Fact Sheet 633

Hotbeds and Cold Frames for Starting Annual Plants

For gardeners who like to start their own vegetable or annual flowering plants in the spring, either a hotbed or a cold frame can be a useful investment. Plants can be started outdoors in the spring and grown to transplanting size by the time the garden is ready. The cold frame is simply an unheated translucent structure that gives protection to the plants from wind, rain, and, to a limited extent, cool temperatures. It is not heated, but an insulated cover can be used on cold nights to retain heat. Solar radiation from the sun warms the air and soil during the day. The hotbed has a source of heat built into the structure. In earlier models, decomposing manure provided the heat; now, however, electric heating cables and other fuel sources are used. The hotbed extends the useful growing season: plants can be started while outside temperatures are still below freezing. Either of these structures can replace the home greenhouse for many outdoor gardeners. This publication describes how to build these structures.

Location

Hotbeds and cold frames (Figure 1) should be located in a protected place with a southern exposure to receive the maximum amount of sunlight. (A lack of good sunlight can result in leggy plants, stretching in search of light.) They should be close to a source of water and to electricity if they are electrically heated or lighted. A building or other windbreak on the north or windward side will help to reduce the operating cost. The site should have good, natural drainage to remove excess moisture from the soil under the structure.

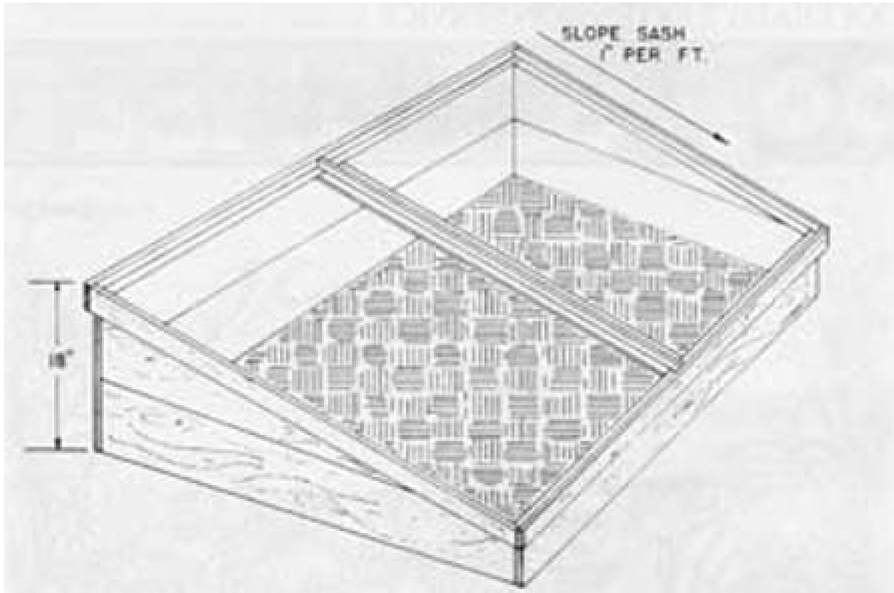

Figure 1. Typical wooden hotbed or cold frame.

Size

The size will depend on growing space needs, available building material sizes, and other factors. It will depend on your planting scheme: kind of plants, number of plants, and spacing between plants and plant rows. The width should allow easy access from one side and, therefore, may be limited to 3 feet for convenience. For the average home garden, a 3- by 6-foot size should be adequate (Figures 2-5). For a larger garden and for starting plants to sell, use a 6- by 6-foot size (Figures 6-9). If more space is needed, enlarge in intervals of 3 by 6 feet so that a standard 3 by 6 sash can be used on top. A width of 6 feet works well for larger units, but the gardener must step into the frame to get full access to all plants. Planning on paper to get an indication of space requirements is a good idea.

