Hotbeds
For Transplant Production

George A. Duncan and C. R. Roberts
Extension Specialists in Agricultural Engineering and Horticulture

University of Kentucky, College of Agriculture, Cooperative Extension Service

Agriculture, Home Economics, 4-H, Development

High-dollar-per-acre vegetable crops such as tomatoes, cabbage, and peppers can be an income booster for many Kentuckians.

To be successful on the early market, vegetable seed must be sown from mid-January to mid-March (Table 4). But, Kentucky weather is too cold for the plants' survival then. Until recently, growers either had to ship plants in from the south or grow their own locally in some type of heated greenhouse.

Unfortunately, finding high-quality, disease-free plants of the desired quantity and variety at the proper time in the south has proven difficult. Likewise, all growers do not have the capital to invest in greenhouse structures.

Heated frames or hotbeds offer a solution to the problem. Seed can be started in these closed, heated, plant growing structures, grown to proper size, then transplanted to the field. Hotbeds involve less investment than most greenhouses; however, considerable time and labor is still required for proper management. To obtain top-quality plants, much attention must be given to ventilation, watering, and growth.

Hotbeds offer an alternative, because they cut cost and allow the grower to produce his own plants. They are beneficial to small-farm operators and part-time employees who need to supplement their income and are also suitable for home gardeners and hobbyists who wish to grow early vegetable or flower transplants for home use.

LOCATION OF THE HOTBED

Your success with a hotbed will largely be determined by its location. It should be on a southern slope in a sunny place where it will not be shaded. The south side of a building is best in residential areas. Sites should be well drained, with surface water directed away from the hotbed. Less heat is needed if the hotbed is not in a windy place. It should be reasonably close to a water supply, and if the bed is electrically heated, close to an electrical service.

HOTBED CONSTRUCTION

A good hotbed frame is tight and well covered so that very little heat escapes. Several materials can be used to construct low-cost frames. One-inch rough oak lumber with 2" x 4" stakes is the most popular material. Polystyrene and polyurethane are new types of rigid insulation board that can be used for the walls and will conserve heat much better than wood. When using rigid insulation board, use stakes for support. One wide wooden board inside the frame between the growing soil and the insulation will protect the insulation board. A more permanent frame may be built of 4-inch concrete blocks or similar materials.

Typically, a hotbed is 6 feet wide and the length is a multiple of 6 or 12 feet. For tomato transplants, the frame should be about 24 inches high on the rear side and sloped to about 16 inches on the front side. Lower frames can be used for smaller plants.

Ground for the hotbed must be leveled. On sloping terrain, place the longest side of the frame across the slope (not up and down). The low side of the frame must face south. Bank the outside of the frame with soil one-half to two-thirds of the wall height (Figure 1). This helps conserve heat by stopping cracks and providing some insulation. Also, provide for drainage around the frame.

Hotbed covers may be of sash, plastic, or similar materials. A double-layer plastic-covered frame will provide a low-cost cover that conserves heat and is fairly durable. Build the cover frame of 2- by 2-inch wood and then cover it on each side with 4-mil or 6-mil clear plastic. Use thin lathe strips to secure the plastic to the cover frame. To keep the cover from sliding off the sidewalls, nail a 1/2- by 3-inch strip to the cover frame edges and hook it over the high side of the hotbed wall. If you prefer, 4- or 6-inch strap hinges can be used to secure one side. Use some type of hook or fastener to hold the other side securely in windy weather. See Figure 1 for construction details and Table 1 for a materials list.
Figure 1. Construction Details of A Hotbed

