



Vegetable Transplant Production

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Transplants are widely used in commercial vegetable production systems. There are several advantages to producing transplants including 1) growing quality plants under protection before setting out in the field, 2) more efficient use of expensive seeds, 3) providing optimal conditions for plant growth that may not occur in the field, 4) growing specific varieties that may not be available locally, 5) eliminating the importation of diseases that do not occur locally, and 6) ensuring ideal plant populations in the field that may be difficult to achieve from seeding.

This bulletin will help you better understand those things needed to grow quality (compact, well rooted, healthy) transplants (Figure 3, right). It introduces things to consider or address when producing vegetable transplants. Transplants are commonly grown in greenhouses. Success depends on knowing the right conditions needed for the crop of interest so the plants are the correct size, are healthy, and capable of withstanding the transition from the greenhouse to the field. The following sections will be briefly covered in this bulletin.

- Transplanting Tray Selection
- Transplant Age and Scheduling
- Growing Mixes and Soil Media
- Seeds and Seeding
- What Transplants Need
- Diseases and Other Problems
- Conditioning or Hardening Transplants

Transplanting Trays

Most vegetables can be grown in any size (number of cells) tray but some sizes are more appropriate.

Tray cell size influences field performance, especially earliness. Large cells provide more room for plant root growth, thus allowing larger, more mature (older plants) transplants without the plants becoming spindly or root bound. Larger transplants generally mature earlier because they are older but may not produce the highest yield. Larger cell size trays also take up more greenhouse space, require more time in the greenhouse, and thus are more expensive to grow.

Plastic trays are the most common (Figure 1, left), come in a range of cell numbers, and are preferred as they are easy to handle and are cost effective. Styrofoam transplant trays and individual pots are more expensive but are used in some instances. Soil blocks, pressed peat pots, or expandable soil pellets (Figure 1, center and right) are other options. Deep-celled trays have a larger volume thus they store more water and fertilizer and may be easier to manage. Deeper cells tend to promote faster growth. With deep trays, it is important to water thoroughly. Regardless of the cell dimensions, make sure the media is wet to the bottom of the plug to promote complete root growth. Shallow cells or trays with high cell numbers need to be watched carefully so they do not dry out. Do not mix deep and shallow cell trays on the same bench, or trays with different number of cells. Mixing tray/cell types makes it more difficult to manage plant growth and ensure proper watering and fertility needs. Regardless of the container used, the idea behind growing transplants in a container is to produce a quality plant that minimizes root disturbance when transplanted to the field.



Figure 1. Various sizes trays (left), peat pot (center), and expandable pellets (right) used for vegetable transplants.

Transplant Age/Scheduling

The optimum age for vegetable transplants depends on both the crop and the tray or container cell size. Growers must adjust their growing practices and schedules for different vegetables and cell sizes. Table 1 provides some general guidelines for transplant production in various cell sizes. Remember that the date of seeding transplant trays depends on the date the transplant will be planted into the field.

Plant hardiness and local climate conditions will determine when to start sowing in the greenhouse. Details on local climate conditions for Utah, including last spring and first fall freeze, and freeze-free periods can be found at the Utah Climate Centers website <https://climate.usurf.usu.edu/reports/freezeDates.php>. You can use this information to help plan plant production to meet local planting schedules.

For instance, if it takes 6-7 weeks to grow a tomato transplant (Table 2), count back 6-7 weeks from your expected field transplanting date and sow the seeds in the greenhouse. If you live near Logan, the average last spring freeze occurs between May 7 and 24. Knowing some details about your location is important considering the range of the last spring freeze for this location. The more information you have, the better you can schedule greenhouse sowing and field planting. Seeding dates in the greenhouse for Logan could be anytime between March 19 and April 5. With more specific

information, you can select a date that provides enough time to have plants ready for planting closer to your location's average last spring freeze.

Growing Mixes/Media

Do not use field or garden soil to grow vegetable transplants. Field soil lacks good structure, may contain pests and diseases, and will have weed seeds, thus transplant growth will be poor. Be careful about how much compost you use in the mix. Some composts have high salt content which may reduce seed germination and growth. In addition, you should know the nutrient content so you can adjust your fertilizer program to meet the plants nutrient needs. Finally, if the compost has not been properly pasteurized, it may harbor diseases, insects, and weeds. If you need to produce organic transplants, consult the ATTRA publications on *Potting Mixes for Certified Organic Production* and *Plug and Transplant Production for Organic Systems*. These will provide detailed guidelines that meet the National Organic Standards.