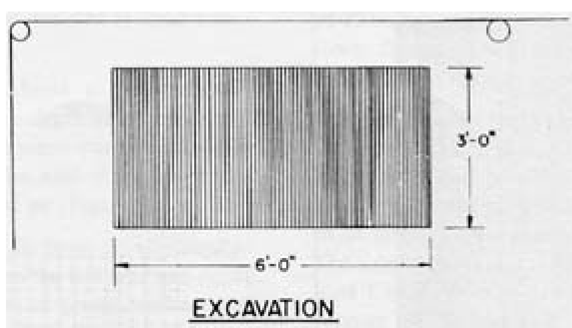

Figure 2. Wooden 3- by 6-foot frame for the average home garden.(Excavation)

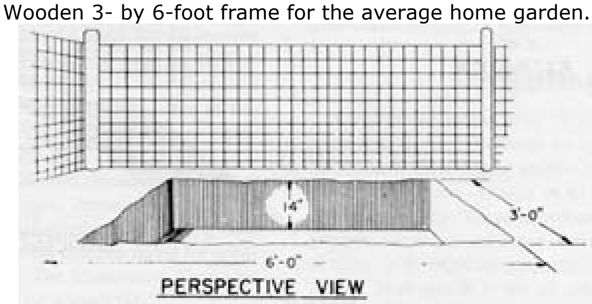

Figure 3. Wooden 3- by 6-foot frame for the average home garden.(Perspective View)

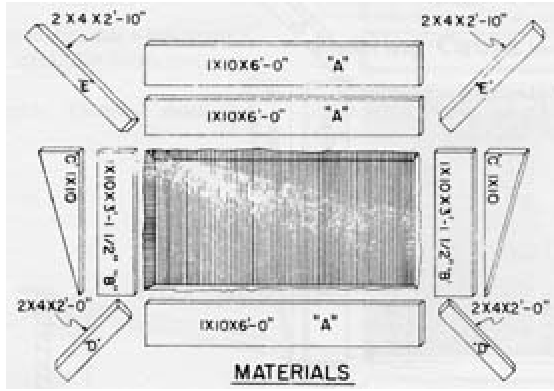

Figure 4. Wooden 3- by 6-foot frame for the average home garden.

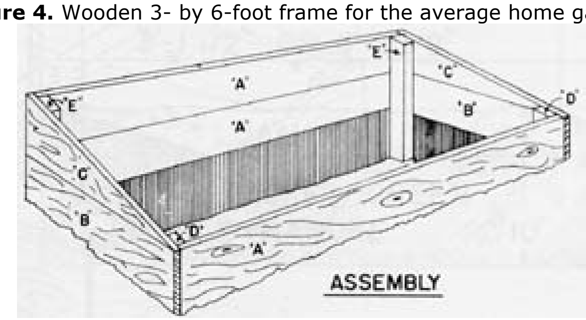

Figure 5. Wooden 3- by 6-foot frame for the average home garden.(Assembly)

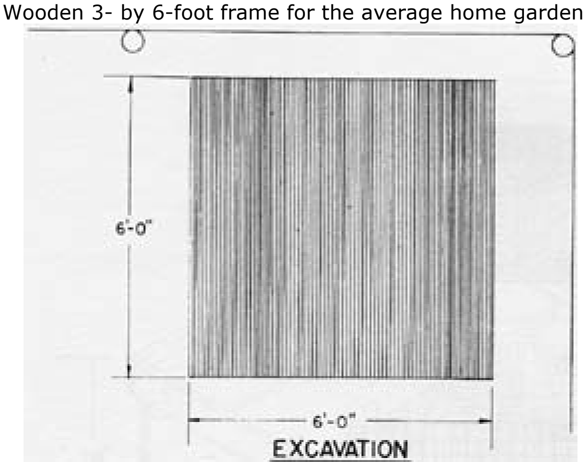

Figure 6. Wooden 6- by 6-foot frame for home garden or business.(Materials)

