CHAPTER 6

TRANSPLANT PRODUCTION

INTRODUCTION

***Transplants**: Young plants produced specifically for transplant into pots (houseplants), the ground (field production), hydroponic systems (greenhouse hydroponics), etc.

*The production of transplants has become an industry in and of itself.

*Why keep the production of transplants separate from the growing of the mature greenhouse hydroponic crop?

1. Each grower can tailor the growing conditions for their plant's life stage needs.
2. The tomato producer, for example, does not have to use precious greenhouse space for seeding and grow-out of the transplants.

*In deciding whether or not to go into transplant production, a grower should consider:

- *The overall operation: can transplant production fit into the existing business? Do the owners have the time and resources needed for such an operation?
- *Is there an availability of money needed to establish such an operation?
- *Do the current growers have the management skills and knowledge of transplant production for the specific crop desired? Remember, the transplant grower can be held responsible for weak or failed crops! So the best possible transplants are required.
- *Is there a market for the transplants and will the operation be profitable?
- *Can the required number of transplants be grown successfully?

*Greenhouse transplant growers are usually growing transplants

- *For commercial sale only
- *For personal use only
- *For both commercial sale and personal use

*Transplants can be started from seeds, or vegetatively using cuttings, grafting, or micro-propagation (tissue culture) methods. However, even with cuttings or grafting, the original material will still come from seed.

TRANSPLANTS FROM SEEDS

*<u>Most commercial vegetable transplants are produced from seed</u>.

*The choice of seed is one of the most important initial decisions a grower can make. Is it heat tolerant? Is it resistant to specific diseases? Is it right for your market?

*As mentioned previously, most varieties used in commercial greenhouse hydroponic production are F1 hybrids (see Chapter 2).
The pollen from one parent plant is transferred to a second parent plant. The resulting fruits contain the F1 (first filial) seeds that are then sold.
F1 hybrid seed is preferred because most of the plants will have the same characteristics and produce the same quality and quantity of fruit.
NOTE: a very small percentage of plants (< 1 plant/1000) may change to "off" types which can include "bull plants" or "chimeras".
NOTE: the seeds in fruit from plants grown from the F1 hybrid seed will NOT produce the same type of plant/fruit as the F1 seed.

*Make sure the seed comes from a reputable company which guarantees their product to be weed & disease free. Others may have "bargain" seeds… full of problems !
Companies with good reputations include (but are not limited to):
Burpee Seeds, Warminster, PA 18974 www.Burpee.com/
DeRuiter Seeds, Inc. Columbus OH 43220,www.deruiterusa.com
Enza Zaden, Salinas CA and world-wide, www.enzazaden.com
Hazera Seeds, Coconut Creek FL, www.hazerainc.com
Johnny's Selected Seeds, Albion, ME, 04910, www.johnnyseeds.com
Nirit Seeds, Israel, www.niritseeds.com
Nunhems Seeds USA, Parma ID www.nunhemsusa.com
Paramount Seeds, Palm City FL (Yuksel) www.paramountseeds.com
Rijk Zwaan, DE LIER, The Netherlands www.rijkzwaan.com/
Rogers Seeds Boise ID www.rogersadvantage.com/products/greenhouse
Sakata Seed America, Yuma, AZ 85365 www.sakata.com
Vilmorin Seeds, France/Tucson AZ http://vilmorin.us/

***A bit about rooting substrates:**
For commercial growing, seeds are usually started in germination cubes and then transplanted to blocks (both can be of various sizes and made of rockwool, coco coir, etc). The blocks, with the seedlings, are then placed on slabs, bags, boxes, etc., filled with rockwool, perlite, coconut coir, volcanic rock, peat-lite mixes, etc.
- Peat-lite mixes (peat, vermiculite, perlite, plus) are used world-wide.
- Rockwool has been used in Europe and Canada for over 40 years.
- Perlite grow bags have been used in the USA for over 25 years.
- Coconut coir has become popular worldwide over the last 15 years. This is biodegradable and may have anti-bacterial & anti-viral properties.
- Volcanic rock in boxes is used by many growers in Mexico.

