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Greenhouses: Its Types and Impact on Crop Production

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A Reshma[1], Syed Sadarunnisa[2]

[1]College of Horticulture, SKLTHU, Rajendranagar, Hyderabad

[2]Department of Vegetable Science, COH, Dr.YSRHU, Ananthrajupeta, Sri Annamayya Dst.

India's agricultural production has advanced significantly since the Green Revolution. However, climatic change and the modification of traditional cultivation practices have resulted in low productivity. To meet global food demand by 2050, food production must increase by about 70%.

Technological advancements now allow crops to be cultivated year-round. Greenhouse technology offers a viable solution by enabling environmental control to enhance both the quantity and quality of crop production — something not possible in open-field cultivation. Consequently, greenhouse farming has gained popularity among progressive farmers for commercial production of high-quality flowers and vegetables.

A greenhouse is a structure covered with transparent or translucent materials such as glass or plastic film. Depending on design and control systems, greenhouses can be fully controlled or partially controlled environments. They are particularly important in regions with excessive rainfall, extreme heat, or cold conditions.

Various types of greenhouse structures are available for crop production, each with specific advantages and limitations based on design, material, and purpose. Therefore, no single design suits all situations. Researchers continue to explore efficient greenhouse management systems focusing on cost reduction, energy efficiency, geometry, temperature control, and climate optimization for sustainable productivity.

Types of Greenhouses Based on Cost

1. Low-Tech Greenhouses

Low-tech greenhouses are simple, cost-effective structures with a total height of less than three meters. The most common type, *tunnel houses*, have curved roofs and limited ventilation. Mechanization is minimal, making them inexpensive to construct. Despite their simplicity, these structures significantly

improve crop productivity compared to open-field farming.

2. Medium-Tech Greenhouses

Medium-tech greenhouses typically have vertical side walls and heights between 2 and 5.5 meters. They feature improved ventilation through side walls or roof openings and use single or double layers of glass or plastic film. These structures offer moderate automation and provide better environmental control than low-tech designs.

3. High-Tech Greenhouses

High-tech greenhouses have wall heights of at least 4 meters, with roof apexes reaching up to 8 meters. They are equipped with automated systems for temperature, humidity, and irrigation control. Cladding materials include glass, polycarbonate, or multilayer plastic films. These greenhouses are highly efficient, environmentally sustainable, and capable of drastically reducing pesticide use. Although their installation cost is high, they offer superior productivity and are well-suited for commercial agribusiness ventures.

Types of Greenhouses Based on Shape

1. Lean-To Type

This design is attached to one side of an existing structure, extending its roof to enclose the area. It is best oriented southward for maximum sunlight exposure. The width ranges from 7 to 12 feet, accommodating single or double rows of benches. Lean-to greenhouses are cost-effective and benefit from proximity to utilities like electricity and water.

2. Even-Span Type

Even-span greenhouses are freestanding structures with two roof slopes of equal width and pitch. They offer greater flexibility and can accommodate more plants than lean-to types. Though costlier, their design allows efficient air circulation and better environmental control.

3. Uneven-Span Type

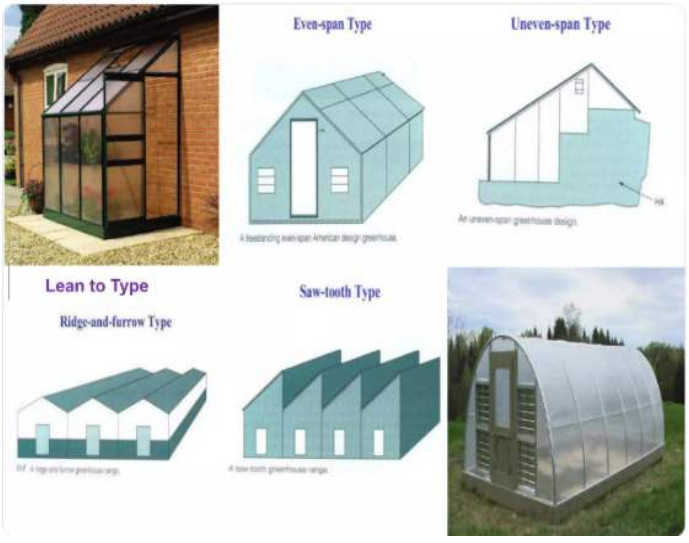
Designed for hilly or uneven terrain, uneven-span greenhouses have roof slopes of different widths to adjust to land gradients. However, due to their complex design and limited automation capability, they are rarely used today.

