



# Greenhouses and Season Extenders

Certain crops grow just fine in Alaska's short growing season, even when direct seeded (planted outside in the spring), while other crops benefit greatly from season extension techniques and/or greenhouses. Cool season crops that do well without any help include potatoes, turnips, radishes, beets, lettuce and other greens, peas and carrots, which can all be direct seeded. Crops in the Brassicaceae family (broccoli, cabbage, cauliflower, kale, etc.), are also cold hardy, although seeds should be started indoors to ensure they reach maturity by the end of the growing season. Many warm season crops that grow well with a little help from season extension techniques include basil, snap beans, strawberries, zucchini and other types of squash, to name a few. Tomatoes and cucumbers are ubiquitous greenhouse crops. Although season extension techniques require additional time and money, for crops such as strawberries it's usually worth the additional effort and expense. In general, more expensive techniques afford a greater degree of control over and ability to use an outside heat or ventilation source. With the additional costs associated with structures such as a greenhouse, it makes sense to grow higher value crops. Any season extension technique will require some additional expense and labor and so two questions could be asked: Is the crop valuable enough (to you or at the market) to warrant the additional expense? Can the crop be grown successfully without additional help?



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- ☀ Popular greenhouse crops in Alaska
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of Alaska Cooperative Extension Service.

## Selecting a site

The most important factor in selecting a location for a cold frame, hoop house, high tunnel or greenhouse is sunshine. Protection from strong winds is also very important since they are more susceptible to wind damage than many other types of construction. Other considerations include factors important in site selection for any type of building: level ground, well-drained soil and a location that does not collect water from the surrounding landscape. It is often recommended that high tunnels or greenhouses in northern climates should be oriented with the long side running in an east-west direction to maximize sunlight, but for home gardeners with a limited number of site options, other location factors often dictate the orientation.

## Season extenders

To get the most from a garden, extend the growing season by sheltering plants from cold weather in both early spring and fall. Row covers, cloches, plastic mulches, hoop houses or a combination of these techniques can save your crops from unexpected frosts in late spring or early fall and can allow you to confidently transplant earlier than you otherwise would.

## Plastic mulches

Plastic mulches are useful for warming the soil and suppressing weeds in Alaska. They should be placed as tightly as possible on the soil; plants such as zucchini, corn, peppers and pumpkins can be grown in the plastic. Clear polyethylene mulch warms up the soil, but also acts as a perfect environment for weeds to grow. Black polyethylene mulch blocks the sunlight required for weed growth, but is not very useful for warming

the soil. A special type of polyethylene mulch called Infra Red Transmitting mulch (IRT-76®) was tested at the UAF Agriculture and Forestry Experiment Station and was shown to warm the soil almost as much as clear plastic mulch, while also suppressing weeds. Equal, if not greater, yields were achieved with clear plastic mulch, but only when herbicides were used.

## Cold frames and hotbeds

Cold frames and hotbeds are inexpensive structures for growing cool-weather crops in early spring and fall. Recycled shower doors or windows work particularly well for a cold frame. They range from simple to elaborate. Cold frames rely on the sun for their sole source of heat. Heat is collected when the sun's rays penetrate clear plastic, glass or fiberglass (Figure 1). Hotbeds are heated by soil-heating cables, steam-carrying pipes or fresh, strawy manure buried beneath the plant rooting zone.

In early spring, a cold frame is useful for hardening off seedlings that were started indoors or in a greenhouse. Hardening off is important because seedlings can be set back seriously if they are moved directly from a protected location to a garden. A cold frame provides a place for gradual adjust-

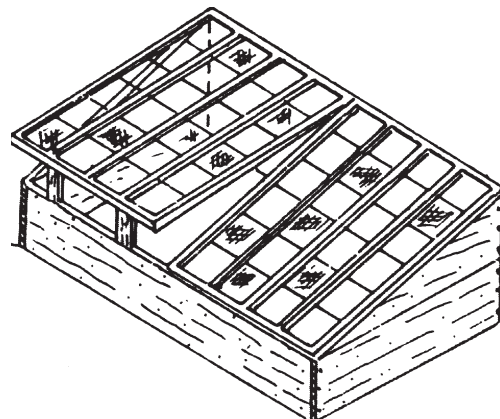


Figure 1.—Cold frame.