Ideally the growing media or soilless mix is made up of peat, vermiculite, and horticultural perlite. Peat helps with water retention while vermiculite and perlite provide drainage and aeration. Together, they promote better root development. Soilless mixes containing fertilizer or compost are options, but they make it more difficult when designing the fertility program for transplants. Media or mixes with no or low-nutrient allow more control over growth since it is easier to add the fertilizer than to

Table 1. Some general guidelines and suggestions regarding transplant production.

Crop	Suggest Tray Size	Seeding Depth (in)	Seed Needs for 5000 plants¹	Transplanting Tolerance²
Asparagus	50, 72	¼	10 oz.	Survives Well
Brassica Crops (broccoli, cabbage)	128, 200	¼	0.75 – 1.25 oz.	Survives Well
Cucurbits (cucumber, melons, squash)	72, 128	¼ - ½	4 – 40 oz.	Special Care Required
Greens (chard, lettuce, spinach)	128, 200	⅛	2 – 4 oz.	Survives Well
Bulb Crops (leeks, onions)	200, 288	¼	0.33 – 0.5 oz.	Survives Well
Solanaceous Crops (eggplant, pepper, tomato)	50, 72, 128	¼	0.5 – 1 oz.	Survives Well to Some Care

Adapted from Knott's Handbook for Vegetable Growers

1-Check with supplier before purchasing to determine actual number of seeds per ounce.

2-Measure of how easy or well the plants survive after transplanting.

Table 2. Optimum germination temperature, time for seed germination, plant growing conditions, and times for different vegetable crops.

Crop	Optimum Germination Temperature Range: Soil (°F)	Days to Seedling Emergence	Plant Growing Temperatures (°F)		Time to Grow (weeks)
			Day	Night	
Asparagus	75-85	7-10	65-75	50-60	10-12
Brassica Crops (broccoli, cabbage, kale)	70-80	5-7	60-70	50-60	5-7
Cucurbits (cucumber, melons, squash)	75-95	3-6	70-80	60-70	4-6
Greens (chard, lettuce, spinach)	60-70	2-4	55-75	45-55	5-7
Bulb Crops (leeks, onions)	65-80	6-10	60-70	45-55	8-10
Solanaceous Crops (eggplant, pepper, tomato)	75-85	5-10	65-80	60-70	6-8

Adapted from Knott's Handbook for Vegetable Growers (4th Edition)

remove what others have added. There are lots of commercial mixes on the market for starting and growing transplants. If you make your own mix, consider equal parts peat, perlite, and vermiculite.

Seeds and Seeding

Always buy high quality, vigorous seeds since seed cost is a low percentage of the total cost of growing the transplant. If seed is to be stored, proper storage

conditions must be provided to maintain seed vigor and viability. Seed vigor refers to how quickly and uniformly the seed emerges from the soil, especially under less-than-ideal conditions. Seed viability is a measure of how many seeds are alive (germinate or emerge). Therefore, high quality seeds with high germination are best when growing transplants. Table 1 provides some indication of the quantity of seed needed to grow 5000 transplants. Many seed

companies have developed processes for enhancing the germination, vigor and uniformity of seed lots. Seeds are regularly primed, pelleted, and treated with fungicides and/or insecticides to improve early performance, help improve seed handling, and protect them from common seedling diseases. The use of these enhanced seeds can help maximize plant production per unit of greenhouse space.

Having selected your trays and seeds, it is best to fill them with pre-moistened growing media. The media should be uniformly packed, then “dibbled” to make a uniform depth for the seed (Figure 2, left). You can make your own dibble board unique to the trays used or purchase commercially

manufactured boards. Seeds are commonly planted between 1/8" to 1/2" deep depending on the species (Table 1). After seeding, cover the seeds with additional soil mix or medium-grade vermiculite. Vermiculite is preferred because it is easy to apply evenly, allows good aeration, and does not support algae growth, or restrict seedling emergence, and does not allow root growth between cells. Water the trays thoroughly before placing in the greenhouse, on heating pads, or in the germination chamber. Some growers use hot water to raise the temperature of soil mix and start the germination process. Water trays with warm water if possible during early growth-stages. Water should be about 65-75 °F.



