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Greenhouses for Home Gardeners in Alaska

Greenhouses are structures designed to help control factors affecting plant growth. There are numerous types of greenhouse structures and they vary in the degree of control over the plant environment, the extent to which they optimize plant growth and the relative cost.

Greenhouses are used by the home gardener to start seedlings that are later planted outdoors, grow vegetables and flowers to maturity and propagate or overwinter tender plants. Successfully growing plants in a greenhouse depends on two factors: selection of a greenhouse structure that will meet the requirements of the plants you intend to grow and effective management of the greenhouse environment to optimize conditions for healthy plant growth. This publication gives a basic overview of greenhouse structures and related equipment.

GREENHOUSE STRUCTURES

There are two basic types of greenhouse: attached and freestanding. Attached greenhouses are also referred to as lean-to greenhouses. They may be attached to the home, garage or another building. Freestanding greenhouses are completely independent structures that come in a variety of different designs.

Attached greenhouses. An advantage of attached greenhouses is that they usually have easy access, which makes it more convenient to attend to plants. They can create an extension of your indoor living space, provide solar heating and add insulation to part of the house. They usually have lower heating costs and lower initial construction costs because there is one less wall to build and

it is easier to tap into the home water, electrical and heating systems. Size limitations and location restrictions are potential disadvantages of attached greenhouses. Both are determined by the availability of suitable exterior wall space. Unlike a freestanding greenhouse, an attached greenhouse might not be located in the sunniest space in the yard. Other disadvantages are greenhouse moisture, summer heat, dirt, insects and chemical odors that may enter the home if there is a door from the greenhouse to the house.

Freestanding greenhouses. Freestanding greenhouses isolate greenhouse activity from the home and offer more flexibility in size, shape and configuration. The best location on the property for light interception, drainage and wind protection may be chosen. Freestanding greenhouses are also easier to expand than attached greenhouses.

Access to freestanding greenhouses may be more difficult, especially if they are used in the winter. They require separate utility services or lines

from the house for water, electricity and for some greenhouses, heat. A freestanding greenhouse usually has higher heating costs than the attached greenhouse. It has more exposed surface, leading to greater heat loss. The freestanding greenhouse also has a higher initial construction cost than the attached greenhouse because it has an extra wall to build plus service line installation.

GREENHOUSE STYLES

Quonset. This is probably the most popular greenhouse style, mainly because it is relatively inexpensive and simple to build. Quonset-shaped greenhouses are constructed with bent pipe frames made of either metal or PVC. The flexible trusses are often anchored into sturdy metal pipe foundations. They are covered with flexible plastic film, either a single or a double layer. A small fan usually provides air support for the double layer. An insulating double layer reduces heat loss, but it also reduces light penetration. Quonset-shaped greenhouses are lightweight, so they must be well anchored to keep them from being blown away. Their light construction also makes them susceptible to damage from heavy wind and snow.

High tunnels. High tunnels are similar in shape to quonset-type structures, but they aren't heated and they aren't considered permanent. One of their unique features is that roll-up sides are used for ventilation and temperature control on sunny days. Crops are typically grown in ground beds.

High tunnels have bent-pipe frames are constructed of metal or PVC.

High tunnels have large doors to permit the use of tractor-mounted equipment in the house. High tunnels are considered season extension structures and do not provide the degree of climate control that greenhouses do.

A-frame. A-frames have sloping sides all the way to the foundation, which makes them the best style for passive snow removal and limiting snow buildup. Like hoop houses, they are relatively inexpensive and simple to build. Frames are often made from two-by-four lumber and are generally covered with a single layer of polyethylene film. People sometimes attach a second layer of film to the inside if they use the house during cooler weather. The biggest drawbacks of the A-frame style is that it limits both house width (and therefore size) and headspace within the house.

Working in an A-frame house is more awkward than in other types of greenhouses, and flats are often grown on the ground because of the lack of headspace. Soil temperatures may remain cold in a greenhouse and lag well behind air temperatures, so if roots of plants placed directly on the ground are cool, restricted growth can occur from reduced water and nutrient uptake even though air temperatures are conducive to good plant growth. One way to limit this problem is to put flats and pots on a layer of insulation placed over the soil.

Gothic arch. Gothic arch greenhouses have an arched roof line and walls that form a continuous shape. Snow slides off them better than from a hoop house but not as well as from an A-frame. They have more headspace than an A-frame but not as much as a hoop house of similar height. Frames are constructed from both pipe and wood. Roof supports must be flexible enough to make the arch curvature (glued plywood strips are one type of material used). Gothic arch greenhouses are frequently covered with polyethylene film, but they can also be covered with flexible fiberglass and polycarbonate panels.

