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GrowingGrowers

Growing Your Own Vegetable Transplants

Small-farm and farmers-market growers may benefit from growing their own vegetable transplants. On-farm production offers greater control of planting date and variety selection and reduces the risk of inadvertently introducing pathogen spores or weed seeds on plants transported from other farms. Selling plants at the farmers market can provide early-season revenue and diversify farm income, but it may not be suitable for all growers because of potential risks.

Though not required, a greenhouse is useful for growing transplants. A four-season high tunnel, or hoop house, also works well as an unheated area for "hardening" transplants and as a growing space when heated.

Common transplants include cucurbits (squash, cucumbers, and melons), solanaceous crops (tomatoes, peppers, and eggplants), brassicas (broccoli, kale, and cabbage), as well as lettuces and strawberries. A small-scale grower can be creative in designing a plant propagation system. This publication is for commercial and "hobby farm" growers who want to grow their own vegetable transplants.

Figure 1. Cool-season vegetable transplants (lettuce, broccoli, cabbage) propagated in a certified organic high tunnel.

Transplant Propagation Stages

Plants have different needs at different stages in their development. This section describes growth stages and what plants need at each.

Seed

A seed contains both genetic material for transplant development and stored carbohydrates that provide energy for germination and growth before leaves form and become photosynthetically active. As seeds, plants survive for long periods of time. Most vegetable seeds will remain viable for several years under proper conditions. (Onion seed is an exception and loses viability in 1 to 2 years.)

To remain dormant, seeds should be kept cold and dry and can be stored in the freezer. When handling seed, count or weigh seed before storing to ensure leftover seeds stay dry and have been stored properly. Over time, vegetable seed loses viability and the germination rate declines. It is important to start with disease-free seed.

Germination

Compared to flowers and especially native species, vegetable seed is relatively easy to germinate given the right conditions. Germinating seed is highly sensitive to environmental stressors such as heat (temperatures above 90° F) and low soil moisture.

Vegetable crops take about 1 to 5 days to germinate. Most vegetable crops require darkness for seed germination, so seed must be buried sufficiently. If buried too deeply, the seedling may have difficulty emerging before carbohydrates stored in the seed are depleted. Proper planting depth is indicated on the seed packet or available from the seed dealer.

Germinating seed typically requires very high (>95%) relative humidity and soil moisture. This can be accomplished in a number of ways as described later in this publication. Supplemental fertilizers are NOT required and actually may inhibit germination.

Shoot Elongation

After the seed germinates, hypocotyl (shoot) and radicle (root) shoots form and begin to grow. The plant draws on storage reserves within the seed to develop the first roots and a shoot that emerges from the soil (Figure 2). This process occurs directly after germination and takes 1 to 3 days. Similar to germination, plants are highly sensitive to environmental stress and susceptible to disease. During shoot elongation, high humidity should be maintained, but it is not as critical as during germination. By the time the cotyledon (seed) leaves open, the seedling should have good access to light and will grow at typical humidity levels (50% to 80% relative humidity). Similar to germination, the plant requires little or no fertilizer at this stage. Low doses should be applied later when the first true leaf develops.

Figure 2. Pepper seedlings emerge from the soil during the shoot elongation growth stage.

True Leaf Stage

After the cotyledon (seed) leaves develop, the first "true" leaf grows and a meristem (growing point) forms to produce new leaves (Figure 3). Once this occurs, the plant requires high-light conditions as provided by a greenhouse or cold frame with full exposure to the sun. Plants at this stage also require supplemental fertilization (50 ppm nitrogen) but can be highly sensitive to nutrient toxicity.

Transplant Growth

Depending on the crop and growing environment, it may be 1 to 7 weeks before the plant is ready to set in the production system. Cucurbit crops are typically ready for the field in 1 to 2 weeks, and solanaceous crops in 4 to 5 weeks if given sufficient light and nutrients needed for proper growth. Fertilizer containing 100 to 150 ppm nitrogen should be applied weekly. Plant growth is dependent on temperature and nighttime minimum temperatures, in particular. If available, plants should be grown in an area with good ventilation and protection from damaging winds.

Hardening and Acclimation

Before a transplant is set in the field it must be properly acclimated to environmental conditions. Transplant stress can occur due to low soil moisture, wind, heat, and a greater amount and spectrum of light. The plant should be introduced to these variables gradually over 7 to 10 days to make sure it is ready for field conditions. A cold frame or hoop

Figure 3. Tomato seedlings with one to two true leaves are photosynthetically active.

house is an ideal environment for hardening transplants because it provides exposure to cool nights, high light, and some wind.