4. Ridge and Furrow Type

This design connects two or more A-frame greenhouses at the eaves, forming a large continuous interior space. The common gutter between them collects rainwater and snow. This layout improves energy efficiency, reduces heating costs, and simplifies internal management.

5. Saw-Tooth Type

Similar to ridge and furrow designs, saw-tooth greenhouses feature roof openings that facilitate natural ventilation. These vents can be opened or closed to regulate internal temperature, providing an effective passive cooling system.



Types of Greenhouses Based on Covering Materials

1. Glass Greenhouses

Glass is the traditional covering material, offering high light transmission, lower humidity, and reduced disease incidence. Common designs include ridge and furrow, lean-to, and even-span types. However, glass greenhouses are expensive to construct and maintain.

2. Plastic Film Greenhouses

Flexible plastic films such as polyethylene, polyester, or PVC are widely used due to their affordability and low heating requirements. These materials make plastic greenhouses more popular among small and medium-scale farmers.

3. Rigid Panel Greenhouses

Rigid panels made from polycarbonate, acrylic, fiberglass-reinforced plastic, or PVC are durable and provide uniform light diffusion. They are more resistant to breakage than glass and can last up to 20 years, making them ideal for commercial applications.

Advantages of Greenhouse Cultivation

- **Increased Productivity:** Enables multiple cropping cycles and enhances yield by 2–10 times compared to open-field conditions.
- **Better Quality Produce:** Ensures uniform size, color, and texture through controlled environments.
- **Efficient Resource Use:** Saves up to 70% water and 50% fertilizers using drip irrigation and fertigation.
- **Reduced Pest and Disease Pressure:** Physical barriers minimize pest entry and disease spread.
- **Off-Season Production:** Allows production of high-value crops even under adverse climatic conditions, fetching premium prices.
- **Employment Generation:** Promotes skill development and participation of rural youth and women in high-tech horticulture.

Impact on Crop Production

A. Vegetable Crops

Crops such as tomato, cucumber, capsicum, lettuce, and leafy greens show significant yield and quality improvement. For instance, greenhouse-grown tomatoes can produce 250–300 tonnes/ha/year compared to 60–80 tonnes/ha in open fields. Controlled fertigation and pollination also enhance fruit uniformity and shelf life.

B. Flower Crops

Greenhouse floriculture supports year-round cultivation of roses, gerbera, chrysanthemum, and orchids. The flowers meet export-quality standards and ensure consistent supply to markets.

C. Fruit Crops

High-value fruits such as strawberries, melons, and grapes can be successfully cultivated under greenhouse conditions, resulting in uniform ripening, better quality, and reduced disease incidence.

D. Nursery Raising

Greenhouses provide ideal conditions for raising vegetable seedlings, tissue culture plants, and ornamental saplings, ensuring high germination rates and strong seedling growth.

Conclusion

Greenhouses play a crucial role in ensuring the year-round supply of vegetables, fruits, and ornamental crops across the world. The type and design of a greenhouse depend on local climatic conditions, available materials, and crop requirements. Among the

various designs, ridge and furrow structures are considered highly efficient, while aluminum frames offer durability. Multi-layer polyethylene films remain the most economical and practical covering material. Efficiently designed and managed greenhouses represent a key step toward sustainable and profitable modern agriculture.