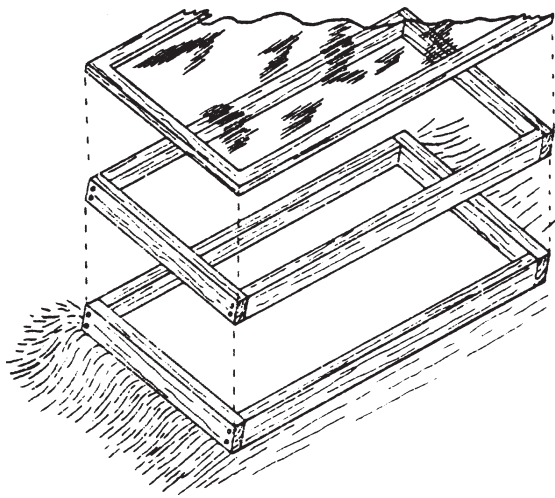


Figure 2.—Dutch light.

ment to outdoor weather. You also can start cool-weather crops right in the cold frame to transplant later to the garden, or you can grow them to maturity in the frame. In the summer, cold frames are useful for growing warm season crops. Annuals can be started in a frame weeks before they can be started in the open. You can replace the soil in a portion of the cold frame bed with a medium suitable for rooting cuttings.

The ideal location for a cold frame is a southern or southeastern exposure with a slight slope to ensure good drainage and maximum light exposure. A sheltered spot with a wall to the north provides protection against winds. Sinking the frame into the ground a bit also provides earth insulation.

To simplify use of the frame, consider a walkway to the front, adequate space behind the frame for removing the sash and perhaps a counterbalance to make it easier to raise and lower the sash. Some gardeners make their cold frame lightweight enough to be moved from one section of the garden to another. Another possibility is the Dutch light (Figure 2), which is a large, but portable, greenhouse-like structure that is moved around the garden.

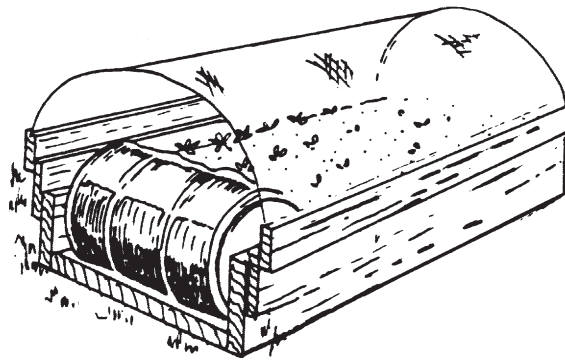


Figure 3.—Solar pod.

New cold frame designs include passive solar energy storage. For example, black containers filled with water absorb heat during the day and release it at night. The solar pod is a design that provides this type of heat storage (Figure 3). Other designs have a very high back and a steep glass slope and are well insulated. They may include movable insulation that is folded up in the day and down at night or during extremely cold weather.

Frames can be built from many materials; wood and cinder block are most common. If you use wood, choose a species that resists decay or one of the new plastic woods. Never use creosote- or pentachlorophenol-treated wood, because these substances are harmful to plants and humans. Kits are available, some of which contain automatic ventilation equipment.

There is no standard size for a cold frame. Size depends on the amount of available space, desired crops, and size of the available covering. Do not make the frame too wide for weeding and plant care; 4 to 5 feet usually is the maximum width. The sash should be sloped to the south to allow maximum exposure to sun.

A simple method of insulation is to place burlap sacks filled with leaves over the

frame at night to protect against freezing. Another method is to stack bales of straw against the frame.

Ventilation is most critical on sunny days when temperatures rise above 55°F. Raise the sash to prevent heat buildup inside the frame. Lower it early enough to conserve heat for the night. An automatic nonelectric lifter is a good investment.

A cold frame can be converted to a hot-bed. For a manure-heated bed:

1. Dig out an area 8 or 9 inches deep (deeper if you need to add gravel for increased drainage).
2. Add an 8-inch layer of strawy horse manure.
3. Cover with 6 inches of good soil.