Table 1 - Materials for 6' X 12' Hotbed Section

<table>
<thead>
<tr>
<th>Items</th>
<th>Size</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Boards</td>
<td>1&quot; x 8&quot; x 12' Oak, or other durable wood</td>
<td>5 each</td>
</tr>
<tr>
<td>End Boards</td>
<td>1&quot; x 8&quot; x 6' Oak</td>
<td>5 each</td>
</tr>
<tr>
<td>Stakes</td>
<td>2&quot; x 4&quot; x 32&quot; Oak</td>
<td>3 each</td>
</tr>
<tr>
<td>Stakes</td>
<td>2&quot; x 4&quot; x 22&quot; Oak</td>
<td>3 each</td>
</tr>
<tr>
<td>Cover Frame</td>
<td>2&quot; x 2&quot; x 6' Oak</td>
<td>10 each</td>
</tr>
<tr>
<td>Cover Frame</td>
<td>½&quot; x 3&quot; x 6' Oak</td>
<td>2 each</td>
</tr>
<tr>
<td>Plastic, 4-mil</td>
<td>(cover frame)</td>
<td></td>
</tr>
<tr>
<td>Plastic, 4-mil</td>
<td>(ground layer)</td>
<td></td>
</tr>
<tr>
<td>Nails</td>
<td>2d and 8d</td>
<td>1 Lb each</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HOTBED SIZE

You should determine the amount of hotbed space necessary to produce the desired quantity of field transplants. Use Table 2 as a guide in determining this size.

Table 2—Plant Production Information For 6’ X 6’ Hotbed

<table>
<thead>
<tr>
<th>Crop</th>
<th>Plants Produced</th>
<th>Seed Needed Per 6’ x 6’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>2500</td>
<td>1/2 oz.</td>
</tr>
<tr>
<td>Brussels Sprouts</td>
<td>2500</td>
<td>1/2 oz.</td>
</tr>
<tr>
<td>Cabbage</td>
<td>2500</td>
<td>1/2 oz.</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>2500</td>
<td>1/2 oz.</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>575 (in 2 1/4” peat pots)</td>
<td>3/4 oz.</td>
</tr>
<tr>
<td>Muskemelon</td>
<td>575 (in 2 1/4” peat pots)</td>
<td>3/4 oz.</td>
</tr>
<tr>
<td>Squash</td>
<td>575 (in 2 1/4” peat pots)</td>
<td>3-5 oz.</td>
</tr>
<tr>
<td>Watermelon</td>
<td>575 (in 2 1/4” peat pots)</td>
<td>1-5 oz.</td>
</tr>
<tr>
<td>Tomato</td>
<td>2000</td>
<td>1/2 oz.</td>
</tr>
<tr>
<td>Eggplant</td>
<td>2000</td>
<td>1 oz.</td>
</tr>
<tr>
<td>Pepper</td>
<td>2000</td>
<td>1 oz.</td>
</tr>
</tbody>
</table>

Information shown in this column refers to the number of bare root plants resulting from direct seeding in beds. If seedlings are transplanted to 2 1/4" peat pots or similar sized containers for growing, a 6’ x 6’ area will grow 575 plants. Much more desirable plants of cabbage, eggplant, pepper, and tomato can be produced for field transplant by growing in peat pots or some similar type containers.

Quantity of seed needed varies with variety of vegetable used. (See label on seed packet.)

METHODS OF HEATING

The three most common ways of heating a hotbed are by electricity, warm air (flue-heated), and manure. The same framework and covering construction can be used for all three methods; however, flue-heated beds will also require underground tile and fire-box construction.

Electrically Heated Hotbeds

Electric hotbeds are well suited for growing several types of vegetable and flower transplants. Construction of an electrically-heated bed requires less labor and material than a manure-heated or flue-heated one, and after construction, it requires less attention. Temperature of an electrically-heated bed is automatically controlled and is readily adjusted to the plants’ needs. Electric hotbeds require proper wiring to ensure safety and dependability and must be cared for properly to conserve heat and keep costs down. Figure 2 shows the electrical service and cross-section details for an electrical hotbed.

The Hotbed Thermostat:

A thermostat with an operating range of 30°F to 120°F is required to automatically switch power to the cable when temperature changes demand. Several kinds of thermostats, illustrated by Figure 3, can be used for soil-heating purposes. With knob-adjust thermostats, temperatures can be set according to different plant or growing conditions. A thermostat with the remote capillary bulb and tube is preferred over the kind that is submerged completely in the soil. Caution: Only thermostats suitable for wet and dirty conditions of a hotbed should be used to ensure safe and reliable operation! Non-weatherproof thermostats must be enclosed in a housing to protect them from weather.