Transplant Size and Age

Pots and trays for transplants are available in a variety of styles and sizes. Size requirements vary depending on the crop, and those prone to becoming root-bound benefit from larger cells.

For vegetable production, propagation trays with 48, 50, or 72 cells are typical because they are made from single sheet and easy to manage during large-scale planting. For growing in plasticulture or on fabric, smaller transplant plugs produced from small 50- or 72-cell trays are beneficial to reduce the size of the hole required for planting (Figure 4) or for compatibility with waterwheel or mechanical transplanters. On the other hand, high tunnel growers may prefer larger transplants that provide an early growth advantage over smaller transplants.

In each case, transplant size and age requirements will vary depending on the application. Transplants grown for sale at the farmers market may need to be more uniform and larger than those for crop production to suit the preferences of home gardeners. One important consideration when propagating transplants is that overly large and root-bound plants often perform poorly when planted in the field. Seeding and transplanting schedules that coincide with field plantings during the optimum transplant stage is critical to the successful production of vegetable transplants.

Figure 4. This newly set tomato transplant is the ideal size for planting and not root-bound.

Figure 5. Vegetable propagation structures. (A) Passive solar greenhouse (B) High tunnel with fixed (temporary) sidewalls and a propane space heater.

Equipment and Supplies

Greenhouses

One of the main barriers for many small farm and urban growers is access to heated greenhouse space. Greenhouses vary substantially in size, structure, cost, and purpose. Small-scale vegetable growers can use passive-solar greenhouses for transplant propagation (Figure 5A). A plastic-covered high tunnel (hoop house) can be used as a coldframe or heated and used like a greenhouse (Figure 5B). If substantial heating is anticipated, sidewalls and end walls should be sealed (as opposed to rolled-up and down).