***Containers** include a variety of forms.
Individual containers may be more appropriate for foliage plants and come in paper, plastic, clay, peat moss, Styrofoam, etc.
Individual plastic net pots or web pots, filled with perlite, clay pellets, Rockwool, etc. are routinely used in air gap, floating or NFT systems (see Chapter 5).
Molded plastic or Styrofoam "plug" or cavity trays, in various sizes and containing tens to hundreds of cavities, can be filled with growing medium

or cubes/plugs for production of multiple seedlings per tray.

Plastic flats can be filled with growing medium or, typically for greenhouse hydroponic tomatoes, pads of Rockwool or foam are used that are sized to fit these trays and divided into small cubes (1.5" X 1.5", 1" X 1", smaller "keen" plugs or even small plugs called "sugar cubes") which are connected at the top (or bottom, less used) but partially separated at the bottom to keep roots from mingling; reduces root breakage at transplant.

All plastic and Styrofoam containers can be sterilized using soap & water and/or 10% bleach. Rinse containers thoroughly with water to avoid soap or chlorine toxicity.

***Seeds** can be sown in a variety of ways depending upon the ultimate use:

For personal use or horticultural crops (trees, shrubs, vines, etc.) plant seeds into individual plant containers or plastic flats filled with various types of sterile growing media (soil, sand, peat moss, vermiculite, perlite, rock wool, rice hulls, coconut coir, compost, etc.).

For research or classroom purposes, plant seeds in moist paper towels or filter paper in petri dishes or other containers with loose-fitting lids (for gas exchange). Make sure paper towels or filter paper are not too wet or dry.

For commercial tomatoes, peppers, cucumbers, lettuce or other crops to be grown in greenhouse hydroponics, plant seeds into "grow cubes" such as Rockwool, Oasis, foam or coir cubes, peat pellets, etc.
NOTE: Mechanical seeders are available for commercial operations.
NOTE: Sterilize media & flats to exclude insects, disease, weed seeds, etc.

***Planting the seeds**

In growing media (like perlite, peat-lite): follow package instructions for depth.

In Rockwool, coco coir, foam or Oasis cubes or other preformed material: these usually have a small hole in the top of each cube into which the seed is placed. In drier regions it may be necessary to sprinkle vermiculite over the holes to maintain moist conditions around the seed.

Time the sowing of seeds so that the resulting transplants are beyond the first true leaf stage but have not yet reached much flowering or any fruiting.

Ex: In Tucson AZ in July/August, tomatoes and peppers take 4 weeks from seed to final transplant, whereas long cucumbers only take 2 weeks !

***Watering and fertilization:**

After sowing, seeds should get water only, no fertilizer, to promote water uptake.

NOTE: Some growers use full-strength nutrients from the seed stage on, but those high salts may make it difficult for the seeds to take up water and start growing.

Apply by hand. Use a watering can or hose. Round sprinkler heads (give more water with less plant damage) are preferred to fan types.

Apply by overhead misters, sprinklers or programmable traveling irrigation booms. For foliage plants, or in cool, humid conditions make sure the last watering is early enough so that leaves dry before dark to avoid foliar disease or spotting.

Apply by flooding the plant trays or water-tight floor (concrete, plastic, etc.) then draining the excess "to waste" or to a tank for recycling. (Caution: recycling can cause spread of disease – See Chapter 4.)

After the cotyledons have opened and the first true leaf is expanded:

Apply liquid fertilizer in dilute form with every watering:

Ex: 110-175 g of a 20-20-20 fertilizer per 200 liters over a 20 square meter area.

Ex: ¼-½ strength hydroponic nutrient solution…. OR

Apply liquid fertilizer at a strong rate every 2 weeks (not recommended):

Ex: 500-700 g of a 20-20-20 fertilizer per 200 liters over a 20 square meter area.

