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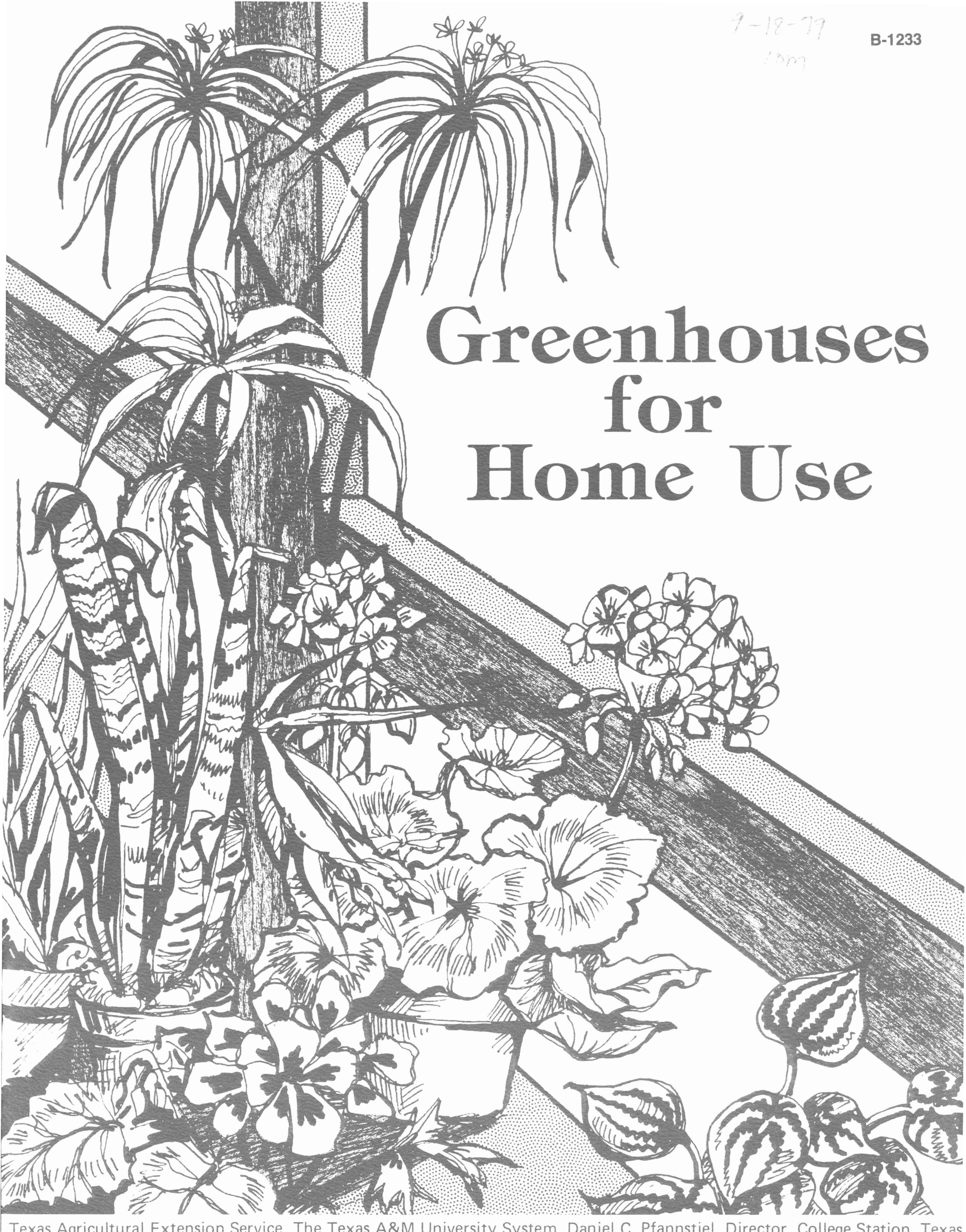
Greenhouses for Home Use



Texas Agricultural Extension Service, The Texas A&M University System, Daniel C. Pfannstiel, Director, College Station, Texas

CONTENTS

A greenhouse can be useful by turning winter into springtime in a small but productive backyard space. One can grow many vegetables which are ordinarily bought, grow plants for an early garden, protect container plants for carry over and rejuvenate hard-to-grow house plants.

Greenhouses for Home Use

John E. Larsen and William S. Peavy*

LOCATION

If there is a choice, a southern or southeastern exposure is best for maximum light penetration especially when a wide variety of plants are to be grown including vegetables. A northern exposure is suitable for producing only plants requiring low light.

Good drainage is needed for the greenhouse area. When necessary build up the site above the surrounding area so that rainwater will drain away.

Consider how the greenhouse will blend with the home and yard. It should enhance rather than detract from the landscape. If the greenhouse may be enlarged in the future, choose an area that will allow for expansion.

Trees near a greenhouse can be a problem. Deciduous trees, however, lose their leaves in the fall and allow sunlight to pass onto the greenhouse. Trees with leaves can help cool the greenhouse. A tree to the west of the greenhouse can provide beneficial shade from hot afternoon sun.

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*Extension plant nutrition specialist-greenhouse vegetable production, and county Extension horticulturist, The Texas A&M University System.