Gable. Gable-style greenhouses have sloping, flat roofs connected to vertical sidewalls. The roof angle determines how well snow slides off as well as the total height of the structure. The well-defined roof line is adaptable to efficient roof-ventilation systems. Frames are constructed from both metal and wood. The gable style provides considerably more head-

The gable style provides more headspace and room for growing plants than the A-frame or Gothic style.

space than an A-frame or Gothic arch and much more room for growing hanging plants above benches. Gable greenhouses can be covered with polyethylene film, but generally a rigid type of material is used such as polycarbonate, glass, acrylic or fiberglass.

Slant-leg. The slant-leg style is similar to the gable style, except that sidewalls are slanted slightly outward. This makes it wider than the vertical-leg gable style, providing additional floor space. Like the gable style, it has a flat, sloping roof that sheds snow well, depending on the pitch. The slanting sidewalls require a reinforced frame, thus slant-leg houses are very sturdy and suited for locations with heavy snowfall and thunderstorms.

A slant-leg greenhouse in Chickaloon Native Village. Glass is used for the south wall.

Geodesic dome. Dome-shaped greenhouses are popular in coastal areas of Alaska because they are less likely to be damaged in high winds and stormy weather. Dome greenhouse kits are available to purchase. Initially, this type of greenhouse is likely more expensive than other styles, but it is a wise investment for areas of Alaska that see high winds. These types of greenhouses require an unconventional layout. Beds are laid out in concentric circles, or pots are used.

Pit. Pit greenhouses are built partially below ground. They are most commonly built where topography is suitable, such as the side of a hill with good sun exposure. Pit greenhouses usually have lower heating and cooling costs since insulation from the earth keeps them warmer in the winter and cooler in the summer. They are relatively expensive to construct because reinforced walls are required in the pit and both interior and exterior drainage systems are usually needed to keep the pit dry.

SELECTING A GREENHOUSE SITE

The most important factor in selecting a greenhouse location is the amount of sun exposure, which should be at least 8 hours per day, but ideally 12 or more. Protection from strong winds is also very important for greenhouses, since they are more susceptible to wind damage than many other types of construction. Factors important in site selection for greenhouses, and for any type of building, include level ground, well-drained soil and a location that does not collect water from the surrounding landscape. It is often recommended that greenhouses in northern climates be oriented with the long side running in an east-west direction to maximize sunlight, but for home greenhouses with a limited number of site options other location factors often dictate the orientation.

GREENHOUSE COVERING

Many high-quality greenhouse covering materials are available these days, but they vary in their strengths and weaknesses. Important properties to consider when selecting a covering are light transmission, heat retention, durability and longevity, maintenance requirements and cost.

Plastic film is the least expensive type of greenhouse covering, but a greenhouse-grade plastic will only last 4-10 years.

Plastic film. Plastic film is lightweight, very flexible and the least expensive type of greenhouse covering. A single layer has high light transmission, but it also has high heat loss in cold weather. Many quonset-shaped greenhouses have a double layer of plastic with an insulating layer of air between them. This reduces light transmission by about 10 percent, but it also reduces heat loss by 35 percent. Use only greenhouse-grade plastics. They have additives that slow deterioration from ultraviolet light, are stronger and have infrared inhibitors that reduce heat loss. Greenhouse-grade plastics will last 4 to 10 years while other plastics will last only one growing season. Some materials also have anti-drip surfaces that reduce droplet formation from water condensing on the interior of the plastic film.

Glass. The introduction of synthetic glazing materials has greatly reduced the number of glass-covered greenhouses, but in many ways glass is still the standard of comparison. It has high light transmission and good durability. Glass has the greatest longevity of any glazing material (25-plus years). Use low-iron glass for the highest light transmission and tempered glass for the greatest strength. Double-pane glass reduces the relatively high heat loss of glass, although some loss in light transmission also results. Glass must be installed and maintained to prevent air and water leakage between the panes. Modern glass greenhouses use rubber or vinyl gasket material below the edge-to-edge glass and bar caps over the top of the seam.

Polycarbonate. Polycarbonate is a rigid plastic covering that comes in sheets that have enough flexibility to bend around gently curved surfaces such as the Gothic-arch greenhouse. It has high light transmission and is low maintenance, very strong yet lighter than glass and is a fire retardant. Polycarbonate is available in single- and double-layer sheets. As with other coverings, the double sheets lose some light transmission but reduce heat loss to a greater extent. Double sheets also have greater longevity than single sheets. Polycarbonate sheets must be installed to allow for some contraction and expansion of the material with temperature changes.