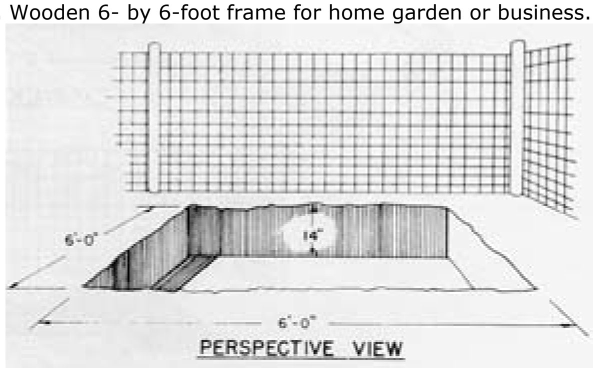

Figure 7. Wooden 6- by 6-foot frame for home garden or business.(Perspective View)

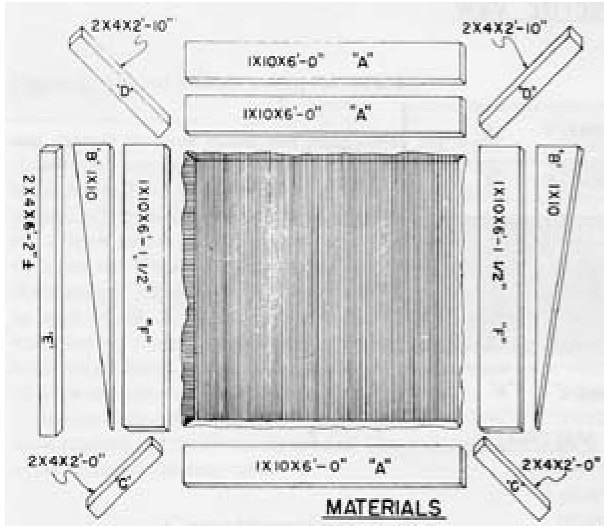

Figure 8. Wooden 6- by 6-foot frame for home garden or business.(Materials)

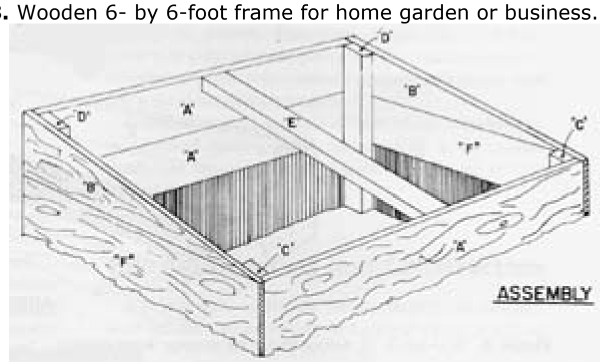

Figure 9. Wooden 6- by 6-foot frame for home garden or business.

Another factor affecting size is the length of heating cable required and the electricity needed. This is discussed in the section on heating cable.

Construction

Materials

Construction materials will depend on how long the frames are to last, how good they must look, and what materials are available. The main considerations for maintaining the growing environment are light transmission through the cover and weathertightness to reduce heat loss.

Concrete is suitable for permanent frames, but treated wood is a durable and more practical material. Treating wood with 2 percent copper naphthenate solution retards decay, or wood that has been pressure treated with chromated copper arsenate (CCA) can be used. Do not use creosote or pentachlorophenol because these preservatives are harmful to plants; borate wood preservatives are water soluble and will leach out if used outdoors. Tongue-and-groove, dressed 2-inch lumber is suggested for weather-tightness, but regular lumber with weather stripping can be used. Figures 2 through 9 illustrate the dimensions of the wood components required for the frame.

The cover of the frame traditionally has been glass, but single or double layers of plastic film can also be used. A double layer of plastic with at least three-fourths of an inch (to 4 inches) dead air space between layers reduces heat loss by 30 percent. Fiberglass, acrylic plastic (plexiglass®), or polycarbonate plastic are alternative rigid plastic materials. The polycarbonate material will yellow in a few years if not surface treated.

A hotbed requires a source of heat which is commonly an electrical heating cable controlled by a thermostat. Guidelines for sizing these are covered under the section on heating.

Site Preparation and Construction

It is important to prepare the site properly to ensure a level bed, weather protection and good drainage. For good drainage, a base of gravel is recommended and, if conditions warrant, drain tile should be installed to remove surface or ground water.