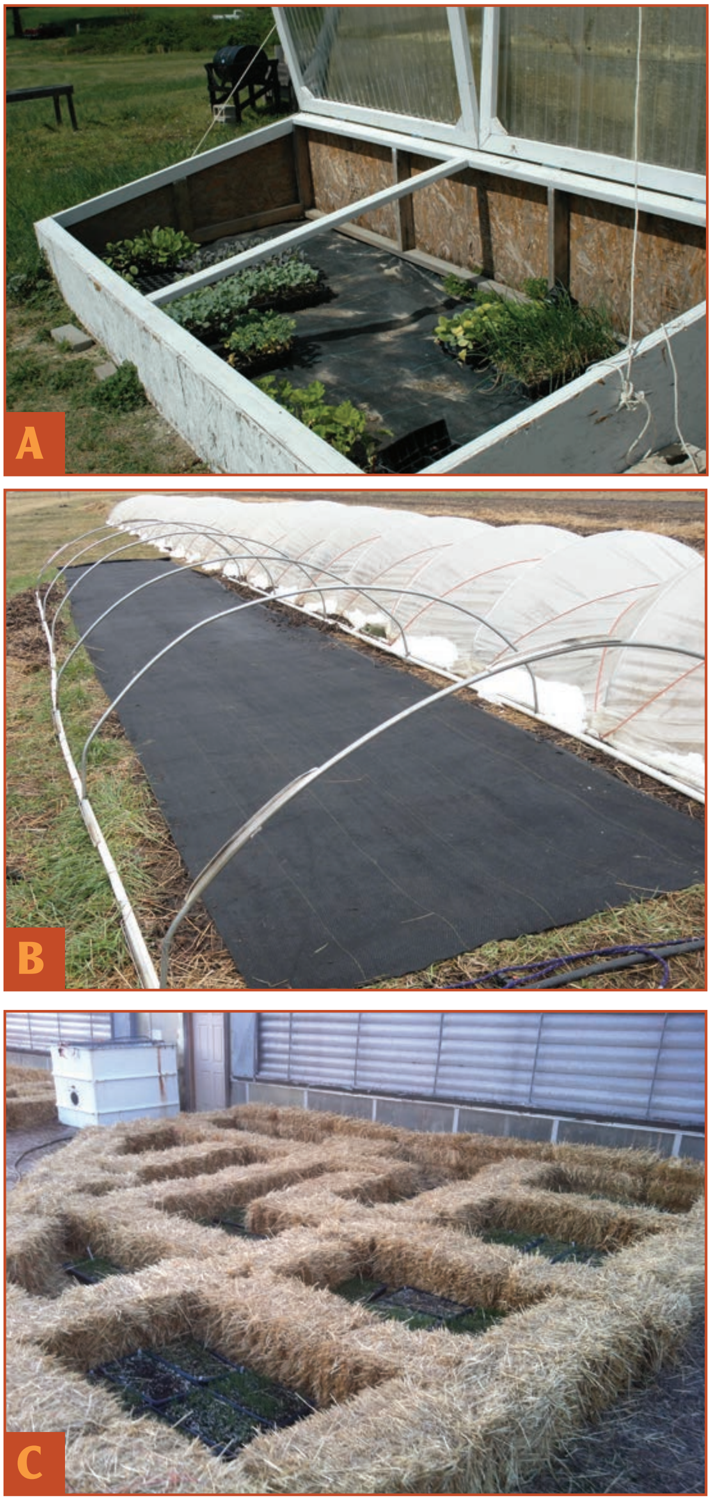

Figure 6. Types of cold frames. (A) Wooden structure with a clear roof that allows sunlight to enter on cold days and can be removed on warm days. (B) Low tunnel with weed fabric that is ventilated early in the morning to prevent the structure from becoming too warm. (C) Straw bales placed around young transplants to protect them from the wind. Row cover and/or plastic can be added at night for protection from frost and freezing temperatures.

Otherwise, traditional greenhouses can be easily designed for vegetable production. Heating should be reliable as vegetable transplant production begins 60 to 90 days before planting. Greenhouse cooling systems typically are not required to produce high-quality vegetable transplants in the Midwest.

Cold Frames

If a greenhouse is not available, a cold frame (Figure 6A), with a heated indoor seed germination area is adequate for a small number of plants. A cold frame does not protect plants on extremely cold nights. Warm-season crops are at risk when temperatures drop below freezing (<30° F). Cool-season crops can tolerate colder temperatures and survive in a cold frame at temperatures of 18° F to 20° F. Small-scale growers or home gardeners may want to move plants indoors to a a garage or shop area on cold nights and move them back outside during the day. Some growers use low tunnels that can be removed on sunny days for optimum growth in the spring (Figure 6B). Straw bales can be used as windbreaks, and row cover or plastic can be applied at night to protect plants from frost (Figure 6C).

Germination Chamber

Growers have options for seed germination both in the greenhouse and other areas of the farm. Soil should be kept warm, and preferably heated from the bottom. Although not required for vegetable crop germination, heating mats may help reduce damping-off diseases and hasten germination (Figure 7A).

A simple germination setup consists of a germination/ heating pad with thermostat and fluorescent light fixtures (Figure 7B). The light fixture is not necessary in the greenhouse. Foam insulation, which can be seen in the background of Figure 7A, keeps the sun from becoming too warm during germination and shoot elongation.

A walk-in cooler can be used to germinate seeds in early spring. A small space heater with thermostat provides just enough warmth for germination. Once seedlings begin to emerge, they can be moved to a greenhouse where they can receive adequate light.

Propagation Supplies

Tools and supplies for seeding growing transplants include soil blocks and custom potting mixes pressed into preformed cubes. There are plastic or styrofoam containers for vegetable propagation. The type of container depends on the application and size requirements. Styrofoam or rigid plastic trays can be reused to reduce waste. Clean between crops with hydrogen dioxide, quaternary ammonium, or other greenhouse products to reduce damping-off and other plant diseases. Household bleach (diluted 1 part bleach to 10 parts water) works, but pots should be rinsed soon afterwards. Bleach can be more difficult to work with and loses effectiveness quickly when organic matter is introduced to the solution.

Figure 7. Tools to encourage germination. (A) Heating mats with natural sunlight in a greenhouse. (B) More complex germination units with fluorescent lights.

Soilless Potting Media

High-quality potting mix (or media) is important for successful propagation. At all growth stages, a developing plant needs access to oxygen and water and physical space to grow. Transplant mixes should be light and highly porous to allow for the oxygen needed to help plant roots absorb water. Transplant mixes typically contain a product such as peat, coir, or pulverized bark treated with a wetting agent. Wetting agents are surfactants that allow water to "stick" to the base material, which in most cases is peat. Media manufacturers use yucca extract as an organic wetting agent for potting mixes for certified organic growers. (Check with your certifier to see what is permitted.) This works well as long as media does not get too old.