For an electric-heated bed:

1. Dig out an area 8 or 9 inches deep.
2. Lay down thermostatically controlled electric cable in 6- to 8-inch loops, evenly spacing the cable but never allowing it to cross.
3. Cover with 2 inches of sand or soil.
4. Lay out hardware cloth to protect the cable.
5. Cover with 4 to 6 inches of good soil.

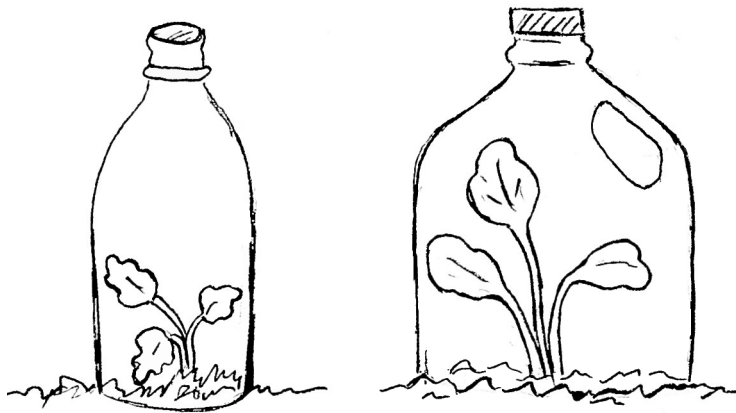


Figure 4.—Cloches made from a cutoff plastic soda bottle and a milk jug.

## Cloches and row covers

Cloches originally were bell-shaped glass jars set over delicate plants to protect them from the elements. The definition has expanded, however, to include many types of portable structures that shelter plants from drying winds and cold air. The idea is to provide a greenhouse-like atmosphere for seeds and small plants in order to get an early start on the season or to extend the fall garden as long as possible.

Cloches are set over individual plants or made into tunnels for whole rows. They trap solar radiation and moisture evaporating from the soil and plants. Cloches generally are lightweight, portable and reusable. The best designs can be closed completely at night to prevent frost damage and opened or completely removed during the day for good air circulation. Make sure cloches are anchored or are heavy enough that they don't blow away.

The hotcap and the ubiquitous cut-off plastic jug are simple forms (Figure 4). More elaborate ones include fiberglass tunnels, special plastic cloches, row covers with slits to allow aeration and panes of glass connected by specially designed hinges to form a tent (Figure 5).

You can quickly assemble an excellent Quonset-type cloche by covering a 4- to 5-foot piece of concrete reinforcing wire with row cover or plastic. The heavy-duty wire comes in 5- and 7-foot lengths. Alternatively, willows or PVC pipe can also be used to build this hoop structure. If you have a raised bed garden, the hoop house can be permanent. If you are planting directly in the ground, rebar can be used to anchor PVC pipe.

Spun-bonded polypropylene is also a popular row cover. It permits passage of air and water, but is substantial enough to trap

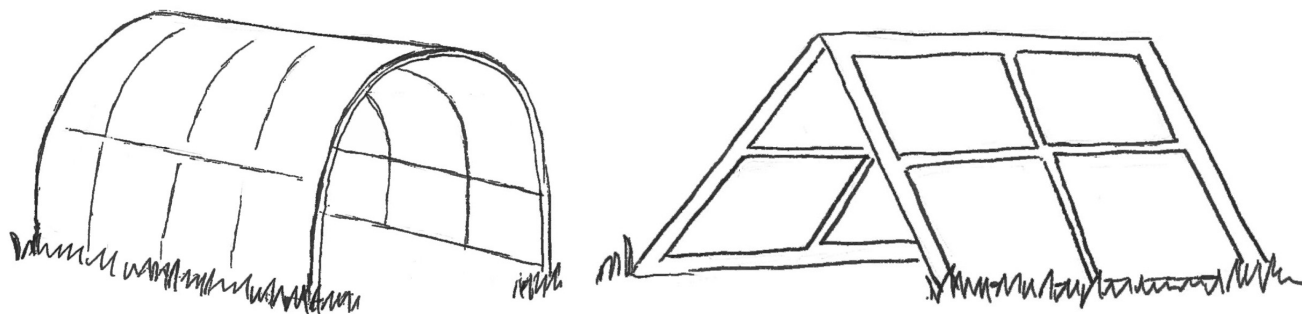


Figure 5.—Season extenders and plant protection methods include plastic and glass.