SIZE

Consider the time required to manage the greenhouse, the plant growing area needed and the work aisle requirements when deciding upon size. Small 6 x 6-foot to 6 x 8-foot greenhouses have about half the space taken up in aisles. Energy costs for heating and cooling small greenhouses are higher in proportion to the floor space than for larger greenhouses. With automatic equipment a greenhouse from 10 x 10 feet and up to about 300 square feet can be managed in a few hours per week.

The reach-in, window-mounted units are small, practical greenhouses when only a few pot plants are to be grown or a flat or two of plants are to be propagated for the garden (figure 1).

STRUCTURES

Greenhouses can be attached to a building or freestanding (figure 1 and 2). By sharing a wall with the home an attached greenhouse uses less heat than a freestanding one with the same floor area. To receive maximum light, an attached greenhouse should share a south wall of the home or a building.

Freestanding greenhouses vary more widely in shapes and styles than attached ones. Conventional gable roof greenhouses have been replaced to some extent by octagon, round, quonset, Gothic arch, dome and A-frame as well as other shapes. If long range plans might include expansion of the greenhouse, consider a shape that can be enlarged.

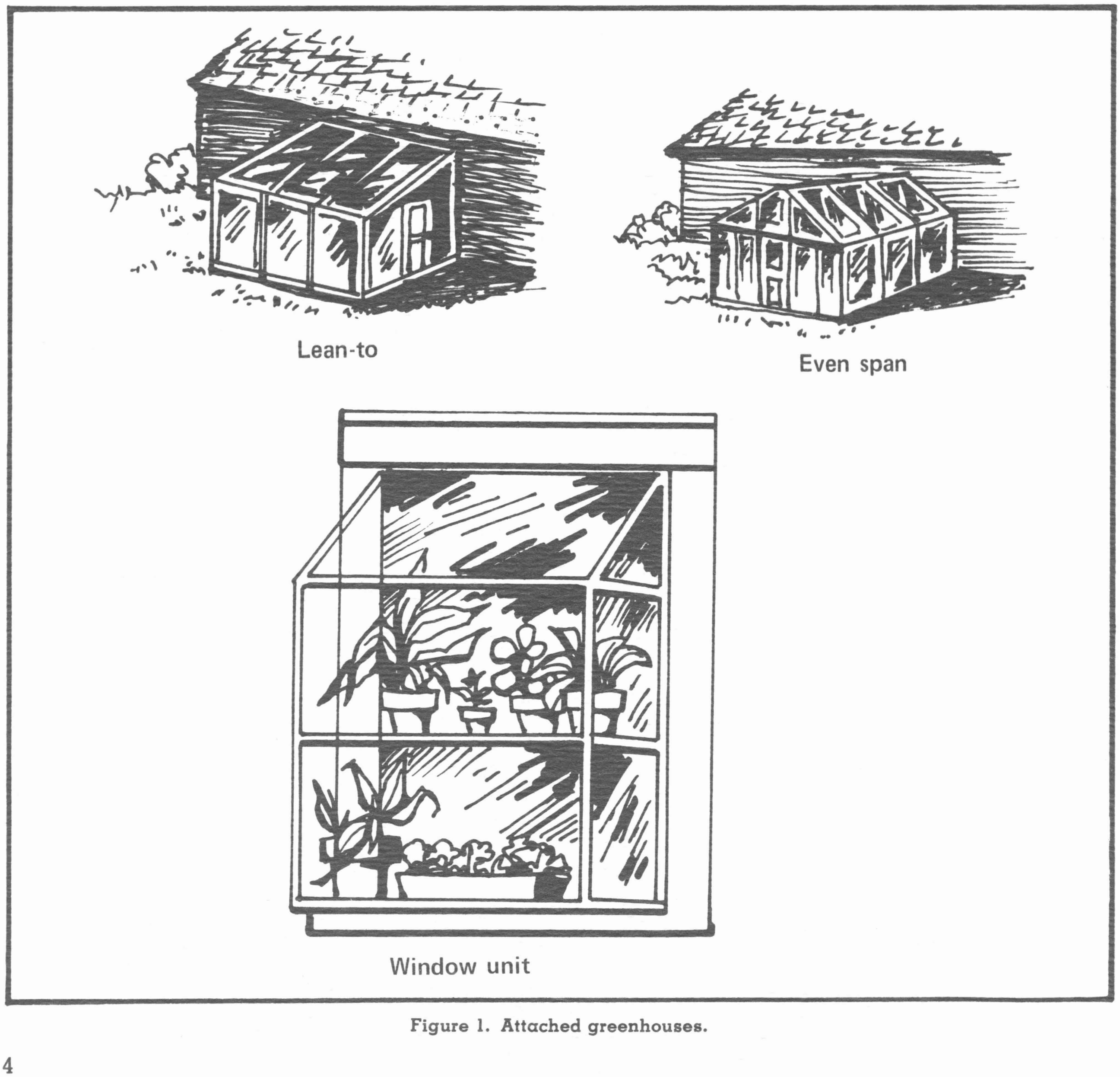

Figure 1. Attached greenhouses.

