

DESIGN AND LAYOUT OF A SMALL COMMERCIAL GREENHOUSE OPERATION

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Abstract

This information sheet outlines the major requirements and factors that should be considered by someone contemplating starting a small greenhouse operation for the production of tree seedlings, nursery stock, perennials, herbs or other specialized crops. It can also be used when planning an expansion of an existing business.

Key Words

Greenhouse design, greenhouse environment, greenhouse lighting, irrigation, fertilization

SITE SELECTION

The following are considerations for site selection listed in a general priority of importance:

Adequate Land

A minimum of 2 acres is needed to allow for facilities, outdoor growing area, access, parking and buffers. Availability of additional vacant land adjacent to the site is desirable for expansion as the business grows. Soil type should provide good drainage.

Quality Water

The amount of water needed depends on many factors including climate, irrigation systems used and crops grown. Water supply should be adequate to meet peak load demands. Tests should be conducted to evaluate water quality for suspended sediments, pH, electrical conductivity, total dissolved solids, alkalinity and hardness.

Orientation

Good solar access is needed throughout the day and year to get enough light energy for photosynthesis. Shelter belts to the north can provide wind protection and energy conservation.

Topography

A site that has a gentle slope to the south increases solar gain and provides drainage of rain and runoff. A fairly level site with a 1% to 2% slope reduces site preparation costs.

Road Accessibility

For wholesale operations, good access to the interstate highway system can improve delivery of supplies and shipping of plants. In retail operations, location on a heavily traveled road will increase the customer base and improve the visibility of the business.

Utilities

The cost of providing electricity and telephone to the site should be considered. Where extensive greenhouse operations are to be installed, the type and availability of fuel may be a concern.

Regulations

Federal, state, and local regulations will influence what can be done and how long it takes to get approval. Zoning, building and wetlands regulations should be checked before selecting a site.

SITE LAYOUT

Facilities Master Plan

A master plan provides a framework for orderly construction of the property and should be based on a sound business plan. The plan starts with a survey of any existing facilities, evaluates the benefits and constraints of the site and establishes where new facilities should be built. A good arrangement is to plan a core area which contains the propagation and production greenhouses, headhouse, storage and parking. Outdoor production areas should be located nearby for efficient plant movement and shipping. Expansion space should be planned for all areas. It is best to do the planning on paper so that several alternatives can be evaluated.

Parking and Access

Good, all weather vehicular access to the buildings and growing areas should be provided. Parking for employees and customers, convenient to the core area is desirable. An adequate number of parking spaces for retail sales may be needed to meet the zoning code. A paved surface is usually required. Other areas and driveways can be unpaved. Surface can be bank-run gravel, pea stone, crushed stone or trap rock. Driveways and parking areas should slope to provide drainage. Swales or underground piping is necessary to carry the water away from the area. Swales should be grassed and slope at least 0.25"/ft.

Storage

An area for storage of materials including soil mix, containers, chemicals and equipment is needed. Indoor storage for some items is desirable for easy access and protection from weather. This can be in a headhouse or separate building. An outdoor area is usually provided for growing mix. Space for an equipment storage shed with a shop for maintenance should be planned. A clear span pole building is a low-cost alternative.

Production Areas

Prime space should be allocated to plant production including growing beds, shadehouses and overwintering structures. Good light, drainage and proximity to water are needed. Production areas should be laid out in rectangular blocks of 1000 to 2000 sq ft. Within the blocks, 6' to 8' wide beds are placed adjacent to 2' wide walkways.

Generally an arrangement with shorter length walkways across the block is preferred over ones with walkways that run the length of the block. Roadways are placed between blocks to transport and maintain plants. These should be 15' to 20' wide to allow movement of trucks or tractors. Gravel or stone on the surface requires a minimum of maintenance.

GREENHOUSES

A key to successful production is a well-designed greenhouse with good space utilization and accurate environment controls. Greenhouses can be classified as free-standing or gutter-connected.

Free-standing Greenhouse

A free-standing greenhouse can have a quonset (hoop), gothic, or gable roof shape. The quonset is usually the least expensive and is available in widths to 34'. Gothic designs have higher light transmission and shed snow easier. Gable designs may use trusses to span a width up to 60'.

The free-standing design is usually the best choice for the small grower planning on less than 10,000 sq ft of growing space. It is easy to build additional greenhouses as more space is needed. A separate growing environment can be provided in each house. Individual greenhouses can also be shut down when not in use. They are also better suited for heavy snow areas and non-level sites. Free-standing greenhouses are less expensive to build as site preparation and erection costs are less.

Gutter-connected Greenhouse

This is a series of gable or quonset arches connected together at the gutter level. Individual bays vary from 12' to 25' in width and have a clearance of 8' to 16' at the gutter. Bays can be put together to get the width desired.

