support by pipe purling running along the distance of the quonset type greenhouse. In general, polyethylene is used as covering material. This greenhouse is useful for a small isolated cultural area and also economical as compared to the gutter connected greenhouses. These houses are connected either in free, standing style or arranged in an interlocking ridge and furrow. In the interlocking type, truss members overlap sufficiently to allow a bed of plants to grow between the overlapping portions of adjacent houses.

2.3 Type of greenhouse based on utility

Greenhouse can be classified based on the utilities and functions. Artificial cooling and heating of the greenhouse are more costly and elaborate. Hence greenhouses are classified as active heating and active cooling system greenhouse based on the artificial cooling and heating.

2.3.1 Active heating system of greenhouses

During the night time, air temperature inside greenhouse decreases. To avoid the cold bite to plants due to freezing, some amount of heat has to be supplied. The requirements for heating greenhouse depend on the rate at which the heat is lost to the outside environment. Various methods are adopted to reduce the heat losses, viz., using double layer polyethylene, thermo pane glasses (Two layers of factory sealed glass with dead air space) or to use heating systems, such as unit heaters, central heat, radiant heat and solar heating system.

2.3.2 Active cooling system of greenhouses

During summer season, it is desirable to reduce the temperatures of greenhouse than the ambient temperatures, for effective crop growth. Hence suitable modifications are made in the green house so that large volumes of cooled air is drawn into greenhouse, This type of greenhouse either consists of evaporative cooling pad with fan or fog cooling. This greenhouse is designed in such a way that it permits a roof opening of 40% and in some cases nearly 100%.

2.4 Types of greenhouse based on construction

The construction of greenhouse is predominantly powered by the structural material,

though the covering material also influences the types of green house. Span of the green house determines the selection of structural components and their construction. Huge the span, efficient should be the material and more structural components are used to make sturdy truss type frames. For smaller spans, simpler designs like hoops can be followed. Greenhouses are broadly classified as wooden framed, pipe framed and truss framed structures based on construction.

2.4.1 Wooden framed structures

In general, wooden frame structures are applicable where greenhouses with span is less than 6 m. Side posts and columns are made up of wooden materials without the use of a truss materials. Pine wood 4 is commonly used as it is inexpensive and possesses good strength. Similarly, locally available timber can be used for the construction of greenhouse as they are good in strength, durability and machinability.

2.4.2 Pipe framed structures

Pipes are used for construction of greenhouses, when the clear span is around 12m. In general, the side posts, columns, cross ties and purlins are constructed using pipes. In this type, the trusses are not used.

2.4.3 Truss framed structures

Green house structures can be made in truss frames, if the span is greater than or equal to 15m. Flat steel, tubular steel or angular iron is welded together to form a truss encompassing rafters, chords and struts. Struts are support members under compression and chords are support members under tension. Angle iron purlins running along the length of greenhouse are bolted to each truss. Columns are used only in very wide truss frame houses of 21.3 m or more. Most of the glass houses are made in truss frame, as these frames are highly suitable for pre-fabrication.

2.5 Types of greenhouse based on covering materials

The principal component of the greenhouse structure is covering materials. They are directly influenced by greenhouse effect interior part of the structure and manipulate the air temperature inside the greenhouse. Selection of frame types and method of fixing also varies with the covering materials. Greenhouses are classified as glass, plastic film and rigid panel greenhouses based on the type of covering materials.

2.5.1 Glass greenhouses

Glass is used as covering material in glass greenhouses (Fig. 2). As a covering material it has the advantage of greater interior light intensity, have higher air infiltration rate, and leads to lower interior humidity and excellent disease prevention quality. Ridge and furrow, lean-to type, even span type of designs are used for construction of glass greenhouse.



Fig. 2: Glass greenhouse

2.5.2 Plastic film greenhouses

The covering materials of flexible plastic films including polyvinyl chloride, polyethylene and polyester are used in this type of greenhouses. As a covering material for greenhouses, plastics are more popular, cheap and the less heating cost as compared to glass greenhouses. Plastic films have short lifespan which is the main disadvantage of this covering material. For example, the best quality ultraviolet (UV) stabilized film can last for four years only. Quonset design as well as gutter-connected design is suitable for using this covering material.