Place the temperature-sensing element (the thermostat or remote-temperature bulb) between loops of the heating cable, approximately 2 to 3 feet out into the bed, or as far as the cord or capillary tube will permit. Some prefer to bury the bulb about 1 inch in the soil, while others set it in a vertical position with the bottom half buried. In the latter position, it is affected by both soil and air temperatures. Do not place the thermostat or bulb directly above a heating cable, and do not allow it to come in contact with a cable. Try to keep it at least 3 to 4 inches away from the cable.

More than one cable may be connected to one thermostat, provided the amperage or wattage rating of the thermostat is not exceeded.

Operation of thermostat: To satisfactorily control the temperature of the bed, the thermostat must have an "open" and "close" range of not more than 5°F (sometimes called "differential" for the thermostat’s operation). If you are not sure about the exact operation of a thermostat, check it as follows:
1. Set the indicator at the maximum temperature desired for the bed.
2. Place thermostat bulb in water heated to the maximum temperature desired for the bed. (Use a reliable thermometer to determine the water temperature. A light bulb operated by the thermostat is handy to indicate thermostat operation. When the set temperature is reached, the light bulb should go out, indicating the thermostat has opened, that is, shut off the current. A slight clicking noise also indicates that the thermostat opened.)
3. If the thermostat did not open at the desired temperature, adjust it until it does.
4. Allow the water to cool 3 to 5°F. (The bulb should light, indicating the thermostat has closed, that is, turned on the current.)
5. If it did not close, make the necessary adjustment or replace it with another one.

Soil Heating Cable:

Selection: Various types of electric heating cable are available. Both lead-covered and vinyl-jacketed types rated for soil installation give satisfactory results when used properly.

In selecting cable you must know how many watts per square foot of bed area are needed to provide adequate heat. In southern areas, 10 watts per square foot have proved adequate. In northern areas, where extremely low temperatures are anticipated during the period the bed will be used, as much as 16 watts per square foot may be needed. Hotbeds for Kentucky should have 8 to 12 watts capacity per square foot of bed area.

Cables vary in length and wattage rating (heating capacity). Some are 60 feet long and are rated at 300 or 400 watts. Others are 120 feet long and are rated at 800 watts. Various other combinations in length and wattage ratings are available.

Spacing: Spacing between loops or sections of cable is important; it governs the number of watts per square foot of soil area. Uniform spacing is essential to obtain uniform heat and prevent the cable from burning out. Determine the proper spacing:

\[
\text{Spacing (in inches)} = \frac{12 \times \text{Wattage of cable}}{\text{Length of cable in feet}} \times \frac{\text{Wattage required per square foot of bed}}{10}
\]

Example: You have a 120-foot cable rated at 800 watts. You wish to supply 10 watts per square foot.

\[
\text{Spacing} = \frac{12 \times 800}{120} = \frac{12 \times 6.7}{10} = \frac{80.4}{10} = 8 \text{ inches}
\]

Spacing between the outside cable and wall is half the spacing between cables (or 4 inches in the example given).

Using the above procedure, calculate the size, length, and spacing of cable to fit your needs and size of hotbed (Figure 4). You should use a 230-volt power connection for cable requirements greater than 1500 to 1800 watts. Use
One 60' length of soil heating cable, 115 volts, 300-400 watts.

Two 60' lengths, 115 volts, 300-400 watts each, or one 120' length, 115 or 230 volts, 600-800 watts.

Longer hotbeds can use longer or multiple cables connected to one or more thermostats.

Figure 4. Typical Electrical Cable Layouts

even less if the thermostat is limited to less watts or amps on 115 volts.

Laying the Cable: Lay the cable on smooth, soft soil at the bottom of the bed. Or, if the bed was excavated, lay the cable on sand that has been spread on the bottom to protect the cable from sharp objects. Some type of hold-down peg or other device may be necessary to keep the cable in position for covering.