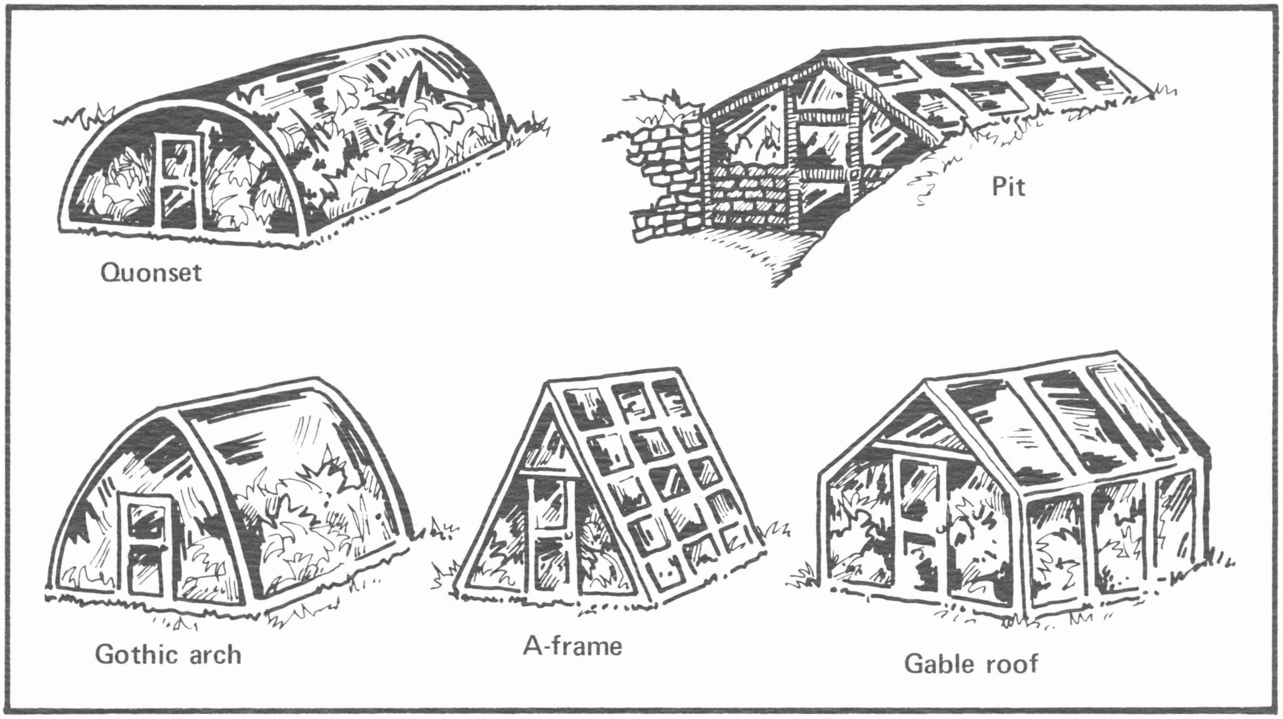

Figure 2. Free-standing greenhouses.

A storage area for tools, pots, fertilizers, chemicals, etc. and a work room for mixing growth medium, seeding, transplanting, etc. is almost a necessity for a greenhouse. It can be separate or connected to the greenhouse. When connected to the greenhouse, locate it on the north end to avoid casting its shadow on the plant-growing area. Also the wall between the two should be tight to prevent passage of moisture which can rust tools and spoil chemicals.

STRUCTURAL MATERIALS

Greenhouses were traditionally covered by glass placed on redwood or cypress sash bars which usually were supported by galvanized steel structural members. Aluminum has largely replaced the wood sash bars and often is used in place of galvanized steel for the structural members in manufactured greenhouses.

Using their own design many people build their own greenhouses from salvaged materials with wood as the framing members. Redwood and cypress are good materials for structural framing and for building benches on which to place containers for a more convenient working height. Treat other types of lumber with a salt-type preservative or copper naphthenate to prevent rot. In addition paint structural members with a good grade of exterior white, mildew-resistant paint for reflecting the light down to the growing area and for sealing in the preservative. When closed, a greenhouse generally is a high humidity chamber conducive to deterioration of untreated wood. Some small greenhouses are manufactured with white PVC pipe for the structural members. Like aluminum and galvanized steel, no preservative is necessary on the PVC pipe.

COVERINGS

Materials commonly used for covering greenhouses are glass, polyethylene film and fiberglass reinforced panels (FRP). While glass is the traditional material, it is expensive, requires a better type of structure than that for other materials, can be broken easily and when broken is difficult to clean up.

Regular polyethylene normally lasts only one winter if applied in the late fall. Polyethylene with UV (ultraviolet radiation) inhibitor may last almost a year. Greenhouse grade M602 polyethylene normally lasts 2 years when applied so that it does not flap in the wind.

Greenhouse grade vinyl film usually lasts 2 or 3 years. Install it so that wind causes little movement of the film. It splits more readily than polyethylene if allowed to flap in the wind. It can, however, be repaired readily by gluing on a patch.

Greenhouse grade FRP is about as expensive as glass. The best quality FRP has Tedlar coating or extra acrylic resins on the exposed surface and should last 10 years or more. Colored panels and those not made for greenhouse use are not recommended. Ordinary FRP darkens rapidly with age.