2.5.3 Rigid panel greenhouses

Quonset type frame is also known ridge and furrow type frame material in which polyvinyl chloride rigid panels, fibre glass-reinforced plastic, acrylic and polycarbonate rigid panels are used as the covering material in greenhouse. These material provide more uniform light intensity throughout the greenhouse and also resistant to breakage than plastic or glass. High grade panels are more durable even up to 20 years. But the panels move to collect dust and also harbor algae, are the main disadvantage of rigid panel types greenhouse, results in dim of the panels and gradually incline in the light transmission.

3. Structural components for greenhouse construction

In structural components, rafters is the primary vertical supporter of greenhouse (Fig. 3). Rafters are generally placed on 2, 3 or 4 foot centers based on the energy requirements to hold the whole structure. It may be truss, curved or arch type depending on the greenhouse width. Purlins provide horizontal supports that run from rafter to rafter. All the structural components are spaced 4-8 feet apart based on the magnitude of the greenhouse. Purlins used in high winds area to provide additional support, connected by a cross tie. Side posts and columns provide vertical supports usually ranging in high point from 1-10 feet. These structural components determine the height of the production area. Sidewalls placed to provide cooling, insulation by proper ventilation.

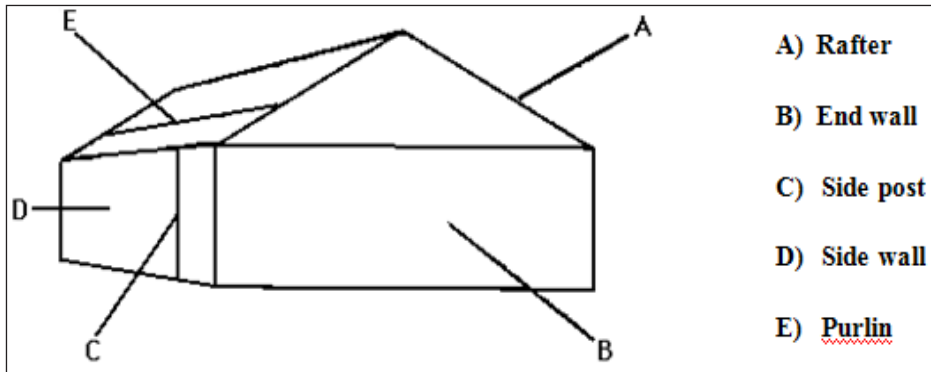


Fig. 3: Primary components of greenhouse

3.1 Framing Materials

Aluminum, steel and wood framing materials are popularly used for construction of greenhouse. However, out of these three, aluminum is the most durable and economical. They are available in different shapes and thicknesses. This framing material can be modified into rafters, side posts and other structural components. Framing material like wood is not used frequently as it deteriorates quickly in the mist facility of greenhouse. If wood is used, it is good to obtain pressure treated lumber that “resists” decompose. There are adequate framing materials treated wood available commercially.

3.2 Covering Materials

Greenhouse covering materials should be clear enough to provide optimum light transmission and long lasting as well as inexpensive. A huge number of materials have been availed on a commercial basis to meet these needs. Glass materials are good for best light transmission for greenhouse crop production but the structural components used to support glass are very costly. Another covering material fiberglass is more long lasting and does not need the substantial structural components as required in glass house. It is used frequently on commercial basis. Miserably, fiberglass is more sensitive to ultra violet (UV) light, allows less light transmission as the fiber get swell. Under certain conditions, the life span of fiberglass is only five years. Double sheets of polyethylene (PE) film, filled with air, is one of the most popular non rigid covering materials on traded greenhouses, give support required for normal operation. Recently available polyethylene (PE) film lasts two years and it needs to be supplanting after the durable time. Although maintenance of these covering materials is expensive, the lower starting investment as well as the less structural components required to hold up this covering materials, has made it most economical for consumer as well as producers. A large number of new polycarbonate and acrylic covering materials are now available for greenhouse.

4. Conclusion

The productivity and efficiency of greenhouse is highly affected by its design. Ridge and furrow design of greenhouse provide the substantial productivity and efficiency in production and most reliable and popularly used framing material for trading greenhouse structures showed aluminium material. Similarly, double sheets of polyethylene film are the most inexpensive covering material available for crop production. However, the initial and long standing costs of the facility, non availability of various structural components, non standardization of region based greenhouse and other structures design and lack of awareness are major limiting factors in the adoption of this technology.

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