After the cable is in position, cover it with a 1- to 2-inch layer of sand or loose sterilized soil. Trays or flats may be set directly on the soil or sand for plant growth. If you plan to grow plants in the soil, place a 1/2-inch mesh galvanized hardware cloth on top of the sand or soil and add an additional 4 inches or more of soil for the root layer. Hardware cloth prevents damage to the cable when sharp instruments are used in the bed. Soil (or sand) should be sterilized or weeds will be a problem.

Precautions: Lay the cable in position carefully to avoid damaging the sheath or conductor. Kinks may damage or break the cable.

Do not cross one cable or section of cable over another.

Do not shorten the length of a cable. A shortened cable may become too hot and burn out.

Electric Wiring:

To operate satisfactorily, the bed must be properly wired and should conform to the National Electric Code and requirements of the local power supplier. Unless you know proper wiring requirements, have a power company representative or qualified electrician assist you in obtaining a safe, dependable installation.

Heating cables are designed to operate on either 120 or 240 volts. Be sure to connect the cable to an outlet carrying the correct voltage.
Install a weatherproof service switch, properly fused and grounded, on a pole adjacent to the bed (Figure 2). The wire size from the electrical source to the switch must be large enough for the distance and heating load. Connect an "outdoor service" grade cable from the switch to the heating cable. Make all connections to the heating cable watertight to exclude moisture.

**Electrical Equipment:**

Table 3 gives equipment required for a typical electric hotbed installation. Electrical service items could serve several hotbed sections and therefore make larger beds more economical in cost per unit.

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility Post</td>
<td>4&quot;x 4&quot; x 12'-16'</td>
<td>1</td>
</tr>
<tr>
<td>Service Wire</td>
<td>As Required</td>
<td></td>
</tr>
<tr>
<td>To Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch Box</td>
<td>2-Pole, 30 Amp Raintight</td>
<td>1</td>
</tr>
<tr>
<td>Service Entrance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable to Hotbed</td>
<td>As Required</td>
<td></td>
</tr>
<tr>
<td>Thermostat</td>
<td>115 or 230V, 15 to 25A,</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Weatherproof</td>
<td></td>
</tr>
<tr>
<td>Outlet (if not With Th'st)</td>
<td>Duplex, box,</td>
<td>1</td>
</tr>
<tr>
<td>and Box</td>
<td>cover</td>
<td></td>
</tr>
<tr>
<td>Soil Heating Cable</td>
<td>600 to 800 watts</td>
<td>120 foot</td>
</tr>
</tbody>
</table>

**Kilowatt-hours used:** A 6- by 12-foot bed will use from 5 to 7 kilowatts a day, depending on its care and the weather. More electricity will be used in cold, cloudy, windy weather and less in warm pleasant weather. Cut costs by following directions when building the bed, and watering in the morning on sunny days.

**Care of equipment:** If cover frames are stored inside between seasons, they can be used for several years. Plastic coverings will usually need to be replaced annually.

Remove, clean, and store thermostat in a protected place. For prolonged life, remove the soil heating cable, roll it up without kinking, and store until ready for use again the next year. Walking on the cable and using shovels and other tools in the bed can be damaging. Frames may either be disassembled and stored, or if built of weather-resistant materials, left in position for another year.

**Warm Air (Flue-heated) Hotbeds**

Hotbeds may be heated by using wood, coal, gas, or fuel oil to conduct warm air beneath the plant growing beds (Figure 6).

Warm air is conducted beneath the plant growing bed by 6-inch tile placed with a rise of 1/2 inch to the foot. This slight rise allows smoke to be drawn to the far end, but too much slope will cause excess heat loss. Flues should not be longer than 60 feet.

Difficulty in maintaining a uniform temperature throughout the soil is one of the major disadvantages of this system. For this reason, we recommend warm air as a method of heating only if electricity or manure is limited as a source of heat.

**Manure Heated Hotbeds**

Manure mixed with straw, if available, is a very cheap way to heat a plant growing bed. A mixture of two-thirds horse manure and one-third straw is the best form of manure for heating plant beds. Microorganisms break down the manure, which in turn generates heat to warm the soil. Fresh manure should be used and prepared as follows.