Acrylic. Acrylic is a rigid plastic glazing that is clearer than polycarbonate, although it may slowly yellow with age. It is available only as a double-layered sheet that lacks flexibility and must be installed on flat surfaces. Light transmission and heat loss are equivalent to double-layer polycarbonate. Acrylic has the longest life expectancy of any glazing except glass, but compared to polycarbonate it attracts more dust and dirt, scratches more readily and is more flammable.

Fiberglass reinforced plastic. Fiberglass is a rigid plastic that will bend around gently curved surfaces. It has high light transmission but comes only in single sheets (flat or corrugated); it also has a high heat loss. Fiberglass-reinforced plastic is lower in cost than other rigid plastic glazing, but it does require more maintenance since it must be recoated every few years.

GREENHOUSE UTILITIES

All greenhouses require a water supply, most need an electrical supply and some require a fuel supply for heat. Home greenhouses are normally connected to utility sources within the home. Before greenhouse construction, make sure the home capacity is adequate for the added connections and peak-use rates. Plan the installation and connections from the very beginning of the greenhouse construction process, where underground lines must be run to freestanding greenhouses.

GREENHOUSE LAYOUT

Greenhouse benches. The layout and design of greenhouse benches determine the amount of usable greenhouse space and the ease of working within that space. Experiment on paper with different bench sizes and different patterns of benches and aisles to help decide on the best overall design. Benches must be strong enough to support the weight of plants and soil (or growth media) as well as the weight of the water in a fully watered pot. They should be a comfortable working height (usually about 30 to 36 inches) and no more than an arm's reach in width. When a bench is accessible from both sides it can be twice as wide.

Benches are constructed from a variety of materials, including wood, galvanized pipe, concrete block and plastic. Wood, because of the moist atmosphere in greenhouses, should be pressure treated with a preservative that is nontoxic to plants.

Bed construction should facilitate good airflow through plants, including air circulation from below the bench. For this reason, greenhouse benches are made from slatted wood, wire mesh or expanded metal sheets for this reason. Slatted wood is relatively inexpensive and easy to work with but doesn't permit as much airflow as wire mesh or expanded metal. Wire mesh is much less expensive than expanded metal sheets, but over time it begins to sag and its useful life is much shorter than expanded metal.

Plants can also be grown directly on benches designed to hold a growing medium/soil. Shallow benches (4-6 inches deep) can be used for plant propagation. Cables can be buried for bottom heat and mist nozzles can be installed above. Deeper benches can be used to grow crops such as tomatoes, cucumbers or cut flowers to maturity.

Slatted wood benches allow increased air circulation.

Tall plants thrive in ground beds.

In addition to efficient bench layout, the creative use of racks, shelves and overhead hanging plants makes good use of all potential growing spaces in a greenhouse. Growing conditions vary, both vertically and horizontally, within even a small greenhouse, so effectively maximizing growing space requires recognition of different greenhouse microclimates and knowing which plants will do well in each of them.

GROUND BEDS

Tall plants, such as trellised tomatoes, cucumbers and corn are frequently grown in ground beds in greenhouses. Beds are often raised and about 3 feet wide; the soil must be 8 to 12 inches deep. They may be loosely mounded or enclosed within a wooden frame. Plant culture is similar to outdoor raised-bed gardening.

GREENHOUSE WATERING SYSTEMS

Hand water. Most home greenhouses are watered by hand with a hose and suitable nozzle. Time to look at every plant and evaluate its condition is an advantage of hand watering. It is also easy to adjust the amount of water based on the needs of different plants. However, as greenhouse size and number of plants

increase, hand watering becomes time-consuming compared with other methods.

Overhead sprinklers. Sprinkler systems are relatively simple to install and convenient to operate. One drawback is that excess water must be applied; this makes up for water deflected by plant leaves and water that falls on areas where nothing is being grown. Also, wet foliage and higher humidity levels increase plant disease potential.

Drip systems. Drip irrigation systems might consist of individual capillary tubes for each pot or drip tape for ground beds. Drip irrigation uses water efficiently and keeps areas with no plants dry so that you can work around plants while they are being watered. Drip systems should be monitored to be sure they are maintained and working correctly to keep the water flowing from emitters. Drip systems are relatively easy to assemble, but they do take more time to set up than most of the other watering systems. This is especially true when individual drip emitters are installed in a large number of pots.

Capillary mats. Capillary mats water plants from below. They are made of water-absorbing materials placed on solid bench tops with a few drainage holes. Pots or flats are put on top of the mat, the mat is watered and water is wicked up from the mat into and through the growing medium. Periodic top watering is recommended to provide leaching and prevent potential salt buildup.