Compost contains surfactants and can be added at low rates (5% to 10% by volume) to custom (untreated) commercial mixes. Many organic growers blend their own mixes, adding compost as one of the components in potting mix recipes. These materials are combined with others that help improve porosity, supply nutrients, and provide a favorable environment for germination and root growth. Combinations of perlite and vermiculite increase porosity in the media.

Typically, nutrients are provided through the potting mix either as incorporated materials (granular fertilizer, feathermeal, soybean meal) or by water soluble applications. It is critical that the media supplies ample nutrients. Little fertilizer is needed during germination and too much can be detrimental. Seedling mixes typically contain less fertilizer and are ground to a finer consistency to maximize soil moisture absorption and facilitate seed-to-soil contact. Transplant mixes typically include a starter fertilizer to provide nutrients for the first 1 to 2 weeks after planting. Starting with clean media and keeping it clean is essential for disease prevention.

Work Area

Although not mandatory, a well-designed potting area can increase efficiency and reduce the chance of injury. A floor area that can be swept with a large workbench provides a suitable area for filling trays and pots. If greenhouse space is limited, a work area can be set up outside the greenhouse in an adjacent head house or covered storage area. Transplanting and seeding should be done in a shaded area to prevent transplant shock and worker fatigue. Elevated work benches can help prevent chronic back injuries. Keeping the work area clean and free of outside soil and other contaminants can greatly reduce exposure to plant pathogens.

Transplant Production

Seed Sowing

Sowing vegetable seed is typically quick and easy, but the amount of time varies depending on whether plants are sown into seedling flats or directly into plug trays. Sowing seed directly into plug trays takes more time than sowing into seedling flats but eliminates the need for transplanting later, which is costly and stressful for plants. Lettuce, brassica, and cucurbit crops are very sensitive to root damage and should always be sown directly into plug trays (Figure 8). A larger germination chamber may be required for warm-season crops sown directly into plug trays because of the higher soil temperatures required and fewer overall plants per tray.

Commercial growers use (heated) walk-in coolers for germination because direct-sown plug trays can be stacked on pallets and covered with plastic to increase humidity while seeds germinate. When sowing, labels should be used to record seed lots and source. Tracking enables growers to determine the source of a seedborne disease and prevent problems.

Figure 8. Sowing seeds directly into plug trays.

Direct-Sowing

Fill the plug cells of the propagation tray with potting media. Water trays down with clear water so media settles into the cells. If there is less than ¼ inch of space between the soil line and the top of the tray, use a dibble or marker to place small depressions in the soil. This ensures that seed is at least ¼-inch deep when covered with mix.

Read the seed packet for planting depth specifications. Place one to three seeds in the center of each plug cell (Figure 9A). Two seeds per cell is typical, but because hybrid seeds tend to be costly and have high germination rates, one seed per cell may be appropriate. For old seed that does not germinate well, up to three seeds per cell is recommended. Cover with seedling mix or standard potting mix and water them in. Make sure seeds are kept in the dark and stay moist during germination.

Plug trays should be kept warm and moist for 7 to 10 days until seed germinates and the plant emerges.

Figure 9. Plug trays. (A) Brassica crops can be sown directly into plug trays with a hand seeder. (B) Once seedlings emerge, they are thinned to one plant per cell.

Be careful when watering germinating seedlings. Use a mister or "fine" water breaker to spread the water flow into fine/small streams to avoid disturbing the soil surface. During germination and shoot elongation on sunny days, you may need to water twice a day. Once seedlings are established (Figure 9B), thin to one plant per cell. Do this 5 to 10 days after sowing to keep from damaging the remaining plant. Apply a low dose (50 to 100 ppm nitrogen) of fertilizer immediately after thinning.

Transplants

Although not common in large-scale, commercial production, seedling trays can be used to germinate vegetable seedlings that will be transplanted into plug trays 7 to 14 days after sowing. This method works better than direct-seeding for solanaceous crops such as tomatoes. It enables growers who sell transplants to produce more uniform plants and typically results in fewer empty cells than direct-sown crops. This allows for germination of a large number of seeds in a small space and a good option for growers with limited propagation area (or seed with low germination rate). In the same way, using a seedling flat makes it easier to increase humidity with plastic or glass coverings during germination.