Ex: 3-4 times full strength hydroponic nutrient solution.

To avoid leaf burn, rinse leaves with water after each feeding.

We hand water full-strength hydroponic nutrient solution 1-2 times / day.

***Boosting seedlings to larger containers/cubes/etc.:**

For tomato seedling production:

If seeds are planted in small plugs or 1-1 ½ inch Rockwool or coir cubes, the seedlings will need to be transplanted into larger blocks (3" with one hole or larger blocks with 2 holes) at least 2 weeks after seeding (sooner, if roots begin emerging from cube, to prevent root damage). Plants will be ready for planting onto grow bags, etc. in another 2 weeks. Plants may have some flowers open on the first truss but should not have any fruit set at transplant.

If seeds are planted as above, but the grower (or this is especially good for schools on a limited budget) does not want the expense of larger blocks, the smaller seedlings in their cubes can be placed directly onto the grow bags. Plant when roots protrude from cube.

For other types of crops – general criteria:

Seedlings should be boosted to larger containers/cubes/etc. when leaves from neighboring plants overlap and shade each other or when roots begin to protrude from the current container/cube/etc.

***Structures for seed-generated transplant production:**

Most vegetable transplant production occurs in some type of controlled environment structure so that the environment can be tailored for the crop being grown. Structure can be from low to high tech:

- Cold frames: low plastic covered structures without heat
- Hot beds: similar to cold frames but with heat
- Greenhouses: transparent enclosed structures with environmental control using light directly from the sun (can be supplemented with artificial lights) With water applied overhead, via misting or flood & drain, etc.
- Growth chambers or rooms: opaque enclosed structures with environmental control using artificial light (can use solar light via fiber optic light pipes).

TRANSPLANTS FROM CUTTINGS:

***Cuttings** are portions of the stem, root, leaf or leaf bud removed from a "parent plant".
These portions are then induced to form roots and shoots by chemical, mechanical and/or environmental means.
The resulting plants will be "**clones**" of the parent plant – same genetic makeup.
Parent plant stock material must be free of disease and insect pests.
Material selected for cuttings needs to be in the proper physiological state so that roots and shoots develop readily.
This method is used mainly to propagate ornamental shrubs, evergreens, floral and foliage crops, as well as various fruit species.
Ex: Tomato plant suckers can be removed, the severed ends placed in water (no nutrients until roots form) and within a few days to a week roots will form.

***Typical uses for cuttings:**
Commercial: transplants from cuttings can be grown either in the ground or by using an aggregate medium or soil mix for rooting in plug trays, flats, etc.
For vegetable/fruit crops: As noted above, most transplants produced from cuttings are horticultural or ornamental species. When vegetable crops (including tomatoes, peppers and cucumbers) are grown from cuttings they are usually produced by small-scale farmers for retail/wholesale or by individuals for home use. NOTE: Cutting production of vegetable crops is very labor intensive, which is why seeds are usually used.
Educational/school: cuttings can be used in the classroom and easily rooted using
*Aeroponic type hydroponic systems, in which the severed ends of, for example, tomato suckers can be bathed in water until they root.
*Floating or air-gap systems, where the cutting ends are kept moist by water wicked up into perlite, etc. from the reservoir below.
When roots form, nutrient solution can be added. (See Chapter 5 for systems)

***Facilities and special considerations for cutting transplant production:**
Most cuttings are produced in some type of protected structure (cold frames, hot beds, greenhouses or growth rooms), though some hardwood cuttings (willow, poplar, rose, etc.) are planted directed into the soil outside.
Because cutting material initially has no roots, **misting** is typically used in greenhouses to maintain a humid environment around the cutting and reduce water loss from the cutting while roots are forming.
NOTE: For a small number of cuttings (home or school use) even a simple plastic dome over the cuttings will help maintain a moist environment.
Also, to reduce water loss, all but the uppermost 4-5 leaves should be removed.
Research in the physiology of plant growth has shown that auxin-type plant hormones, including the naturally occurring IAA (indoleacetic acid) and the synthetic chemicals, IBA (indolebutyric acid) and NAA (naphthaleneacetic acid) promote root growth. Therefore, treating the cut ends can increase the number and hasten the development of roots.