A greenhouse drip system uses water efficiently.

Ebb and flow benches. Ebb and flow benches are similar to capillary mats in that plants are watered from below. They differ in how the water is delivered. The ebb and flow bench is periodically flooded with a pool of flowing water, the water is drained and the cycle is repeated at regular intervals that are appropriate for the water needs of the plants.

Hydroponics. Water is the essential component of growing plants hydroponically. There are a variety of hydroponic systems, ranging from plants anchored by rock in a trough of water to plants grown in Styrofoam trays that float in a pool of water. In all types of hydroponic culture, water must be well aerated, free of disease, and provide a steady supply of nutrients to plants. Hydroponic systems are complex. They must be consistently monitored, and nutrient solutions must be mixed and adjusted accordingly.

Fertigation. Healthy plant nutrition is frequently maintained in greenhouses by using soluble fertilizers that are delivered to plants in their irrigation water. A number of devices are available to help accomplish this. The simplest and probably the most useful and economical for a small home greenhouse is a proportioner that can be attached between a faucet and a hose. The proportioner has a tube that is placed in a bucket of fertilizer concentrate, and when water moves through the proportioner it "siphons" some concentrate and mixes it with the water flowing to the irrigation hose. Fertilizer injectors pump fertilizer concentrate into the irrigation stream. They are more accurate than proportioners and useful as the numbers of plants and thus volumes of water increase. They can also be plumbed into automated irrigation systems. When using fertigation, a backflow preventer must be used to keep fertilizers from flowing backwards into water sources such as wells and ponds.

GREENHOUSE VENTILATION SYSTEMS

Ventilation systems promote airflow through a greenhouse and help control both temperature and humidity.

Natural ventilation. Most home greenhouses are small enough that natural ventilation provides adequate air exchange. Natural ventilation depends on differences in temperature inside and outside the greenhouse. Ventilation effectiveness increases as the temperature difference increases. Warmer, more humid greenhouse air rises out of vents in the top of the greenhouse and is replaced by cooler, dryer air from outside that enters through lower side vents.

Greenhouses that rely on natural ventilation require adequate vent area to provide enough airflow and air exchange. Ridge vents along the peak of the greenhouse are the most efficient in removing air, and a general rule of thumb is that the total area of the vent openings (ridge plus side) should equal 20–30 percent of greenhouse floor area. Although natural ventilation is effective, it sometimes benefits from the assistance of a small fan to speed the flow of stagnant air. The air also moves passively along pathways of least resistance, and a properly placed fan can introduce some turbulence that reduces channeling and results in more uniform overall airflow. Sometimes such fans are placed in the ceiling and blow vertically downward across the bulk flow of air.

GREENHOUSE HEATING SYSTEMS

Many home greenhouses are operated seasonally and shut down during the colder parts of the year. They do not require a permanent heating system, but portable gas and electric heaters are used by many to provide supplemental heat during spring or fall cold spells. Small, portable heaters work well to protect plants on unexpectedly cold nights, but gas heaters that are not vented to the outside can create problems if they are not maintained and burning cleanly. Incomplete combustion can create ethylene gas, which is a plant hormone that causes abnormal, distorted growth in excessive concentrations. Tomatoes and fuchsias are very sensitive to ethylene.

Several types of permanent heating units can be installed in greenhouses that are operated during the colder parts of the year. The choice of a heater often depends on local availability and cost of different fuels. A heater must be properly sized so that it has adequate capacity to heat the greenhouse on the coldest night of operation. Required heater output is determined by calculating potential heat loss, which depends on the surface area of the greenhouse, the insulating value of the glazing, wind conditions and the temperature difference between inside and outside air. As discussed above, venting the heater to the outside is necessary to remove potentially harmful gases.

Portable heaters protect plants during the spring and fall.

These are some of the most important factors you should consider when planning and building a home greenhouse. For a more in-depth discussion of greenhouses suitable for commercial growers, see UAF Cooperative Extension Service publication *Controlling the Greenhouse Environment*, HGA-00336.

FOR MORE INFORMATION

Bartok, John. 2000. "Greenhouses for Homeowners and Gardeners," NRAES-137. Ithaca: Natural Resource, Agriculture, and Engineering Service.

Biomass Greenhouse Handbook: http://www.cchrc.org/biomass-greenhouse-handbook

Greenhouse Plans
University of Tennessee: https://ag.tennessee.edu/BESS/Pages/GreenhousePlans.aspx

www.uaf.edu/ces or 1-877-520-5211

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