"Row trays" or open seedling trays can be used depending on the number of seeds to be sown (Figure 10A). With row trays it is easier to distinguish multiple varieties because plants are compartmentalized into rows. For transplanted crops, use a fine seedling mix and make sure seedling trays are filled ½ to ⅔ full with media. Water the trays and sow with a hand seeder to disperse seeds evenly.

Solanaceous crops can be planted as thickly as 250 to 500 seeds per square foot (Figure 10B). Cover seeds with about ¼ inch of fine seedling mix and water with a fine mister. When watering seedling trays, it is critical not to disturb the soil surface. Using a hose-end mister or dedicated pump sprayer when watering germinating seedlings is recommended.

Once the first true leaf begins to develop, transplant seedlings into plug trays or larger cell trays for growing in the greenhouse or cold frame (Figure 10C). Start by filling plug trays with standard potting mix and wetting them with clear, unfertilized water. Using a dibble or the end of a marker, punch holes approximately 1½ to 2 inches deep in the cells. Holes should be large enough to allow for the seedling and root system.

Separate plants carefully without damaging the roots or breaking the stems. Loosen the soil from the bottom by running a dibble or marker under the block of soil in the seed tray. Pull on the seedling by the leaves or stem to separate the plants and roots without breaking stems. Place the seedling in the pre-dibbled hole so at least 75 percent of the root system is buried in the media. Carefully press the soil around the plant to ensure good seed-to-root and

Figure 10. Seedling trays. (A) Tomato seedlings grown to be transplanted in row trays or (B) Traditional seedling trays. (C) After the first true leaf develops, seedlings are transplanted into plug trays or larger pots.

stem contact. Gently water plants with a mister or fine breaker. Apply starter fertilizer (100 to 150 ppm nitrogen) to stimulate new growth and promote a healthy root system. This is a good stage to fertilize transplants for the first time.

Seedling Management

Regardless of whether a crop is sown directly from seed or transplanted, conditions should be monitored closely during germination. Crops may have certain requirements for germination. For example, seedless watermelon varieties require very warm temperatures of approximately 90° F. Follow guidelines provided by your seed supplier.

During germination, maintain high humidity by using a glass cover or plastic dome over the seedling tray. If growing in a greenhouse, it is critical to cover the plastic dome to prevent it from becoming too hot on sunny days. Styrofoam sheets work well for this purpose. If not using a cover to maintain humidity, water seedling flats two or three times a day depending on the amount of sun trays receive. Once the hypocotyl emerges from the soil, light is required to initiate photosynthesis and to signal the plant to develop stems and leaves (Figure 11). If left in the dark too long, seedlings quickly become tall and spindly and do not grow properly. Light should be introduced when about 25 percent of the hypocotyls have emerged. Natural (sun) light is ideal as long as seedlings do not get too dry or hot in the greenhouse. Fluorescent lights also work very well for germinating seedlings and until they develop the first true leaf.

Figure 11. Greenhouse-grown tomatoes maintain uniform growth with bottom heat and attention to water and fertilization needs.

Managing Transplants

Once seedlings are established (either transplanted or direct-sown) and start forming new "true" leaves, they must have sunlight. Fluorescent lights will not provide enough light for proper growth. Larger lighting systems such as metal halide, high-pressure sodium, and newer LED lighting systems can be used but may be expensive to purchase and operate. Fertilize growing transplants to ensure good growth and plant performance. For most vegetables, a typical fertilizer rate is 100 to 200 ppm nitrogen for seedlings, and 200 to 300 ppm nitrogen for transplants every 7 to 10 days. Temperature requirements will vary based on the type of crop and whether it is a cool- or warm-season plant. For warm-season crops, good growing temperatures range from 65° to 85° F. Warmer conditions encourage plant growth. Nights below 60° F decrease growth of warm-season crops. Growing transplants under cool nighttime conditions yields short, compact crops durable to field conditions at planting.

Although warm-season crops tolerate temperatures down to 45° F, growth stops below 50° F. Propagators can slow or speed growth to fit planting schedules by adjusting the temperature. This technique produces healthy robust plants ready to perform in the field.