The acrylic (plexiglass) panel, although expensive, is an excellent material, glass clear and resistant to weathering and breakage. A double acrylic panel provides about 40 percent savings in heating costs over that of a single panel.

Use polyethylene with most glazing materials for a second layer covering to provide 30 to 40 percent savings in heating costs. Allow from 1 to 4 inches between the existing cover of glass, fiberglass or other material and the polyethylene for best insulation effect. Many commercial greenhouses employ two layers of M602 polyethylene fastened to the house so that the edges are sealed. A small blower creates a dead air space by forcing air between the layers. The film becomes essentially a rigid covering and moves little in the wind whether installed on small or large greenhouses. Usually a relief valve must be installed near the blower to prevent excessive pressure on the film when a blower is used that is capable of exerting static pressure of about a 1-inch column of water. About 0.4 inch of static pressure is satisfactory to prevent most wind movement on the top film layer.

VENTILATING AND COOLING

During bright sunny days a greenhouse can become too warm for most plants even when the outside temperature is near or below freezing. Cooling a greenhouse should be automatic since frequent checking of manually controlled vents and fans is required to prevent plants from getting too hot or cold. Thermostatically controlled fans or blowers in conjunction with evaporative coolers eliminate manual work and are the best way to ventilate and cool a greenhouse. Introduce air from the blower above the tallest plants. Plants can become chilled and wilt as a result of direct cold air drafts.

For maximum air flow exhaust the air from an evaporative cooler through an air escape vent three or more times the size of the outlet from the blower. To obtain the most uniform cooling, the air when introduced high in the greenhouse should escape near the floor level. Experience has shown the escape vent should be located on the same side from which the air is introduced (figure 3). Use a lightweight louver, hinged at the top and opening to the outside, to close the air escape vents. Pressure

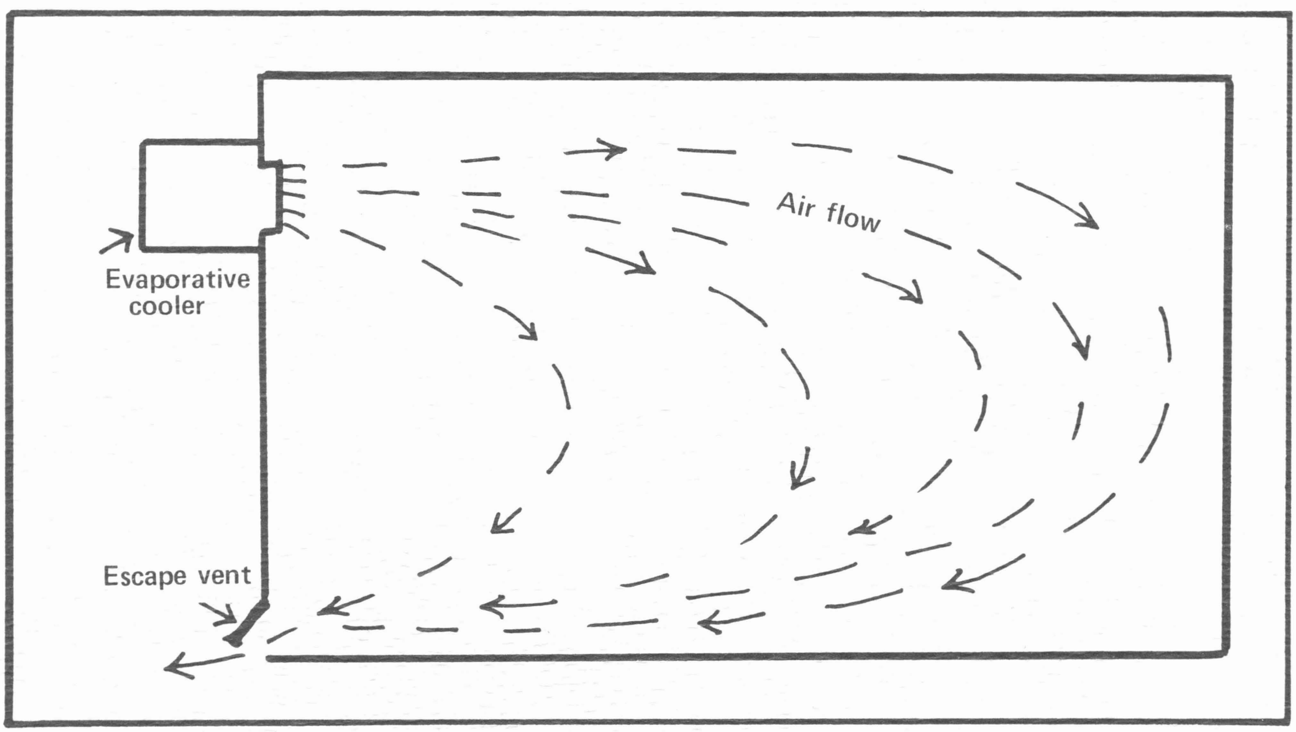

Figure 3. Cooling and ventilating.