Figure 2. Dribble board (left), heating pad under seedlings (center), and simple heated germination chamber (right).

Heating pads or a germination chamber (Figure 2, center and left) can significantly improve seed germination, early plant growth, and plant uniformity compared to placement in the greenhouse. Germination chambers are best insulated to control temperature and relative humidity at levels appropriate for the crop. The confined area also minimizes the cost of heating the greenhouse to germination temperature. Good air circulation is important to ensure uniform temperature and humidity throughout the chamber. Germination time will vary between seed lots, so check the trays regularly. Move the trays to the greenhouse after the root cracks the seed coat but before shoots emerge from the soil. Leaving the trays in the germination chamber too long (until seedlings emerge above the soil) results in

excessive stem elongation and “leggy” or floppy plants. Trays should only be in the chamber for 2 or 3 days (36-72 hours depending on the crop).

Once removed from the germination chamber, trays are moved to the greenhouse for growing out. Production times vary by crop species, depend on day/night temperatures, and other management practices (Table 2). Trays are commonly grown on benches and sometimes on cement floors. Keep trays off soil or the ground to prevent root growth through the bottom of the cells. Disease problems are easier to manage when trays are grown on benches. The floors or benches should be level to prevent water from running into low spots.



Figure 3. Non-uniform (left) vs. uniform (center) seedling growth in the greenhouse. Non-uniform conditions result in erratic seedling emergence, uneven plant height, and variable leaf emergence. High quality, well rooted transplants (right).

Transplants Needs

The growing stage is defined as the period of growth from seedling emergence until plants are hardened-off prior to field transplanting. During the growing stage, transplants need the right environmental conditions (temperature, ventilation, light), good watering practices, and the correct fertility to optimize plant growth and quality.

Environment Issues

Trying to raise a variety of different vegetables within the same greenhouse environment can be a challenge since each crop has its own unique environmental requirements (Table 2). Mixing cool temperature liking brassicas with warm loving solanaceous crops makes it hard to standardize conditions unique to each. Wherever possible, grow crops with similar requirements together so they can be managed alike. Note the different vegetable crops response to optimum day and night growing temperatures (Table 2) and use this to help standardize crop management decisions. Ideally, conditions from seeding through emergence should be appropriate for the specific crop so plants are uniform across the tray and bench (Figure 3, left and center).

Warm-season vegetables (cucurbits and solanaceous crops) get chilling injury when exposed to temperatures above freezing but below 50 °F for an extended period. Chilling causes stunting of growth and can effect field establishment. For these types

of crops, maintain a minimum greenhouse temperature of 50 °F.

One method of managing plant growth is to expose plants to different day/night temperatures (DIF) in the greenhouse. Higher day than night temperature gives a positive DIF and promotes growth while a lower day than night temperature gives a negative DIF which retards growth. High temperatures early in the day can cause considerable stretching in vegetable transplants, so keep mornings slightly cooler to minimize growing “leggy” plants.

Some ventilation may be needed in the greenhouse particularly on bright, cold days. Without air exchange, CO₂ levels may drop which reduces growth (lower photosynthesis), and humidity levels may become elevated which increases disease potential.

Plant growth control is important because elongated transplants are more susceptible to stresses after field planting. “Leggy” plants are the result of too much heat, low light conditions, over-fertilizing, and/or overwatering. While light management is difficult and supplemental lighting is expensive, transplants growing in bright conditions are more robust, have thicker stems, have more leaf waxes, and begin re-growing sooner after transplanting in the field. If plants seem to be “leggy” check the cleanliness of the glass or plastic on the greenhouse to be sure they get sufficient light.