Preventing Plant Diseases

Damping-off is the most common issue in transplant production (Figure 12), but other diseases also may affect transplant health, field performance, or both. Damping-off is a general term that refers to infection and death of germinating seeds or emerging seedlings. Damping-off diseases are caused by fungal and fungal-like plant pathogens such as *Rhizoctonia solani*, *Pythium* spp., and *Fusarium* spp. They can be categorized as preemergent and postemergent diseases. Both are more likely during cool, wet conditions.

Preemergent damping-off occurs when germinating seedlings become diseased underground and typically results in what appears to be poor germination. Postemergent damping-off occurs when the plant stem is infected and typically results in a stem canker or lesion. If infection is severe, the lesion or canker may spread, collapsing the stem and causing the plant to die. Pathogens that cause damping-off may be introduced to a propagation facility in contaminated soil or water.

Other diseases may affect specific crops — for example, bacterial spot, bacterial speck, and bacterial canker in tomato. Learn more about seedling diseases in the *Midwest Vegetable Production Guide for Commercial Growers*. Here are sanitation and cultural practices that are essential for disease prevention.

- Start with disease-free seed.
- Use a clean soilless potting mix that supplies good drainage. Keep bags or bins of potting mix closed and minimize potential contamination by soil or other materials being blown, splashed, or tracked in on shoes or boots.
- Do not use compost in seedling mixes that are used for germination. It can be beneficial to use compost in custom potting mixes for larger transplants.
- Use new or cleaned and disinfected pots and trays for every new crop.
- Place pots on mesh benches or other surfaces with good drainage.
- Use heating mats or some other type of germination chamber to hasten germination and warm the soil environment.
- Irrigate plants with fresh, clean water. Do not let hose ends touch the floor or ground, or they may pick up pathogens in soil residues and introduce them to pots.
- Avoid splashing water or soil from pot to pot. If a disease is introduced, splashing will spread it further.
- Reduce humidity to ambient levels (50 to 80%) and provide light once seedlings emerge from the soil to prevent damping-off.
- Seed treatments are commonly used on vegetable crops.
- Provide adequate air circulation to reduce foliar diseases and prevent damage by ethylene and other atmospheric pollutants.

Figure 12. Cucumber seedlings showing symptoms of postemergence damping off.

Conclusions

Growing high-quality transplants requires substantial investment of time and money but can be valuable for vegetable growers regardless of the scale of the operation. Growing transplants to sell at the farmers market provides income in early spring to offset the cost of transplants for field production. It is important to follow a planting schedule. Plants that are too large are not useful for large-scale field plantings and may be more susceptible to wind damage after planting.

Sunlight is a necessity for successful plant propagation. Transplants should be exposed to full light once the first true leaf develops. Hardening transplants for 7 to 10 days is a critical step, particularly in the Great Plains where high winds and storms can ruin a transplant crop after it has been set in the field. Be prepared to manage transplants carefully and provide daily care.

Tips for Healthy Transplants

Keep plants from growing too large or becoming root-bound. Although transplants must be large enough to survive, plants that are too large or root-bound will not perform well. Some crops are more sensitive to crowding than others. Cucurbits, for example, do not like to be crowded, but solanaceous crops will tolerate it to some degree. Do not plant too early and control growth during propagation to avoid problems.

Toss out old growing media. The wetting agent in soil-less media expires. Certified organic mixes, in particular, have a limited shelf life. Although commercial mixes do not list an expiration date, they last about 12 months if stored properly. Cover potting media to protect it from wind and rain. Repeated wet and dry cycles compromise the efficacy of the wetting agent.

Give plants enough light. Insufficient light is a common problem for first-time propagators. It results in leggy plants that may not survive in the field. Light is essential for root growth.

Plant extras. It is better to have too many transplants than too few. A tomato plant that costs 20 cents to propagate may produce more than $50 of tomatoes at market. Having a good number of healthy transplants to choose from is an advantage at planting time. Sell extras at the farmers market or give them to neighbors.

Use compost wisely. Compost may be added to a transplant mix to supply nutrients and act as a wetting agent, but it may contain damping-off pathogens, weed seeds, or herbicide residues that may be harmful. Germinating seedlings in mixes with added compost poses a significant risk to the propagation system. When adding compost to plug trays or containers for transplanting, use compost only from trusted sources.

Cary Rivard, Ph.D., Fruit and Vegetable Specialist and Director
K-State Research and Extension Center for Horticultural Crops at Olathe
Department of Horticulture, Forestry and Recreation Resources

Megan Kennelly, Ph.D., Plant Pathologist, Department of Plant Pathology

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