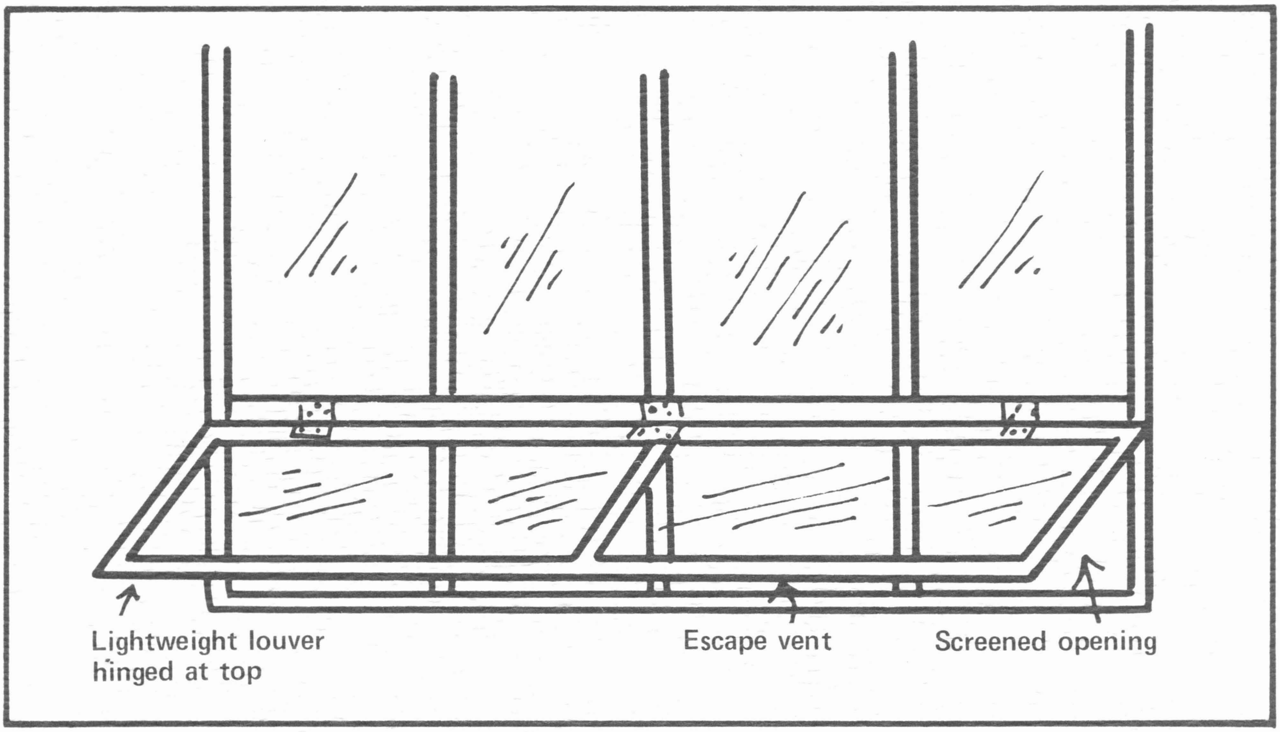

Figure 4. Louvered escape vent.

from the incoming air forces the louver to open automatically. Use magnetic cupboard door latches to keep the louver tightly closed and yet allow it to open readily from the air pressure created by the fans or blowers. Screen the outlet vent against rodents and most insects.

Evaporative coolers are sized by the volume of air flow given in CFM (cubic feet per minute). The air flow from a cooler should exchange the entire volume of the greenhouse one and one-half times per minute for maximum cooling. Most ratings of evaporative coolers are given in CFM of free-air flow; however, the rating in CFM of free-air flow is about one-sixth less in a greenhouse because of the static pressure created by restricting the air flow through the exhaust vent and the cooling pad. For example, a 10 x 10-foot greenhouse contains about 800 cubic feet. To offset the static pressure, consider the contents about one-fifth greater (800 +800/5 × 960 cubic feet). A small evaporative cooler on the market with a fan instead of blower has a rating of 2,400 CFM. Thus, the 2,400-CFM cooler should be able to exchange the air more than two times per minute.

During the winter it is desirable to have less frequent change of air in the greenhouse than 1½ to 2 times per minute. With bright weather, the outside temperature can be in the 30° range while inside the greenhouse it may be 85°. Thus, it requires relatively little cold air to bring the greenhouse temperature down to 75° to 80° which may be the desired temperature for plants. Therefore, while an exchange of air at 1½ times per minute is desirable for summer cooling, less than one exchange per minute is better for winter ventilation. Thus, a two-speed motor is best for driving the fan for all-purpose ventilating and cooling, with the low speed used for the first phase of ventilation during winter (figure 3).

For example, during sunny winter days when the greenhouse warms to a thermostat setting of 70°, the low speed of a two-speed motor is activated. Cool air is blown into the greenhouse above the plants, mixing with the warm air. Then it is exhausted out the vent at floor level (figure 4). When the air at the thermostat has cooled to about 68°, the fan turns off, again allowing the greenhouse to warm to about 70° when the cycle is repeated.