Manure-heated hotbed. To build a manure-heated hotbed, excavate the bed area to a depth of 14 inches and fill with 10 inches of well-packed green manure. On top of that put 4 inches of loam soil. The wall of the frame will sit on the ground around the filled pit (Figure 10).

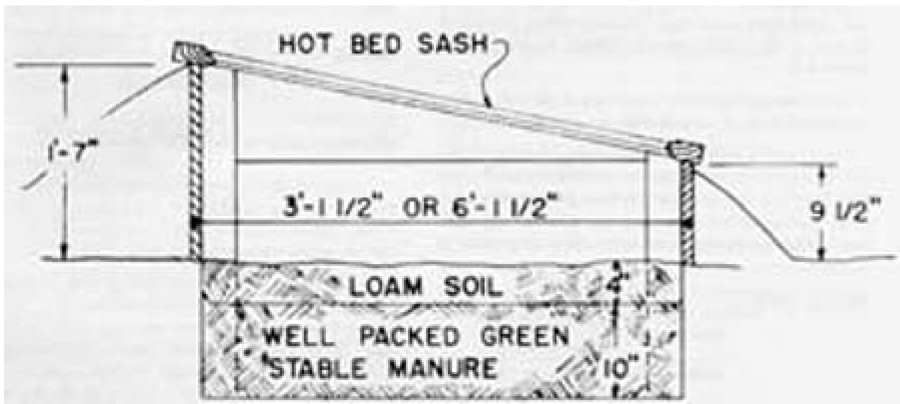

Figure 10. Typical cross section of manure-heated hotbed.

Electrically-heated hotbed. To build an electrically-heated hotbed (Figure 11), excavate the bed area to a depth of 14 inches and fill with 6 inches of gravel, well-tamped down. Cover the gravel with burlap or plastic screening that will support soil or sand and prevent it from moving down into the gravel. Add 2 inches of sand, the heating cable, and another 2 inches of sand. (The sand provides a protective layer for the heating cable.) Moisture in this layer during the heating season will move the heat to the soil and plants above. Over the sand, place a ½-inch protective layer of mesh hardware cloth. Finally, add 4 inches of soil or other growing medium. Prepared mixes can be purchased, or use a 1:1:1 mixture of rotten leaves, garden soil, and sand. Have the growing medium tested for fertilizer and lime requirements. The Cooperative Extension Service will conduct the test for a small fee.

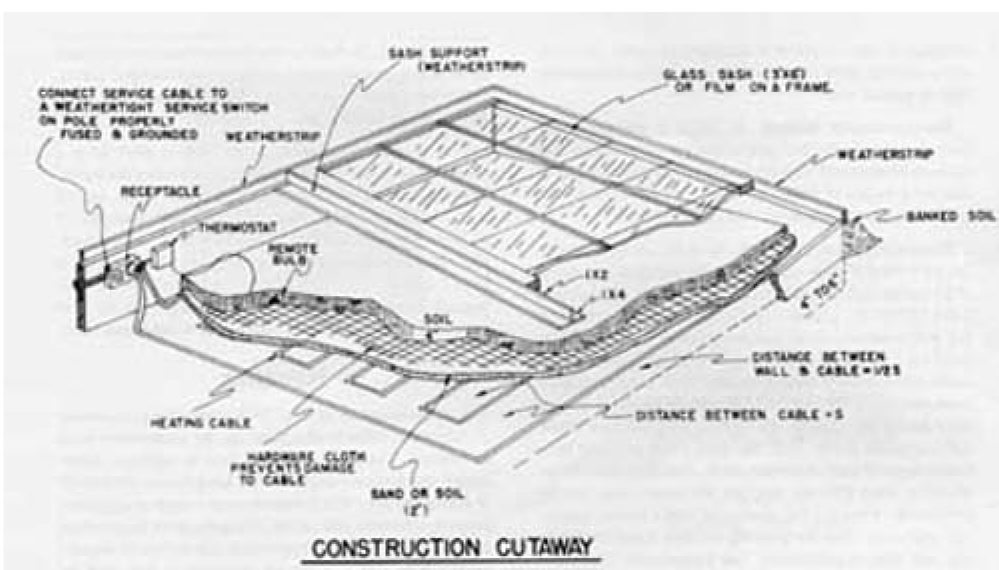

Figure 11. Construction cutaway of an electrically-heated hotbed.

