

Transplanting and Direct Seeding

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Introduction: Transplanting & Direct Seeding

UNIT OVERVIEW

Learning to recognize optimal soil moisture and weather conditions, grow and prepare healthy seedlings, properly prepare planting beds, and follow up with optimal irrigation, weed control, and plant protection are keys to successful transplanting and direct seeding.

In this unit, a short lecture compares transplanting and direct seeding, including the benefits of each; reviews the plant, soil, and environmental conditions to consider prior to transplanting and direct seeding; and briefly addresses post-transplanting/seeding practices. Two field demonstrations introduce students to the basic equipment and practices associated with direct seeding and transplanting techniques used in traditional French-intensive gardening, and in small- to medium-scale field production.

Refer to Unit 1.2, Garden and Field Tillage and Cultivation, and to Unit 1.3, Propagating Crops from Seed, and Greenhouse Management, for additional information relevant to the material presented here.

MODES OF INSTRUCTION

- > LECTURE (1 LECTURE, 45–60 MINUTES)
The lecture introduces the basic concepts associated with transplanting and direct sowing in the garden and field
- > GARDEN-SCALE TRANSPLANTING DEMONSTRATION (1–1.5 HOURS)
The garden-scale demonstration outline details the basic skills and concepts for direct seeding annual crops and transplanting both annual and perennial container-grown plants. Following the outline is a set of step-by-step instructions for students on seedling and soil preparation, direct seeding, and transplanting techniques.
- > ASSESSMENT QUESTIONS (0.5 HOUR)
Assessment questions reinforce key unit concepts and skills
- > POWERPOINT
See casfs.ucsc.edu/about/publications and click on Teaching Organic Farming & Gardening.

LEARNING OBJECTIVES

CONCEPTS

- The optimal physical environment conditions favorable for successful transplanting
- The optimal soil moisture conditions favorable for successful transplanting
- The optimal seedling development and pre-treatments necessary for successful transplanting

SKILLS

- How to cultivate and prepare a bed appropriate for sowing seeds of various sizes or for transplanting starts
- How to sow small- and large-seeded crops using hand methods and push seeders
- How to transplant from a cell tray and flat format
- How to water-in/irrigate recently transplanted seedlings
- How to irrigate seed beds for optimal germination

Lecture 1: Transplanting & Direct Seeding

Pre-Assessment Questions

1. What is the difference between transplanting and direct seeding?
2. What are some of the reasons to transplant vs. direct seed crops?
3. What type of crops are better suited to transplanting vs. direct seeding?
4. Why do crops need to be “hardened off” prior to transplanting?
5. What are some of the environmental conditions most conducive to successful transplanting?

A. Transplanting versus Direct Seeding: Advantages and Appropriateness of Each Technique

1. Transplanting and direct seeding defined
 - a) “Transplanting” refers to the act of transferring seedlings from containers in the greenhouse (cell trays, flats, pots, etc.) into the garden or field
 - b) “Direct seeding” or “direct sowing” refers to planting seeds in the field to germinate in place
 - c) Note that there are no hard and fast rules about which crops are transplanted vs. directly sown; there are advantages and disadvantages to each method, and a number of factors will play into the decision regarding which approach to use. These include scale of planting, labor availability, length of season, types of seeders available, weed management capacity, and greenhouse and land availability. In some cases, transplanting a difficult-to-transplant crop can pay off if the market offers a premium for early harvest. See Appendix 1, Field-Scale Transplanting Guide, for recommendations regarding transplanting vs. direct sowing of various crops.
2. Transplanted crops
 - a) Advantages of starting crops in greenhouse
 - i. Greater climate control: Temperature, humidity, water
 - ii. Soil mix can be tailored to specific crop, as per fertility and drainage capabilities (see Appendix 8, Sample Soil Mix Recipes, in Unit 1.3, Propagating Crops from Seed, and Greenhouse Management)
 - iii. Offers protection from predators and elements: Wind, rain, birds, snails, etc.
 - iv. Greater season extension (can start crops earlier indoors)
 - v. Intensive rather than extensive management of seedlings: E.g., one 12” x 24” flat of leeks can plant a 4’ x 50’ bed with 6 rows at 6”/row (600 seedlings). Fewer resources—time, water, weeding, etc.—are required to care for 1 flat of leeks vs. 1 direct-sown bed.
 - vi. Weed management: Transplanted crops have a better chance at outcompeting weeds than seeds sown directly in the ground
 - b) Advantages of using greenhouse-grown transplants
 - i. Rapid crop successions (e.g., from cover crops to cropping and from one crop to another), as ground is not “tied up” with developing seedlings
 - ii. May allow for greater control over specific density of crops; save labor on thinning
 - iii. Get ahead of weeds (till in or “flame” weeds ahead of transplanting), thus saving labor on hoeing and weeding (see Unit 1.10, Managing Weeds)
 - iv. Conserves water: Less water required to irrigate transplants vs. irrigating seed beds
 - v. Fewer seeds needed to grow starts vs. direct seeding/thinning
 - vi. Creates better stand: Possible to have almost perfect establishment; less regular if thinning direct-seeded crops to a stand