If the temperature continues to climb inside the house to 80° with the low speed fan operating, a second thermostat wired in conjunction with the first changes the low speed to high speed and activates the pump which circulates water through the cooling pad. During winter, to prevent freeze damage to the water lines and pump, the water is normally drained and the pump disconnected with only the high speed fan allowed to operate for maximum cooling.

One two-stage thermostat can be used; however, the factory setting is normally 3° between the first and second stage. To obtain a 10° difference between low and high speed fan operation, use two two-stage thermostats wired properly.

When a single speed motor is used to drive the fan or blower, the cooling is rapid during winter weather, with frequent on and off cycling of the fan. Also the temperature drop in the greenhouse can be more than desirable before the thermostat has time to adjust to turn off the motor.

Maximum cooling is obtained with the high speed fan and water circulated through the cooling pad. Whether the greenhouse is cooled sufficiently during hot weather is determined by the relative humidity of the outside air. The lower the relative humidity, the cooler the greenhouse will be. In general, West Texas has much lower relative humidity than does East Texas and the Gulf Coast area. However, the relative humidity is generally the lowest in the heat of the day when the most cooling is desired. Evaporative coolers normally lower the greenhouse temperature to or below the outside temperature in most areas of Texas. Obtain additional cooling by applying some type of shade material on the outside of the greenhouse covering to block and reflect some of the solar radiation.

Most commercially available shade fabrics are black or dark green. Dark fabrics are not as desirable as those which are white or light colored. Dark colors absorb the heat which is then reradiated, with about half being radiated into the greenhouse. A white material which gives the same percentage of shading as a black material maintains a cooler greenhouse because much of the solar radiation is reflected rather than absorbed by the fabric.

A white shade material readily available is white wheat flour and water mixed to a consistency for spraying or brushing on the greenhouse covering. Another shade material is white exterior latex paint that is diluted with 20 to 30 parts of water. While this material has excellent sticking ability, it requires brushing with detergent and water to remove it in the fall when more light is needed. A whitewash made with hydrated lime and water is difficult to remove except with a muriatic acid solution. Acids can be harmful to aluminum and galvanized metal. Some commercial shading compounds also are difficult to remove. White bed sheeting, muslin and cheese cloth have been used, but are difficult to anchor against the winds when installed over the top of the greenhouse. A shade fabric material applied inside the greenhouse is not as effective as when applied over the top unless it is applied directly against or within an inch or two of the greenhouse covering.

HEATING REQUIREMENT

Formulas satisfactory for calculating the heating requirements are given for a single layer covering (1.2 BTU's per hour per square foot of exposed plastic area per degree temperature differential) and for a two-layer covering (0.8 BTU per hour per square foot of exposed plastic area per degree of temperature differential).

Temperature differential is the difference between the desired temperature inside the greenhouse and the temperature outside. Therefore to calculate the temperature differential one must know the lowest temperature which normally occurs every year in a particular area. For example, in the Bryan-College Station area the normal lowest temperature is 20° even though in the past 10 years the temperature has dropped twice below 20°.

A 10 x 10-foot greenhouse with 7-foot eaves and about 11 feet over the gable roof from eave to eave gives about 400 square feet of exposed area. If 63° is the desired inside temperature and 15° is the normal lowest temperature in a given area, the heating requirement for a single layer plastic covering is 1.2 times 400 times 48 (63 – 15) or 23,040 BTU's per hour. For a double layer plastic covering the heat requirement is 0.8 times 400 times 48 or 15,630 BTU's per hour.

The high cost of energy for heating makes a double layer covering desirable since the formula shows a greenhouse with a double layer covering has a heating requirement one-third less than a single layer covering. Actually, a double layer covering saves up to 40 percent when the two layers are from 1 to 4 inches apart. Apply 2- to 4-mil polyethylene lining on the inside of a wood frame greenhouse by stapling the film to the structural members. For greenhouses with metal framing, clip the plastic liner to the metal with spring-type clothespins or plastic tape. Or support by wires stretched from the corners and below the roof purlins. Then clip the seams together with clothespins or similar-type clips.

HEATING

Most home greenhouses in Texas are heated with gas (LP or natural gas) or electricity. A few home greenhouses connected to the residence share the central heating system of the home. Electric heaters do not require a vent pipe and are therefore 100 percent efficient for the power input. Electric heating is the most costly of the types used. Table 1 gives the approximate cost comparison of three fuel sources.

Table 1. Energy comparisons

Electricity	1 KWH (1,000 watts)	3,413 BTU
Natural gas	1 cubic foot	about 1,000 BTU
Propane	1 gallon	91,000 BTU

Electricity - no venting required or desirable
Gas heaters - should be vented. Most gas heaters are about 80 percent efficient.

Cost comparison of 1,000,000 BTU of usable heat

Electricity	293 KWH	@ $ .05/KWH	$14.65
Propane	13.75 gallons	@ $ .40/gallon	$ 5.50
Natural gas	1,250 cubic feet	@ $2.00/1,000 cubic feet	$ 2.50

For best heat distribution, use a fan behind the heat exchangers with moveable deflectors in front to distribute the heated air uniformly in the greenhouse. When benches are employed, place the heaters beneath the benches when space is left between the benches and the greenhouse side to allow air to circulate around the greenhouse walls. Place benches with welded wire fabric or hardware cloth instead of wood slats directly against the wall since the wire does not impede air circulation. If benches are not used, hang the heaters from the roof. With two heaters a circulation pattern is caused when a heater is used in each end of the greenhouse but on opposite sides (figure 5).