A gutter-connected greenhouse offers the greatest flexibility. The vertical sides give good space utilization and gutter height of at least 12' provides an air buffer and room for an energy truss and shade/blanket system. Gutter-connected greenhouses are usually most efficient and economical in a size of at least 10,000 sq ft. Heat can be centralized and heating costs are as much as 25% less than an equal area in free-standing greenhouses. Utilities are centralized and easier to install. Be sure to provide space for future

expansion, as most businesses tend to grow rapidly.

Glazing

Double poly is a low-cost material with a 4-year life. Corrugated polycarbonate is a more expensive alternative with a life of 20 years. Polycarbonate and acrylic structured sheet glazing provides greater insulation but increases initial cost.

Although initially more expensive, wide pane glass is the preferred glazing where high light levels are required during the winter. Energy blankets can help to reduce heat loss and also provide shading during the summer.

Layout

A headhouse, either one section of the greenhouse or an attached building, is desirable. It should contain a work area for flat filling and transplanting, receiving and shipping area, utility room, office and employee room. Build it high enough so that storage can be overhead. Adequate water, electricity and telephone should provide for an expansion phase.

It is best to have concrete floors throughout the headhouse and greenhouse for cleanliness and access. Adequate drainage should be provided.

Depending on the crops to be grown, production can be on the floor or on benches. Fixed peninsula benches or a moveable bench system may be used to increase growing space. A system of carts or overhead trolley conveyors can be employed to reduce material handling costs.

Germination Rooms

Germination can be done on the benches in the greenhouse, but it is better to have a separate room or chamber. Good heat control and a fog system can provide the ideal environment. Lighting can give the seedlings a good start once they germinate.

ENVIRONMENT CONTROL

Heat

A hot water boiler is the best choice for a heating system. Water temperature can be modulated to meet the needs of the different systems. Each greenhouse or bay should have independent temperature control for different crop needs. Hot air furnaces or unit heaters are a good choice

where the greenhouse will be shut down for the winter as water systems need to be drained.

Bottom heat in the floor or under the benches is important for uniform root zone temperature. Floor heat can be provided with EPDM tubing placed in a sand layer or in concrete. Bench heat can be provided with either EPDM tubing on the benches or low-output fin radiation under the benches. It is best to limit this zone of heat to no more than 20 BTU/sq ft as excessive drying of the growing mix can occur. Water temperature should not exceed 100 °F. Root zone heat will provide only about 25% of the total greenhouse heat needs on the coldest night in northern climates. Heat exchangers or fin radiation around the perimeter and under the gutters are installed to provide the remaining heat. These should be zoned separately.

Cooling

Natural ventilation depends on temperature and wind gradients to remove the heat from the greenhouse. Locating the greenhouse where it can intercept the summer breezes and providing large roof and sidewall louvers is important.

A fan and louver system will give more positive ventilation. Although more expensive to operate than a natural ventilation system, it will give better temperature control. The system should be designed to give a ventilation rate of about 2 cfm/sq ft during the winter and 8 cfm/sq ft during the summer. Several stages of ventilation capacity are better than a single stage.

Evaporative cooling, either fan and pad or fog may be necessary if plants will be grown during the summer. The moisture provided picks up excess heat that is exhausted by the fans.

A horizontal air flow (HAF) system will give good air movement and uniform temperatures. Small fans are placed to develop a horizontal pattern of air movement that mixes the air, removes moisture from leaf surfaces to reduce disease potential, and increase carbon dioxide to the plants.

Energy Conservation

With the high cost of fuel, installation of energy conservation measures is important to reduce production costs. Double glazing, perimeter insulation, energy blankets and wind breaks should be considered. Management practices, such

as growing crops that require cooler temperature, purchasing plugs or prestarted plants, keeping the growing space full and the use of supplemental carbon dioxide can also help.

Supplemental Lighting

To overcome variable weather conditions and still meet a production schedule, supplemental lighting may be needed, especially in the propagation area and nursery. High-pressure sodium (HPS) fixtures are the most efficient and should be installed to provide at least 900 foot-candles at plant height.

Controls

For small operations, a controller should be installed to control heating and ventilation equipment. Computer control is best for integrating the heating, cooling, lighting and other systems in larger operations. It also provides a record of the environmental factors so that timing of the crop can be repeated or adjusted.

Irrigation

Uniform irrigation is very important, especially for plants grown in plug trays with small cells. A computerized boom system can be programmed to water different sections of the greenhouse at

different rates. These units are very versatile and will eliminate most hand watering.

Other systems used in greenhouses include mist for propagation areas, overhead watering for mature crops and drip for hanging baskets and crops grown in ground beds. Capillary watering mats may be best for potted plants grown on benches. Ebb and flood watering is becoming popular for bench or floor systems where uniform watering and containment of the nutrient solution is desired.

Pesticide and Fertilizer Storage

Separate cabinets or sheds located away from work and growing area should be used to store pesticide and fertilizer materials. They should have heat to prevent liquids from freezing and ventilated to remove hazardous fumes. Personal protective clothing and spray equipment should be stored separately.

Installation of a well controlled greenhouse will pay for itself in better quality, greater production and more uniform plants. Be sure to plan all systems for expansion.