heat, shield young plants from wind and insects and provide a modified atmosphere for early vegetable crops. Lay these row covers loosely over a planted row in early spring. As the plants grow, they raise the light-weight cover. You can leave these covers on most vegetable plants until warmer weather. These covers also protect turnips from root maggots. Spun-bonded polypropylene fabrics come in different weights, with heavier weights affording greater protection from frost but allowing less light through. These fabrics generally offer between 3 and 5 degrees of protection from frost. They should be anchored with soil, stones or wood (stakes are not ideal as they create a hole in the cloth). With care, this cloth can be used year after year.

### Hoop houses or high tunnels

The next step on the continuum of season extension techniques is a hoop house, which you can walk through, or a high tunnel, which you can drive a tractor through. Crops are almost always planted directly in the ground in these structures. Hoop houses or high tunnels can be a pleasant place to

work on a rainy day, are inexpensive and simple to build, offer increased reliability, can decrease disease, weeds, and pest incidence, and increase yield and quality of warm season crops. However, in contrast to greenhouses, these light-weight structures can be easily damaged by snow or wind, so they must be well anchored. They can also be more labor intensive because they often lack automated ventilation or heating systems. An advantage for commercial growers is that since high tunnels are not considered permanent structures, they are not taxable.

Hoop houses can easily be built from PVC pipe, white spruce poles or willows. An easy, inexpensive way to make a hoop house is by converting carport structures. Hoop house or high tunnel kits, usually made from bent metal pipe (galvanized steel), can also be ordered. Special high tunnel kits come with a fancy wire called “wiggly wire.” This wire is designed to hold the visqueen on without tearing holes in it. A double-walled high tunnel, with a fan to maintain air space in between the layers, is an inexpensive way to insulate a hoop house; however, this decreases light penetration to some degree.

## Greenhouses

Greenhouses, although generally more expensive than other season extension techniques, provide the greatest degree of control. Because they are permanent, greenhouses can more easily be insulated and heated, if desired. Automatic ventilation systems can also provide increased reliability with relatively less labor. In Alaska, greenhouses are used to start seeds in the spring, grow crops such as tomatoes and cucumbers and provide the perfect environment for beautiful hanging baskets. Some growers use greenhouses year round to grow crops hydroponically using geothermal heat. Greenhouses are broadly categorized as attached or free-standing.

### 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, and they may provide solar heating and add an insulation layer to 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. Compared to a freestanding greenhouse, site location may not be the sunniest space in the yard. Another disadvantage is that greenhouse moisture, summer heat, dirt, insects and chemical odors may enter the home.

### Freestanding greenhouses

Freestanding greenhouses isolate greenhouse activity from the home and offer more flexibility in greenhouse size, shape and configuration. They can be constructed in the best location on the property for light interception, drainage and wind protection. 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 house usually has higher heating costs than the attached house. It has more exposed surface, leading to greater heat loss. The freestanding greenhouse also has a higher initial construction cost than the attached greenhouse since it requires an extra wall and service line installation.

### 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 (Figure 6). 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 drawback of the A-frame style is that it limits both house width (and therefore size) and headspace within the structure.

It is more awkward to work in an A-frame house than in other styles of greenhouses, and flats are often grown on the ground due to the lack of head space. Soil temperatures may remain cold in a greenhouse and lag well behind air temperatures,

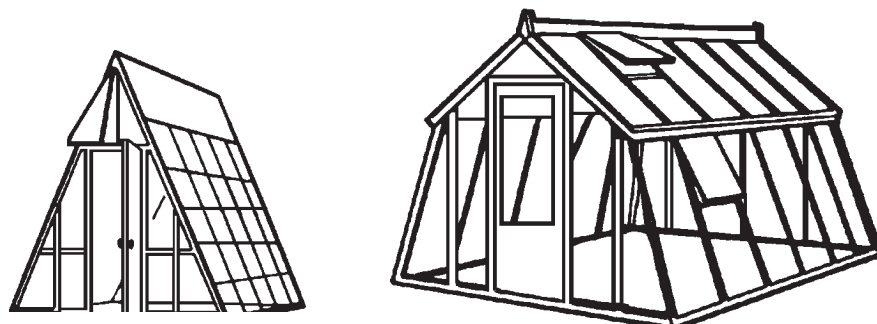


Figure 6.—A-frame and slant-leg greenhouses.