- c) Root nature of transplanted crops: Fibrous roots transplant better than taproots (see Unit 1.3 for additional details)
 - d) Examples of transplanted crops: Lettuce, chard, kale, brassicas, fennel, tomatoes, peppers, fresh onions (in clusters), storage onions, basil (in clusters); at a garden scale, squash and cucumbers are often transplanted (see Appendix 2, Common Transplant Spacings; Common Seeding Rates and Thinning Distances for suggested spacings)
3. Direct-sown or seeded crops
- a) Advantages of direct seeding
 - i. Scale of production: Many crops are direct sown on a large scale to avoid costs associated with greenhouse production and transplanting
 - ii. Certain crops grow well at high density and/or are more easily harvested at high density, and are therefore better suited to direct sowing (e.g. cilantro, baby spinach)
 - b) Root nature of direct-sown crops: Often taprooted crops (e.g. beets, carrots, spinach, parsnips) are direct sown so as not to disrupt the taproot by transplanting
 - i. Exceptions: Most crops, including taprooted crops, may be transplanted if sown and transplanted in clusters
 - c) Intended density of crops: Direct-seeded crops require sowing at a high density and eventual thinning (see Appendix 2). Precision seeders, such as Earthway and Jang (pronounced “yang”), can help reduce the need for thinning in the garden. Other precision seeders used on a field scale include the John Deere 33 (for small seed) and John Deere 71 (for large seed). Stanbay seeders are commonly used in large-scale field production. See illustrations in Appendix 3, Transplanting and Irrigation Equipment.
 - d) Examples of direct-sown crops: Sweet corn, snap beans, carrots, beets, turnips, spinach, cilantro, dill
4. “Pelleted” seed
- a) Pelleted seed is used in both transplanting and direct sowing. It is coated with a clay-based material to make it larger, more uniform, and easier to handle.
 - b) Advantages and disadvantages of pelleted seed
 - i. The uniform size and shape of pelleted seeds makes them better suited for tractor-mounted or push seeders, as well as for vacuum seeders in a greenhouse
 - ii. The “pelleting” process decreases seeds’ length of viability; it is viable for a shorter time than raw seed
 - iii. Pelleted seed is more expensive than raw seed

B. “Hardening Off” Period Prior to Transplanting: What It Is and Why It’s Important

1. Hardening-off period (3–30 days) defined: “Hardening off” a transplant refers to making a gradual transition from greenhouse to outdoor field conditions
2. Physiological adjustments plant makes in the process of hardening off:
 - a) As seedlings are exposed to increased airflow (wind) and a greater temperature swing, the cells of the plant “toughen up.” Stems thicken and strengthen, making them more suitable to field conditions.
3. The hardening-off process:
 - a) Depending on environmental conditions, a hardening off period might start with bringing transplants outdoors for a few hours a day in mild conditions and bringing them in at night for a few days. The length of time the seedlings stay outdoors is increased gradually over a period of a week or a few weeks. In mild climates, a hardening off period of 3–4 days may be sufficient.

- b) Examples of hardening-off progressions:
 - i. From an enclosed greenhouse to an open-ended hoop house, and then to the field.
 - ii. From an enclosed greenhouse to tables or pallets under cover (e.g., shade cloth, plastic, or row cover) that can be rolled up during the day and rolled down at night in cooler temperatures, and then to the field

C. Assessments of Plant, Soil, and Environmental Conditions Prior to Direct Seeding or Transplanting

1. Seedling development necessary for successful transplanting
 - a) Shoot development: Generally 4–6 true leaves; for quick-growing plants such as lettuce and Asian greens, 2 sets of leaves may be adequate if there is adequate root development (“root knit”)
 - b) Root development: Roots should be well developed and branching. If started in a cell tray, roots should knit together in a well-formed unit that can hold up when pulled from the cell. In flats, roots should hold together in a root ball without dropping soil (assuming soil is wet). See Appendix 4, Seedlings at Transplant Maturity; Planting Depths for illustration of root knit.
2. Seedling pre-treatments necessary for successful transplanting
 - a) Soil/media moisture: With transplants started in cell trays or in flats, it is best to water thoroughly soon before transplanting (an hour or less)
 - i. Flat-grown seedlings: Planting media at 75–80% of field capacity
 - ii. Cell-grown seedlings: Seedling trays saturated (dripping wet)
 - b) Thorough watering helps the soil/root ball hold together, and gives the plant a boost before and during transplanting, which—even when done at optimum conditions—is still a disruptive event for young plants. By starting with wet roots, planting under optimum conditions and irrigating immediately/soon after transplanting, the “shock” of transplanting can be reduced.
 - c) Alliums are an exception—they can be “bare rooted” during transplanting, and therefore need drier soil in the cell tray or flat to allow the roots to be separated from each other and from the planting mix
3. Soil conditions favorable for successful transplanting or direct sowing (see Unit 1.2, Garden and Field Tillage and Cultivation, for more information on bed preparation)
 - a) Soil moisture: 75–80% of field capacity at a garden scale; 50–60% field capacity at field scale to avoid soil compaction when using planting equipment (see Appendix 5, Estimating Soil Moisture by Feel in this unit, and Unit 1.5, Irrigation—Principles and Practices, for more on field capacity)
 - b) Degree of secondary cultivation: Smaller seeds and small transplants such as lettuce require greater secondary cultivation, i.e. finer tilth. E.g., small-seeded crops such as carrot seeds need a finely tilled bed for seeds to have adequate soil contact, and for the cotyledons to penetrate the soil surface.
 - c) Large transplants, e.g., tomatoes and peppers, can handle less fine tilth as they will not have to push through the soil surface
4. Optimal physical environment conditions favorable for successful transplanting of flat-grown seedlings
 - a) Low light levels, e.g., cloudy or foggy conditions, or late afternoon/early evening. Planting late in the day gives the plant time to recover and adjust during a period of low transpiration (night and early morning hours).
 - b) Low temperatures: Plant in morning or later in afternoon to avoid exposing roots to the heat of midday
 - c) Low wind speed