Precautions:

- Avoid kinks and damage to the cable when laying it.
- Do not lay cable over cable. Hot points may cause damage.
- Do not shorten the cable. Electrical shorts may develop at the break.

Cold frame. To build a cold frame, excavate to a depth of 10 inches and fill with 6 inches of well-tamped gravel. Cover the gravel with burlap or plastic screen and add 4 inches of soil or other growing medium.

Frame walls. The walls can be built in place or in a shop. Corner posts seated into the pit will anchor the frame. These posts can be placed--or the entire frame can be built--before the pit is filled. The back wall should be 18 to 24 inches high and the front wall 9 to 12 inches high. The side walls should slope toward the front at a rate of at least 1 inch per foot. See Figure 11 for details of the sash support. Build the sashes, perhaps hinging them for convenience in opening. A pole can be used to hold them open.

Heating

A soil temperature of 70 to 75 °F is ideal for germination of most seed. After seedlings are up, the temperature must be reduced. Cool-season crops--such as cabbage, cauliflower, and lettuce--require an air temperature of 60 to 65°F during the day. Warm-season crops--such as eggplant, peppers, tomatoes, and melons--require an air temperature of 65 to 75°F. Night air temperature can be 5 to 10 degrees cooler. Note that it is the air temperature that must be controlled; a soil temperature near 70°F is generally good for root development.

Heating Cable

Electric heating cable comes in various sizes. A heating cable kit usually contains the cable as well as a built-in thermostat. Heating cable is encased in a protective coating to insulate the electrical conductor; do not cut or damage the insulation.

Cable size depends on how many watts per square foot of bed area are needed to maintain adequate heat. Depending on your location, use between 10 and 15 watts per square foot as a guide. In southern areas 10 watts per square foot have been adequate; very cold areas need a minimum of 15 watts but can use up to 20 wans per square foot. For starting plants in the spring after the coldest weather is over, fewer watts are needed. The total wattage required is the area of the hotbed times the wattage requirement per square foot.

$$\text{Total wattage required} = \text{Inside length (ft)} \times \text{inside width (ft)} \times \text{desired watts per square foot}$$

Cables vary in length and wattage rating (heating capacity). Design a system on paper to avoid installation problems later. The wattage rating per foot gives an indication of the spacing that will be needed. Use the following equation to find the spacing between the loops or sections of cable.

$$\text{Spacing (inches)} = 12 \times \frac{\dfrac{\text{Wattage rating of cable}}{\text{Length of cable (ft)}}}{\text{Wattage required per square foot of bed}}$$

The spacing between the outside wall and the cable is half the spacing between cables.

The number of cables required also can be determined in terms of wattage. The equation is

$$\text{Number of cables needed} = \frac{\text{Total wattage required}}{\text{Wattage of available cable}}$$

Example:

Suppose a 36-foot cable is rated at 220 watts. The bed is 6 feet long and 3 feet wide. To supply 12 watts per square foot

$$\text{Spacing} = \frac{12 \text{ x } (220 - 36)}{12} = \frac{12 \text{ x } 6}{12} = 6 \text{ inches}$$

$$\text{Number of cables} = \frac{12 \text{ x length x width of bed}}{220}$$

$$= \frac{12 \text{ x } 6\text{x } 3}{220} = 0.98 \text{ (one)}$$

In this example, a 220-watt heating cable providing 12 watts per square foot can be used to heat 220 ÷ 12 = 18 square feet of bed (useful for matching cable size to bed size). In this case, the available cable matches the requirements, and one cable is enough. In other situations it may be necessary to check several cables to get the best match.

The operating cost will depend on many factors, but tests have shown that a 3- by 6-foot bed uses 1 to 2 kilowatt-hours of electricity per day. The 220-watt cable operating 10 hours a day is 2200 watt-hours or 2.2 kilowatt-hours.