ELECTRIC HEATING

A 10 x 10-foot greenhouse requires about 23,000 BTU's per hour for a low outside temperature of 15°. Since a 1,000-watt heater furnishes 3,413 BTU's per hour (table 1), the 23,000-BTU requirement would be supplied by a 6,700-watt heater (23,000/3,413 × 6.7 KW or 6,700 watts). If electric heaters are not available in the size required, use two or more of a particular size. Commonly available heaters are 1,650 to 5,000 watts with some in combinations such as 2,000 and 4,000 watts. Connect two heaters to one stage of a two-stage thermostat and the other two to the second stage. When the night temperature drops sufficiently, two heaters are turned on by the thermostat and cycle on and off until the temperature drops sufficiently so that these heaters operate constantly. As the temperature drops further in the greenhouse the second stage of the thermostat is activated

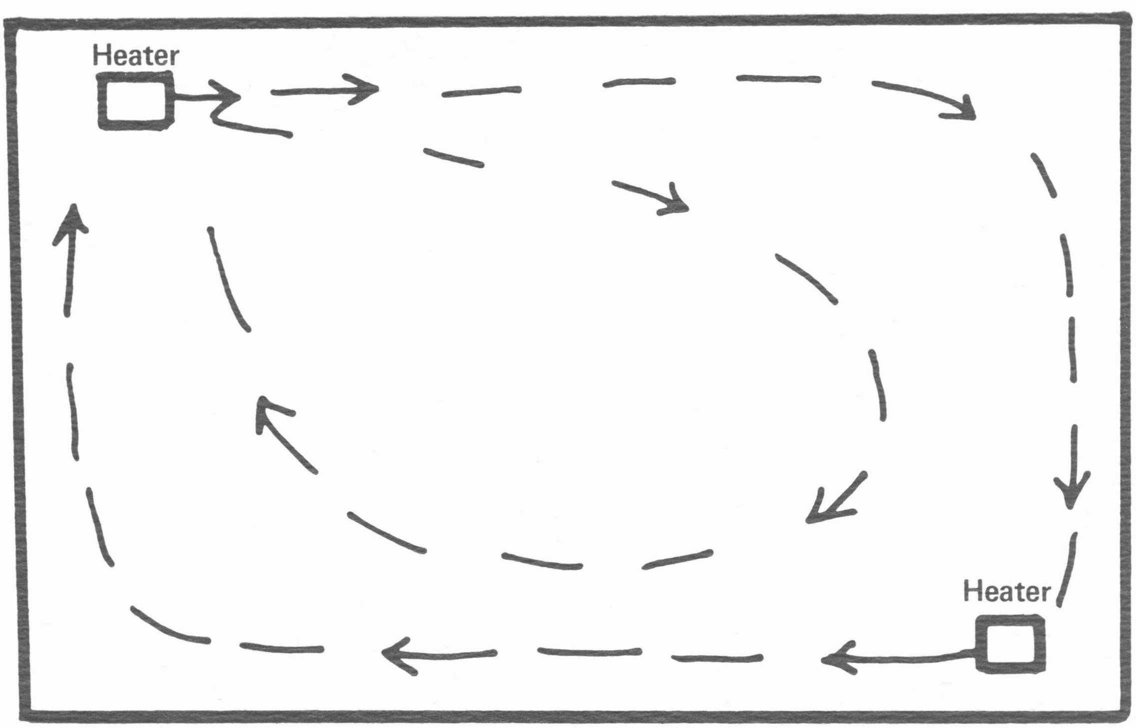

Figure 5. Floor plan showing circulation pattern with two heaters.

and the second two heaters turn on. The second two will cycle on and off until all four heaters no longer heat the greenhouse to the second stage thermostat setting when all four run constantly.

Extension cords are not satisfactory for use with electric heaters. Use adequate wiring to carry the load for the distance involved. Install a switch box with circuit breakers inside the greenhouse.

GAS HEATING

Gas heaters are available from about 10,000 BTU's for small bathroom-type ceramic heaters which require no venting to 20,000 BTU's and larger which require venting for greenhouse use and fans for circulating the heat. When the bathroom-type heaters with ceramic plates are installed in the correct upright position, the ceramic plates become red hot and give complete combustion of the gas to mainly carbon dioxide and water vapor. Normally, no undesirable, incomplete combustion products such as ethylene are given off from such heaters. Ethylene in very small amounts causes 2,4-D herbicide-type damage to many plants. However, these unvented heaters cause water vapor which condenses on the inside surface of the greenhouse covering and may cause undesirable dripping of water on plants. Regardless whether the heaters are vented or not, some opening to the outside must be provided for fresh air to be admitted to replace that used in combustion of the gas. As a rule of thumb provide 1 to 2 square inches of free opening to the outside for each 3,000-BTU input of a gas heater.

When any space-type heater is used without an attached mounted fan, locate a small electric fan above the heater near the roof to circulate the heat in the greenhouse.

