Transplant production has replaced direct seeding for many vegetable crops. One of the primary advantages offered by transplanting is earlier fruit production, allowing growers to capture better market conditions. In addition, the high cost of hybrid seed makes it desirable to use each seed as efficiently as possible. Transplanting also gives the crops a competitive advantage against weeds. This section addresses the special skills and knowledge required for successful transplant production.

**Greenhouse**

Most growers use polyethylene-covered greenhouse structures to provide warmth and protection from the environment. Although cole crops do not need the more moderating conditions a greenhouse provides, they can be grown in coldframes, lean-tos, or covered wagon beds.

The heater is one of the most critical features of a transplant greenhouse. Vegetable transplants must be kept at the appropriate temperatures. However, if heaters are improperly exhausted, the transplants can be stunted or deformed. To prevent heater fumes from returning into the greenhouse, chimneys vented out of the top of the house should extend 2 feet above the ridge.

There should be some provision for bringing fresh air into the greenhouse. Some heaters vent fresh air into the greenhouse every time the furnace operates. For others, a hole or holes should be cut in the greenhouse wall and fitted with a tube to feed outside air to the heater. Avoid this problem by placing a plastic sheet on the ground. The heater must be kept in the appropriate temperature. If the roots are allowed to grow into the ground beneath the tray, avoid this problem by placing a plastic sheet on the ground. The heater is one of the most critical features of a transplant greenhouse. Vegetable transplants must be kept at the appropriate temperatures. However, if heaters are improperly exhausted, the transplants can be stunted or deformed. To prevent heater fumes from returning into the greenhouse, chimneys vented out of the top of the house should extend 2 feet above the ridge.

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The peat pot type containers have the advantage that the root system need not be disturbed upon planting. This is important in crops such as cucurbits that are sensitive to root disturbance. Peat pots are more forgiving of over watering than the other containers. However, peat pots have to be reordered every year. If peat pots are planted partially above ground, moisture is “wicked” away from the plant, often resulting in plant death. (Peat pellets do not have this disadvantage.)

The polystyrene and Todd planter flat are both designed so that the transplant must be “popped” out of the tray, thus disturbing the root system. This is particularly true if the roots are allowed to grow into the ground beneath the tray. Avoid this problem by placing a plastic sheet on the ground. Both the polystyrene and Todd planter flats must be watered with care. The Todd planter flat has a pyramidal design that forces roots downward to an open bottom where the roots are air pruned. Some polystyrene containers have open bottoms as well. (Tube type have open bottoms, groove type have small drainage holes.) An advantage of the polystyrene and Todd planter flats is that they may be used for several years. In general, peat type containers are the most expensive, followed by the Todd planter type, and then by the polystyrene type.

The number of plants in a tray depends on the cell size for each plant. Vegetables are commonly grown in trays with 30 to 300 cells. In general, larger cells lead to greater early yield in fruiting crops. Larger cells are also easier to manage because the greater soil volume holds more water and nutrients. Due to the expense of building and maintaining greenhouse space, many growers have moved to smaller and smaller cell volumes so that more transplants can be grown in the limited space available. Some growers use two different cell sizes, the larger cell size for the crops they expect to harvest earlier, and the smaller cell size for crops they expect to harvest later.

**Seeding and Growing**

Most vegetable transplants are sown one seed per cell. As a general rule, plant vegetable seeds at a depth two times their diameter. Vegetable seeds vary in their temperature requirements; most vegetable seeds germinate in the 70 to 90°F range. The time from seeding to transplanting varies from 3 to 4 weeks (e.g., muskmelon) to 10 to 12 weeks (e.g., celery). Vegetable seed may be ordered with special features, including seed priming and pelleting. Primed seed have been partially hydrated and then dried down, resulting in earlier germination and better uniformity. Priming may be
useful for hard-to-germinate seed such as triploid watermelon. Seed may be pelletized to make it easier to handle. In this process, varieties with small seed or irregular seed such as lettuce are coated to make the seed larger and uniform in size and shape. This process makes mechanized planting easier.

The growing mix should be well-drained and free of disease-causing organisms (pathogens). Most commercial mixes fit this description and perform well. These mixes are often referred to as "soilless mixes" since they are composed primarily of peat or coconut coir, perlite or vermiculite, and sometimes bark or ash. These mixes usually come in bales or bags and have been pasteurized (sufficiently heated to kill soil microorganisms capable of causing disease problems). It is advisable to test the mix before using it to make sure the pH is within an acceptable range (5.5 to 6.5) and to determine the initial nutrient content of the mix.

Most mixes include a small amount of fertilizer, but transplants usually benefit from additional regular fertilization with N, P, and K once true leaves appear. Depending on the initial nutrient level in the mix, including Ca and Mg in the fertilizer solution may also be advised. Soluble synthetic fertilizers (21-5-20, 20-10-20) and liquid organic fertilizers (fish emulsion) are commonly used. The best rate, frequency, and method of fertilization will depend on your potting mix and watering practices. Common alternatives include a 50 to 200 ppm N solution applied at every watering or a 300 to 500 ppm N solution applied weekly. To make a 100 ppm N solution, use 0.42 lb. (6.6 oz.) of a 20% nitrogen fertilizer for 100 gallons of water. Over-application of nitrogen in the ammoniacal form can be detrimental to transplants. This problem can be minimized by not over-applying N and by using fertilizer that contains most N in the nitrate form. Check the bag label.