Place manure into a compact, flat-topped pile. If it appears dry, water it down. In 3 or 4 days, when it begins to steam, turn the inside of the pile to the outside so that fermentation will be uniform throughout. After 3 to 5 days and one more turning, manure should be ready to place in the bed. If weather is extremely cold, which often is the case when cabbage seed are planted, manure for the hotbed should be readied 2 weeks before the seeds are planted.

For best results, dig a pit about 18 inches deep (Figure 5). The pit should be about 1 foot wider and 1 foot longer than the frame to be used. Put layers of manure 5 to 6 inches deep into the pit, and tramp firmly, especially in the corners and along the edges. Continue adding layers and packing until manure is at ground level, then put the frame in place as shown in Figure 5. A 4- to 6-inch layer of soil or soil media mixture can then be placed over the manure in which the plants are grown. Manure will settle as it decomposes, hence the need for a well firmed bed. Manure must be replaced annually.

![Figure 5. Cross-section of A Manure Hotbed Showing An Unlined Pit That Has Been Filled with Manure](image)
After a good hotbed is constructed, knowing the exact growing requirements preferred by each plant type is very important.

Starting the Seed:

Plant seed directly into ground beds; leave seedlings until ready for pulling, then transplant them to the field bare-root. Germinating media should be about 4 inches deep, with a layer of plastic film directly beneath the soil to prevent roots from going deeper. If this procedure is followed, the row spacings for the hotbed shown in Table 4 should be used for the different crops shown. Tomato seed and other vegetable seeds similar in size should be planted 1/4 to 1/2 inch deep; seed such as cucumber and melons should be planted 1 inch deep.

If you plan to transplant the seedlings to peat pots before taking them to the field, sow the seed in flats approximately 14 inches wide, 20 inches long, and 3 inches deep. Leaving a 3/4-inch margin at the top, fill flats with river sand, vermiculite, calcined clay, or a media of one part soil, one part sand, and one part peat moss. Desired soil temperatures for germination are shown in Table 4. About 7 to 10 days are required for most vegetable seed to germinate. Table 4 lists the recommended seeding dates for various vegetable crops and the desired planting date for the field, but this will vary a few days from one area of the state to another.

If soil is used for germinating the seed or growing the seedlings, sterilize it to control diseases, insects, and weeds. Sterilize by heating soil to 180°F and maintaining this temperature for 30 minutes. Methyl Bromide may also be used to sterilize plant beds and soil used for transplanting.

Transplanting Seedlings:

Transplant seedlings from the flats to small pots when the first true leaf begins to form. A good potting mixture can be made of two parts sterilized soil, one part sand or perlite and one part peat moss. Put the moistened soil mix into 2 1/4- or 3-inch peat pots or their equivalent for good results. Numerous other types of containers are now manufactured and are available to the plant producer if he wishes to use them. If seedlings are transplanted to containers filled with soil or some similar mixture, place them on top of a sand layer covered with a plastic barrier which covers the heat source. The plastic film prevents plant roots from growing into the media below and...
presenting problems when the plants are ready to be removed. Remember to handle transplants carefully.

**Watering the Plants:**

Overwatering causes many problems in hotbeds, and may increase damage from fungus diseases. Plants should be watered in the morning rather than late evening. This allows droplets on the plants to dry before night.

**Ventilating the Plant Beds:**

On bright, sunny days, hotbed temperatures will increase rapidly. Hang a thermometer at plant level and keep the temperature below 85°F. If it rises above that, prop open one edge of the frame cover to let fresh air enter the beds. Remember to keep plants away from cold drafts.

Vegetable transplants such as cabbage, broccoli, eggplant, tomato, pepper, and lettuce do best when grown slowly and steadily. Excessive water, nitrogen, and high temperatures can result in tender, "leggy" plants. Such plants do not perform well when transplanted to the field.