Water Issues

Make sure you use high quality water, test for pH, salt levels, and nutrient content of the water supply. Ideally, water should have a pH of 6.5 - 7.5. At these levels, micronutrients are more available. Hard water may need supplemental treatment as well. Tests will also tell the EC (electrical conductivity) or Total Salts of the water (combination of all cations and anions). The EC should be less than 2.0 and ideally lower than 1.0. High values may burn the roots due to high salt content, and remember, when you add fertilizer to the water, you are raising the EC. Finally, some water sources have high nitrate levels due to ground-water contamination or natural deposits. Knowing the nitrate concentration provides a starting point before adding extra nitrogen fertilizer to the water.

The amount of water and frequency of irrigations depend on cell type, growing media, greenhouse environment, ventilation, sunlight, and plant size. It is important to water trays thoroughly, moistening the entire plug, which promotes root growth to the bottom of the cell. Allow the plug to partially dry down before re-watering, but do not let the plants wilt, as wilting damages both the shoots and roots. Water thoroughly, preferably in the morning. Plants may need water late in the afternoon, but try to time the watering so leaves do not remain wet overnight.

Fertilizer Issues

To grow high quality plants an appropriate fertilizer program is needed. Well-grown transplants will have adequate nutrient reserves in their stems and leaves to ensure rapid establishment under a wide variety of field conditions. Vegetable transplants are usually fertilized with soluble fertilizer which is applied with the irrigation water. Most soluble fertilizer mixes vary in percent nitrogen (N), phosphate (P_2O_5), potash (K_2O), and micronutrients. A common fertilizer concentration of 100 parts-per-million (ppm) of N, P, K is suitable for most vegetable transplants. This should maintain steady growth. Increasing or decreasing the ppm can speed up or slow down growth.

Transplants should be watered daily and fed periodically to promote the desired amount of growth. Fertilizer requirements vary depending on cell size (larger cells require less fertilizer), and the initial nutrient levels of the growing media (any

fertilizer in the media). The different vegetable crops vary in their response to fertilizer, so the fertilizer program should match the crop. The brassica crops are low fertilizer users and may need one to two applications per week. The cucurbits grow quite fast and may only need five to six total applications. The leafy greens grow too vigorously when fertilized regularly so feed about two times per week. The solanaceous crops have modest fertilizer needs and require two to three applications per week. It is best to watch how the plants are growing and tailor the fertilizer program to achieve acceptable plant quality without encouraging excessively vigorous (soft) growth.

Diseases and Other Problems

Diseases occur frequently when growing vegetable transplants. The primary way of controlling diseases is by good sanitation and careful management of the greenhouse environment. Always control weeds inside and outside the greenhouse as most harbor disease organisms. Do not reuse trays unless they are washed, dipped in chlorine bleach (10%) or a registered disinfectant, and thoroughly rinsed to remove toxic residues.

Ventilating the greenhouse daily promotes air movement and reduces humidity. Overwatering is the most common problem contributing to disease. Too much water results in seed rots and damping-off disease. If damping-off or foliar fungal diseases are not controlled by better water or humidity management, treat with approved fungicides. Use only registered products, rates and application information for disease management of vegetable transplants in the greenhouse. Water plants thoroughly in the morning and "spot water" in the afternoon. Never water in the evening. Dry leaves are less likely to get foliar fungal diseases. Maintain steady plant growth through proper nutrient management as over-fertilization makes plants more susceptible to diseases.

Greenhouses should be equipped with a sprayer dedicated to herbicides and another sprayer only for fungicides and insecticides. Otherwise, contamination may occur and cause serious damage to greenhouse plants. Weeds inside and just outside the greenhouse should not be sprayed with herbicides. Fumes may drift or be sucked into the greenhouse and impact the seedlings growing there. Do not spray trays that are left outside or store trays

near herbicides. Plastics absorb the herbicides and these contaminated trays cannot be cleaned effectively.

Be sure heating equipment in the greenhouse is running properly. Natural gas, propane, wood, or oil, when not completely burned or ventilated properly, gives off gases that are injurious to plants. Young transplants are especially sensitive. Plants that turn yellow, are stunted, or have leaf edges and tips that become dried and blackened, may be “sick” from these off-gasses. Tomato plants are very sensitive to “off-gasses” and are “good” indicator plants for this problem.

Watch for problem insects in the greenhouse. Fungus gnats are not “nuisance pests” but cause serious root damage and can spread several root diseases. Aphids can become a problem as well. Regularly check plants for insects and set out yellow sticky cards to help monitor insect populations. If populations get severe, treat plants with approved insecticides. Use only registered products, rates and application information for vegetable transplants in the greenhouse.