The wiring to the hotbed must be adequate to conduct the amperage (wattage of cable divided by line voltage) of the cable without causing more than a 2-percent voltage drop in the service line. The wiring must conform to the National Electrical Code and to local codes. Outdoor wiring and watertight connections are required. These items should be installed by a qualified electrician. As a guide, a 15-ampere service at 120 volts provides 1800 watts and a 20-ampere service at 120 volts provides 2400 watts, not considering voltage losses. These are maximum limits.

Thermostat

Many heating cable kits have a built-in thermostat set to maintain a fixed temperature; others have adjustable thermostats. Most temperature sensors are buried an inch deep in the soil at a point one-third the distance from front to back and side to side of the hotbed. Figure 5 shows a service cable entering a thermostat switch and receptacle. A remote bulb sensor is shown. Note the cable spacing instructions. Other details of a typical hotbed are also shown.

The thermostat and its sensor should be checked in a water bath with an accurate thermometer before use. There should be a few degrees temperature difference between the built-in on and off settings, with the off at 70 °F unless it is adjustable. It may turn on at 67 °F and off at 70 °F. Place the sensor in the water bath and slowly adjust the water temperature while watching the thermostat switching unit. Instructions for performing this test should be included with the heating cable.

Do not put the thermostat sensor in contact with or directly above the heating cable. The high heat of contact could damage the sensor, and the close proximity may give inaccurate readings of the soil temperature.

Ventilation

The purpose of ventilation is to avoid extremes in the temperature of the hotbed or cold frame and to control the relative humidity.

The sun's radiant heat is trapped inside the hotbed or cold frame during the day, warming the growing medium and the air. Although stored heat can help maintain a warm temperature at night, high air temperature during the day can put considerable stress on the young plants and even kill them. Therefore, ventilation is very important on sunny, mild days.

Air temperature should not be permitted to go above 85 °F, less for some plants, unless the ambient air temperature is above 85 °F. The top of the bed can be raised to allow warm air to escape and cool air to enter. The size of the. opening will regulate the rate of ventilation. Temperature-sensitive gas piston devices are available to lift the cover of the bed when it is hot.

Many plant diseases develop rapidly in high temperatures and high relative humidities. Controlling the relative humidity through proper ventilation is an effective way to control these diseases.

On cold, rainy, or windy days there is a danger of chilling the young plants, so the sash of the structure should open on the side away from the wind, if possible, or be opened very little so there is limited air flow.

Watering

Watering is also very important; keep the soil moist but not wet at all times. Good soil moisture is needed for efficient heat transmission and for prolonging the life of the heating cable. Soil moisture also makes water easily available to the plants.

Frequent light applications of water are better than less frequent heavy applications several days apart. Watering in the morning followed by proper ventilation will reduce the danger of "damping off" disease which causes seedlings to rot at the ground surface.

The ground should be kept slightly moist because heat from the heating cables moves more readily in moist soil. Also, dry sand can be an insulating material, causing the cable to overheat. Good drainage in the gravel below the cable reduces heat loss to the ground.

Reference

Stanley, J. M. 1964. **Electric Heating of Hotbeds.**USDA Leaflet No. 945.

Plans available through Extension offices:

- 5941 *Plastic-covered Greenhouse--Cold frame.* A 5- by $7^2/_3$-foot structure of 2- by 2-inch lumber. Top can be used as a cold frame or the top and bottom together as a simple greenhouse.
- 5971 *Hotbed and Propagating Frame.* A 6- by 6-foot frame of wood with ½-inch thin-wall galvanized steel conduit forming the top frame to support a cover.
- 6080 *Mini-hotbed and Propagating Frame.* A 3½- by 5-foot frame using No. 8 Gauge 6- by 6-inch welded wire and a plastic top.
- 6206 *Hotbed.* (The plan illustrations are shown as figures in this publication.) The plan gives dimensions of wood framing for building 3- by 6-foot and 6- by 6-foot frames. It also specifies how to calculate the quantity needed and how to install heating cable.

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