**Fertilizing Transplants:**

When adequate nutrients are not available in the soil media, plants will develop poorly, becoming yellow and stunted. Soil mixtures for transplants should have fertilizer added before transplanting begins, especially if the soil is low in nutrients. A soil test is the best way to determine fertilizer needs. Send soil samples to the Soil Testing Laboratory, Agricultural Experiment Station Building, University of Kentucky, Lexington, Kentucky, 40546, or to your county Extension agent, indicating that you want the greenhouse soil test. Called the Spurway test, it checks soil for nitrate nitrogen, phosphorus, potassium, pH, calcium, and soluble salts. Good vegetable transplants can be grown if the Spurway test shows a nitrate nitrogen (NO₃-N) reading of 12 to 15 parts per million (ppm); phosphorus (P) 6 to 7 ppm; potassium (K) 30 to 40 ppm; a pH of 6.0 to 7.0; calcium (Ca) 90 to 150 ppm; and a soluble salt reading expressed as EC x 10⁻² of around 150. Soluble salt readings above 200 can cause stunting or death of transplants.

For further plant production, insect and disease control information, refer to Extension publication ID-36, "Commercial Vegetable Crop Recommendations," available at your county Extension office.

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Table 4.- Summarized Transplant Production for Kentucky

| Crops | Seeds to Expect | Seed Depth | Seed Spacing | Satisfactory Growth Temp. | Soil Temp. | Transplant Spacing | Transplant in Field Setting | Avg. Field Setting Date
|-------|----------------|------------|--------------|--------------------------|------------|-------------------|-----------------------------|----------------------|
| Broccoli | 9,000 | 6,000 | 2 | 2 | 80°F | 65 60 | 2-3 | 3 x 3 | 3-4 | Mar. 25 | Aug. 20 | 3-4 | May 1-15**
| Brussels Sprouts | 8,500 | 6,000 | 10 | 2 | 80 85 | 55 50 | 2-3 | 3 x 3 | 3-4 | Mar. 25 | Apr. 5 | 3-4 | May 1-15**
| Cabbage | 8,500 | 6,000 | 4 | 2 | 80 85 | 65 60 | 2-3 | 3 x 3 | 3-4 | Mar. 10 | Apr. 14 | 3-4 | May 1-15**
| Cauliflower | 10,000 | 6,000 | 2 | 2 | 80 85 | 65 60 | 2-3 | 3 x 3 | 3-4 | Mar. 15 | Apr. 20 | 3-4 | May 1-15**
| Cucumber | 1,000 | 700 | 1 | 2 | 95 95 | 75 70 | 2-3 | 3 x 3 | 3-4 | May 1-15** | Apr. 10 | 3-4 | May 1-15**
| Melon | 1,200 | 700 | 1 | 2 | 90 90 | 75 70 | 2-3 | 3 x 3 | 3-4 | May 1-15** | Apr. 14 | 3-4 | May 1-15**
| Squash | 300 | 250 | 1 | 2 | 95 95 | 75 70 | 2-3 | 3 x 3 | 3-4 | May 1-15** | Aug. 15 | 3-4 | May 1-15**
| Watermelon | 500 | 400 | 1 | 2 | 95 95 | 75 70 | 2-3 | 3 x 3 | 3-4 | May 1-15** | Aug. 15 | 3-4 | May 1-15**
| Tomato | 10,000 | 7,000 | 1 | 2 | 85 85 | 70 70 | 2-3 | 3 x 3 | 4-5 | May 1-15** | Aug. 15 | 4-5 | May 1-15**
| Eggplant | 6,000 | 5,000 | 1 | 3 | 85 85 | 70 70 | 2-3 | 3 x 3 | 4-5 | May 10-15** | Aug. 15 | 4-5 | May 10-15**
| Pepper | 4,500 | 2,500 | 1 | 2 | 85 85 | 70 70 | 2-3 | 3 x 3 | 4-5 | May 10-15** | Aug. 15 | 4-5 | May 10-15**

*Note: Field setting dates listed apply to Kentucky in general based on the last expected killing frost (L.E.K.F.) in the spring on April 20. The Western end could be listed 10 days earlier based on April 10 L.E.K.F. date.

**Hotcaps may be needed for early plantings.

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