Algae or mold can sometimes become a problem on the surface of soilless mixes. Covering seeds with vermiculite can help prevent algae from forming. Algae is mostly a problem during cool, damp, overcast weather. Hydrated lime spread underneath the benches and good weed control in the greenhouse will prevent algae from growing. Finally, keep your eyes out for rodents. Mice and voles may set up “house” in the greenhouse and feed on young seedlings. They can do a lot of damage in one night.

Conditioning/Hardening Transplants

Conditioning or hardening are approaches used to prepare transplants for the vastly different conditions found in the field. Conditions in the field are often colder or hotter, more windy, and wetter or drier than the greenhouse. During conditioning, transplants accumulate carbohydrate reserves in their stems and build up a waxy cuticle on their leaves allowing them to better withstand these harsh conditions. The goal of conditioning plants is to slow the growth of the plants, not to stop growth completely.

One common conditioning treatment is to reduce the greenhouse temperature through ventilation. Ventilation also increases air movement which helps harden plants. However, do not reduce the temperature below 50 °F for crops that are chilling sensitive like tomato or watermelon. It is common practice to move plants outside to help condition them. If the temperature outside is likely to fall below 50 °F, bring plants back inside. Cool season crops like cabbage and lettuce can be over conditioned when the temperature falls below 40 °F. If exposed too long to these cold conditions, the brassicas may receive enough chilling to transition the plant from vegetative to reproductive growth, which is undesirable. Remember, you just spent several weeks growing high quality plants. Over conditioned transplants resume growth slowly, may not mature as uniformly, and often produce lower yields than non-conditioned or moderately conditioned transplants.

One can also condition transplants by reducing the amount of water provided. Slowly dry out the soil mix but do not let plants wilt excessively. Watering every other day rather than daily may be sufficient to slow plant growth. You can also harden-off transplants by withholding fertilizer provided the plants are not starved. If plants were grown with 100 ppm of fertilizer, reduce this to 50 ppm to slow growth. Excessive nutrient starvation can significantly delay field establishment and plant regrowth.

Some growers use mechanical stimulation to toughen plants. Though not widely used, the goal is to bend the plants without tearing leaves or breaking stems. This repeated stimulation slows leaf expansion, stiffens the stems, and encourages wax buildup on the leaves. Brush the plants by hanging plastic or some other material from irrigation booms and operate the booms frequently (10 or 20 times per day) by dragging the plastic over the plants. You can also use a wooden dowel, PVC pipe, fiberglass rod, or your hand to brush the plants. Always be sure the plant leaves are dry before mechanical stimulation so you do not spread disease.

Finally, transplants can become acclimated and conditioned to field conditions by exposure to full sunlight. Transplants may not receive full sun in the greenhouse so moving them outside also helps build up leaf waxes. Protect them from drying winds,

check them regularly, and water as needed. For cool season plants, if frost is forecast, move the plants inside. Warm season plants should be moved inside if temperatures are forecast to go below 50 °F

There is some evidence that suggests transplants do not need any conditioning before planting to the field. If plants are growing at a steady pace, have been grown in a bright, well lit greenhouse, have been watered and fertilized appropriately, they establish as well as conditioned plants. If the transplants were raised in less than ideal conditions, some conditioning is warranted to ensure they withstand the transfer from the greenhouse to the field.

Quick Facts

- Growing high quality transplants requires attention to detail.
- Use quality soil media and the right size tray for the plant. Seed at the proper depth and germinate the seeds at the correct temperature.
- Do not allow seedling to emerge from the soil in the germination chamber or on heating pads. This contributes to “leggy” growth.
- Grow plants at the right greenhouse temperature for the species and maintain uniform growth with proper water and nutrient management.
- Watch for disease and insect problems and keep production areas weed free.
- Conditioning or hardening treatments can prepare plants for field conditions. However, over hardened transplants are slow to resume growth.

Additional Resources

- Greer, L. 2005. Plug and Transplant Production for Organic Systems. National Sustainable Agriculture Information Service. IP160. <https://attra.ncat.org/horticultural.html>
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