A disadvantage of space-type heaters without thermostatic controls is that one must ad-

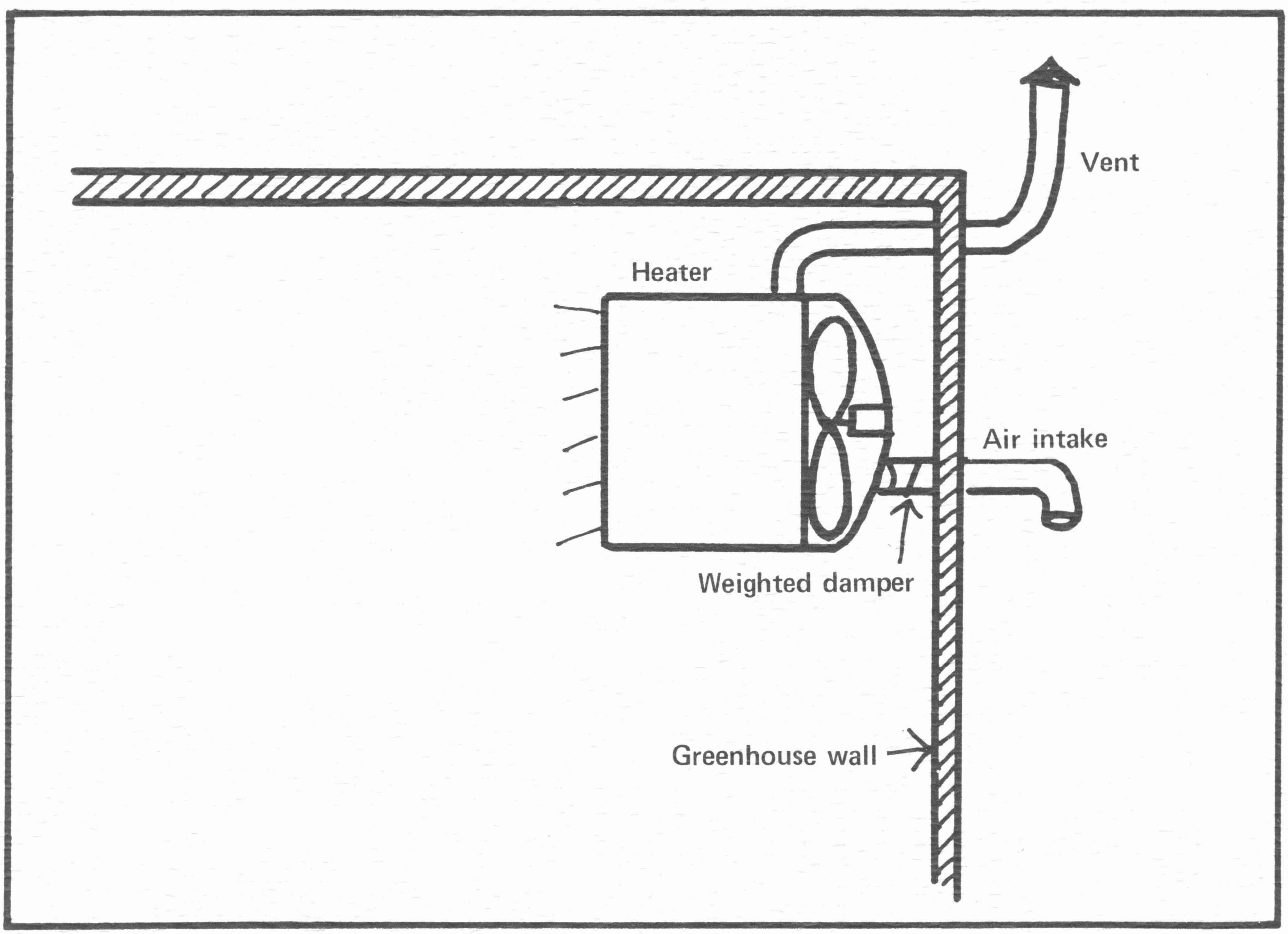

Figure 6. Automatic fresh air intake.

just the heater for the anticipated temperature each night.

Most gas heaters are from 70 to 80 percent efficient; therefore a heater rated as 20,000-BTU input provides a maximum of 16,000-BTU output in the greenhouse. The difference between the BTU input and output is lost out the heater vent.

A method to save heat and admit fresh air into the house without any free opening to the outside is shown in figure 6. A downspout pipe with a slightly weighted damper inside the pipe is installed with one end behind the heater where the fan is located and the other end through the greenhouse wall with an elbow attached. When the heater fan turns on, a vacuum is created in the pipe which automatically opens the damper. Fresh air enters through the pipe and causes sufficient pressure in the greenhouse to push the combustion products out the heater vent pipe.

HUMIDIFICATION

Some plants such as tropical foliage plants and orchids grow best at relatively high humidities. The humidity increases automatically when an evaporative cooler is operating. However, during the heating season greenhouses can become quite dry with low relative humidity. In dry climates place pans of water on the floor and under the benches to increase the relative humidity or obtain automatic humidifiers from greenhouse supply companies if desired.

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