so if the roots of plants placed directly on the ground are cool, growth may be restricted 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 roofline 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 angle determines how well snow slides off, as well as the total height of the structure. The well-defined roofline is adaptable to efficient roof-ventilation systems. Frames are constructed from both metal and wood. The

gable style provides considerably more headspace than an A-frame or Gothic arch and has much more room for growing hanging plants above benches. Gable greenhouses can be covered with poly-

ethylene 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 (Figure 6). 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, with the result that slant-leg houses are very sturdy and suited for locations with heavy snowfall and thunderstorms.

### 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 can have lower heating and cooling costs, since the earth acts as insulation to keep 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.

## Greenhouse benches and beds

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 you 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 an arm's reach in width. When a bench is accessible from both sides it can be twice as wide.

Benches can be 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 top. Greenhouse bench tops 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. Greenhouse bench materials should be light-colored (or painted white or aluminum) to reflect light and maximize light interception by plants.

Plants can also be grown directly in solid bottom benches with sides that are filled with 4–6 inches of growing medium. This

type of bench is commonly used for plant propagation, where cables can be buried for bottom heat and mist nozzles installed above.

Plants can be grown in solid bottom benches to maturity, depending on their size and rooting depth. They are frequently used commercially for growing cut flowers. In addition to efficient bench layout, the creative use of racks, shelves and overhead hanging plants can take advantage 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 and hoop houses. Beds are often raised and about 3 feet wide; the soil must be 8 to 12 inches deep. Ground beds may be loosely mounded or enclosed within a wooden frame. Plant culture is similar to raised-bed gardening out of doors.

## 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, paying attention to where underground lines must be run to freestanding greenhouses.

## Ventilation

Ventilation systems promote airflow through a greenhouse and help control both temperature and humidity. The importance of managing temperature and humidity in greenhouses is discussed in more detail in the UAF Cooperative Extension Service publication, *Controlling the Greenhouse Environment*, HGA-00136.

## Heating

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 many gardeners provide supplemental heat during spring or fall cold spells with portable gas and electric heaters. 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 the 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.

## Popular greenhouse crops in Alaska

### Tomatoes

Because tomato pollination and fruit set depend on a greater degree of temperature control than many crops, it's best to grow them in a greenhouse. Optimal temperatures for tomatoes range from a minimum of 60°F during the night to no more than 80°F during the day. Humidity levels of 70 percent are optimal for tomatoes.

### Cucumbers

Cucumbers are sensitive to temperature, humidity, light, carbon dioxide, moisture and fertilizer salts. Optimal temperatures for cucumbers range from a minimum of 65°F and 70° to 75°F. Humidity levels of 70 percent are optimal.

For greater detail on growing these popular crops in greenhouses, refer to UAF Cooperative Extension Service publications *Cucumber Production in Greenhouses*, HGA-00434, and *Greenhouse Tomato Production*, HGA-00435.

## Glazing and covers

Glazing is the light transmitting material used to cover season extenders or greenhouses. Many high-quality glazing materials are available, but they vary in their strengths and weaknesses. Important properties to consider when selecting a glazing are light transmission, heat retention, durability, longevity, maintenance requirements and cost.

### **Plastic film**

Plastic film glazing is lightweight, very flexible and the least expensive type of greenhouse covering. A single layer has high light transmission, but also high heat loss in cold weather. Many hoop houses have a double layer of plastic with an insulating layer of air between them. This reduces light transmission by about 10 percent, but 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, compared to other plastics that will only last 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+ 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. Older greenhouses had overlapping panes with a bed of glazing compound and sealant. 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 glazing, but the sheets have enough flexibility to bend around gently curved surfaces such as the Gothic-arch greenhouse. It has high light transmission, low maintenance, is very strong yet lighter than glass and is a fire retardant. Polycarbonate is available in single- and double-layer sheets. As with other glazing materials, 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 for greenhouse glazing 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.