Transplants that are too tall and tend to fall over are often referred to as "spindly," "shanky," or "leggy." Such transplants may have low survival rates in the field. Spindly transplants are produced under low light conditions, high fertilizer rates, and/or overwatering. Greenhouse structures that let inadequate light in or cloudy weather could be the culprits. Artificial lights could be helpful during inclement weather, but may be cost prohibitive. Use a fertilizer containing a lower percentage of P. For instance, try 21-5-20 rather than 20-20-20. It is important to provide adequate P, but not too much. Underfertilization with P will produce short plants, but yields will also suffer. Hot days and cold nights favor leggy transplants. If night temperatures are equal to or higher than day temperatures, stem elongation will be reduced. It may be sufficient to lower the temperatures for a two-hour period starting at dawn.

To prepare transplants for the harsher environment of the field, it is necessary to harden them off. Transplants may be hardened off by withholding water and lowering the temperatures moderately during the last week or so of growth. Some growers place transplants in wagons and wheel the transplants outside on appropriate days to get the plants used to field conditions. The transplants are wheeled back inside during nights and especially harsh weather.

Transplants should be irrigated as soon as possible after transplanting. Some transplanters are equipped to irrigate transplants at the time of transplanting. Otherwise, arrange to irrigate soon. Applying a small amount of starter fertilizer in the transplant water is often beneficial. See Fertilizer Recommendations, p. 3, for starter fertilizer recommendations. If transplants are held in the greenhouse to replace those that don't survive, remember to avoid using transplants that have begun to vine or flower.

Diseases

Diseases that are likely to affect vegetable transplant production in Midwest fall into two types: damping-off diseases caused by soilborne fungi and transplant diseases usually associated with fungi or bacteria which survive with seed or plant residue. Both types of diseases can cause extensive transplant loss.

Damping-off may occur before or after seedlings emerge from the soil. Pre-emergence damping-off occurs when fungi infect seeds as they germinate. As infection progresses, seeds rot and eventually disintegrate. Poor stands become apparent several days or weeks later.

Post-emergence damping-off is usually observed in seed flats or among transplants. Fungi infect stems at or near the soil surface. The affected area of the stem takes on a water-soaked appearance and sometimes becomes constricted. Eventually, the stems are unable to maintain structural support of seedlings, which usually collapse and die within 24 to 48 hours.

Damping-off can be caused by any or all of three groups of soil borne fungi, *Pythium*, *Rhizoctonia*, and *Fusarium*.

The following are control measures to prevent damping-off diseases:

- Use uncontaminated soil mix. Use a commercially prepared soilless growing mix sold in 3-4 cu. ft. bales or bags. A common mistake is to open a bag of "clean" soil mix and place it on a dirty floor or some other unclean surface prior to planting. Remember that your soil is only as clean as the dirtiest surface with which it has come into contact.
- Plant seeds shallow and in warm soil.
- Use soil mixes that drain well.
Table 1. Vegetable crops frequently grown as transplants and the diseases that are most often observed on the seedlings. The pathogens that cause these diseases may be borne on the seed.

<table>
<thead>
<tr>
<th>Vegetable Crop</th>
<th>Disease</th>
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<tbody>
<tr>
<td>cabbage</td>
<td>black rot</td>
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<tr>
<td></td>
<td>Alternaria leaf spot</td>
</tr>
<tr>
<td>cucumber</td>
<td>angular leaf spot</td>
</tr>
<tr>
<td>muskmelon</td>
<td>anthracnose</td>
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<tr>
<td></td>
<td>gummy stem blight</td>
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<tr>
<td>pepper</td>
<td>bacterial spot</td>
</tr>
<tr>
<td>tomato</td>
<td>bacterial canker</td>
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<tr>
<td></td>
<td>bacterial speck</td>
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<tr>
<td></td>
<td>bacterial spot</td>
</tr>
<tr>
<td>watermelon</td>
<td>anthracnose</td>
</tr>
<tr>
<td></td>
<td>gummy stem blight</td>
</tr>
<tr>
<td></td>
<td>watermelon fruit blotch</td>
</tr>
</tbody>
</table>

Seedborne/residueborne diseases affect most vegetable crops. The pathogens (disease-causing microorganisms) that cause these diseases survive in seeds or plant residues, not in soil mixes. Outbreaks of these diseases often show up as clusters of diseased plants. Symptoms often include brown lesions with yellow halos on leaves. In contrast, environmentally induced problems often occur uniformly throughout the seedlings or only in one location (for example, close to an outside wall).

Several different fungal or bacterial pathogens may be introduced into a transplant facility via contaminated seed or transplants (Table 1). Once introduced, these pathogens may continue to cause problems year after year if proper precautions are not taken.

Several measures should be taken to minimize or prevent the introduction of a seedborne/residueborne pathogen into a transplant facility.

- Avoid saving seed unless you are specifically trained and equipped for seed production.
- Frequently inspect seedlings as they are growing.

- Separate seedlots from one another. Save all information regarding seed purchases.
- Irrigate in the morning to ensure drying of soil and leaf surfaces.
- Check the label for specific mention of greenhouse use when treating transplants with fungicides/bactericides.
- Use good sanitation. Plant pathogens often survive in soil and plant residues. Therefore, sanitation is as important for a greenhouse as it is for a kitchen. Greenhouse floors should be as free of soil and residue as possible; plastic or cloth floor coverings provide a barrier between dirt floors and transplants. Transplant trays and flats should be new or cleaned and disinfected before each transplant generation.

Growers who want more detailed information on disease prevention and control in the greenhouse may refer to the Purdue Extension publication “Preventing Seedling Diseases in the Greenhouse,” <www.agcom.purdue.edu/AgCom/Pubs/BP/BP-61/BP-61.html>.