The rooting substrate should be a combination of a high water holding capacity organic material (peat, coir, sphagnum moss, fine bark, etc.) and a course material to increase air pore spaces and drainage (perlite, vermiculite, sand, pumice, rockwool, etc.).

The rooting substrate needs to be sterile or sterilized before use, since the cuttings will have open wounds, susceptible to disease, when planted.

The use of "bottom heat" will help to induce faster root growth. Use electric cables or mats or hot water tubes running under the grow beds or trays.

TRANSPLANTS USING GRAFTING

***Grafting**

A technique for connecting two previously separate plant parts such that the resulting plant will live and grow as one.

Stock = the lower part of the graft including the roots.

Scion = the upper part of the graft including the shoot and dormant buds from which new stems, leaves, etc., will grow. The "producing" part.

Very labor intensive; widely used in commercial tomato transplant production.

***Why use grafting?**

There are several reasons to use grafting including to maintain clones that can not be easily maintained by other asexual methods, to repair damaged parts of trees, or to create specialized growth forms.

Vegetable growers, in Europe, have been using root stocks with resistance to such root pathogens as *Fusarium* and *Verticillium* wilt with soil agriculture.

Grape vines, fruit trees and roses are typically grafted to add disease resistance.

Researchers/growers are finding that grafting on a cold-tolerant root stock can confer some protection from the cold to a previously cold-sensitive scion.

Hydroponic vegetable growers are also now using grafted plants, not just for pathogen protection (even though plants are grown in sterile media they can still be exposed to pathogens) but also to increase yields of many greenhouse vegetable crops, including tomatoes with high-powered, vegetative root stocks that can support 2 heads.

***Special considerations for producing grafted transplants:**

The root stock and scion must be compatible (usually same Family or Genus).

The cambium (new cell generating tissue) of the root stock and scion must be in direct contact with each other for proper fusion (i.e., the same size).

Both the root stock and scion must be in the proper physiological stage to promote the fusion of the two parts into one.

Cut surfaces must be wrapped after joining to prevent water loss.

Grafts must be kept in high humidity to reduce water loss and in low light to reduce respiration and loss of precious sugars.

As the new plant heals, care must be taken to promote the desired growth habit.

Once the graft has healed the plant can be treated as any other plant.

TRANSPLANTS USING MICRO-PROPAGATION (TISSUE CULTURE)

***Micro-propagation:** The use of sterile tissue culture methods to propagate important crops including woody plants, orchids, palms, ferns, bulbs and ornamentals.

***This technique is used:**

For mass propagation of important clones.
To produce pathogen-free plants.
Potentially, to provide plants year-around for nursery sale.
Specifically for tomatoes and other vegetable crops, micro-propagation has the potential to produce mass numbers of clones for hybrid seed production.
NOTE: This is already being done for some hybrid seed.

***Special considerations:**

Micro-propagation requires a large monetary input for facilities and labor.
Specialized laboratories, growth chambers, high-tech equipment as well as trained personnel are required.
A large, controlled storage facility will be required for the transplants produced.
Precautions must be taken to prevent pest and disease contamination or the occurrence of "off-type" plants (i.e., genetic mutations).
Plants are started from various tissue masses in agar (callus material), and then specific plant hormones are given to induce root and shoot development.
Special methods are required to slowly acclimate the new plants to the greenhouse or the out-of-doors where they will ultimately grow.

Agar ("callus" formation) (hormones: roots/shoots)	→	Growing medium (plant development)	→	Growing conditions (GH or outside)

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