## Watering systems

### *Season extenders and greenhouses*

#### **Hand watering**

Most home greenhouses are watered by hand with a hose and suitable nozzle. One advantage of hand watering is that it gives the gardener time to look at every plant and evaluate its condition. It is also easy to adjust watering to be able to apply different amounts of water to different plants. However, as greenhouse size and number of plants increase, hand watering becomes time-consuming compared with other methods.

#### **Drip systems**

Drip irrigation systems or soaker hoses are efficient for watering when using season extenders. In greenhouses, drip systems can be individual capillary tubes for each pot or drip tape for ground beds. Drip irrigation is very efficient in water use and keeps the non-plant areas dry so that you can work around plants while they are being watered. Drip systems require close observation to be sure they are working correctly and need maintenance 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 to a large number of pots.

#### **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 grower 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.

#### **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 the non-growing areas. Also, wet foliage and higher humidity levels increase the potential for plant disease. Overhead sprinklers are sometimes used in high tunnels, but more frequently in greenhouses.

#### **Greenhouses only**

In addition to the previously mentioned watering systems, the following techniques work well for greenhouses.

#### **Capillary mats**

Capillary mats water plants from below. They are 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.

### 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 bench top of an 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 central part of the entire growing system for plants grown hydroponically. The water supply is built into other aspects of plant culture. 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 and free of disease and provide a steady supply of nutrients to plants. Hydroponic systems require more monitoring time, more attention to their operation and more mixing and adjustment of nutrient solutions, thereby adding to the system complexity.

## Natural ventilation

### Season extenders and greenhouses

Natural ventilation generally provides adequate air exchange for season extenders and small greenhouses. 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.

Natural ventilation requires 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. Solar-powered levers that sense the temperature can be invaluable in cutting down the stress of manually ventilating a hoop house or greenhouse.

### Greenhouses only

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.

## Pollination

When covering crops that flower and fruit, it's important to consider how they will be pollinated. For



crops such as strawberries, opening and closing row covers with clothes pins or another mechanism is one way to provide access to pollinators. This is also easily done with hoop houses or high tunnels. Planting flowers on the ends of hoop houses or high tunnels or even inside can be a way to draw in pollinators. For more information on encouraging beneficial insects in your garden and season extenders or greenhouses, see UAF Cooperative Extension Service publication, *Beneficial Insects and Spiders of Alaska*, PMC-10075. Pollination for tomatoes in greenhouses is often simulated by shaking the plant or

by buzzing them with an electric buzzer intended for such use. Seedless cucumbers do not require pollination although seeded varieties do. In a greenhouse, female flowers should be manually pollinated with a male flower.

## For more information

### UAF Cooperative Extension publications

- Growing Everbearing Strawberries as Annuals in Alaska*, HGA-00235.  
*Beneficial Insects and Spiders of Alaska*, PMC-10075.  
*Controlling the Greenhouse Environment*, HGA-00336.  
*Cucumber Production in Greenhouses*, HGA-00434.  
*Fluorescent Lights for Plant Growth*, HGA-00432.  
*Greenhouse Tomato Production*, HGA-00435.  
*Greenhouses for Home Gardeners: Structures and Equipment*, HGA-00337.  
*Plastic Mulch and Row Covers for Vegetable Production in Alaska*, FGV-00647.  
*Plastic Mulch and Row Covers for Vegetable Production in Alaska* (DVD), HGA-01268.  
*The Attached Solar Greenhouse*, EEM-01259.

### UAF School of Natural Resources and Agricultural Sciences

- Growing Fresh Vegetables; Midnight Sunlight and the Earth's Warmth*, SNRAS/AFES Misc. Pub. No. MP 09-10.  
 Matheke, G.E.M., P.S. Holloway, and P.J. Wagner. April 1991. *IRT-76® Polyethylene mulch film and growth of sweet corn in Fairbanks, Alaska*. Number 25. Research Progress Report.

### Other publications

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*High Tunnels*  
 High Tunnels.org and [www.hightunnels.org](http://www.hightunnels.org)  
*Planning and Building a Greenhouse*  
 National Sustainable Agriculture Information Service: <http://attra.ncat.org>