- d) High humidity
 - e) As environmental conditions are rarely optimal, steps can be taken to reduce stress by having at least some, if not all, conditions right. E.g., if it is windy, wait until the temperature is cooler. Or if it is hot, wait until the wind dies down. Irrigating immediately after transplanting will help the plant recover from stress.
5. Irrigation must be ready to go prior to transplanting; at the field scale, make sure sprinklers or t-tape are set up before or immediately after transplanting takes place. Transplants must be watered in immediately after planting to establish root-soil contact and minimize transplant shock.

D. Additional Field-Scale Considerations

1. Incorporation of cover crop residue through primary tillage (see Unit 1.2, and Unit 1.6, Selecting and Using Cover Crops)
 - a) Mowing (flail or rotary)
 - b) Apply compost prior to residue incorporation, if necessary
 - c) Incorporate cover crop residue with spader or offset wheel disc
 - d) Wait an appropriate amount of time for cover crops to break down in the soil (irrigating can speed this process) so as not to plant into soil with partially-decomposed residue (usually 2–4 weeks, depending on soil moisture, temperature, and volume of cover crop residue)
2. Review field soil conditions prior to tillage
 - a) Soil moisture range: 50–60% of field capacity to avoid soil compaction
3. Establishment of seedbed through secondary tillage techniques
 - a) Rototill or disc field to improve surface uniformity following residue breakdown. Note that with some soils/implements, this step can be skipped. E.g., mechanical spading or multiple passes with a disk can act as both primary and secondary cultivation.
4. Bed formation
 - a) Form beds with lister bar and shovels or rolling cultivator
 - b) Shape bed with bed shaper (see Appendix 3)
 - i. In wet conditions (e.g., coastal California winters), raised beds can improve drainage
 - ii. In dry conditions, flat beds can minimize drainage
 - c) Pre-irrigate to germinate weed seed; if using drip tape, pre-irrigate 1 week in advance
 - d) Cultivate unplanted beds at as shallow a depth as possible with an under-cutter or “weeder” bar, sweeps, knives, or rolling cultivator to knock back the newly germinated weeds and reduce weed pressure. See Unit 1.10, for additional information.
 - e) Ensure good tilth: It is important for roots of transplants to have access to water held in soil pores; large clods don’t hold water
 - f) Plant beds with seeder, transplanter, or by hand

E. Post-Transplanting and Direct Seeding Considerations

1. Irrigation
 - a) Maintain adequate soil moisture for seeds and transplants: This is particularly critical for small, direct-seeded crops
 - i. Garden scale: Microsprinklers, oscillators, or a hose with a watering wand or “rose” attachment can be used to maintain surface soil moisture; seed beds should be watered when half the soil surface has dried (see Appendix 6, Garden-Scale Seed Bed Irrigation). At the depth of the transplant’s root ball (usually 2–4 inches deep) soil should be watered when it is at the edge of “balling up.” It’s better to apply water earlier than needed than to wait until the plant is stressed.

- ii. Overhead irrigation may be appropriate until field crops are established, at which point it may be appropriate to switch to drip irrigation to minimize water use and weed growth (see Unit 1.5)
 - iii. Large-seeded crops and large transplants can be planted to moisture following irrigation and weed cultivation; irrigation can then be delayed to allow the crop to get a jump on weed growth (see Unit 1.10)
2. Insect and mammal damage
- a) Floating row covers can be used for the first 2–3 weeks after crop emergence or transplanting to minimize or prevent damage by insect pests (e.g., flea beetles, cucumber beetles), birds, and mammals: Covers can be placed directly over the crop or draped over easy-to-make hoops and staked to form low tunnels. After 2–3 weeks crops are usually large enough, and have developed tougher, less succulent leaves, for the row covers to be removed (unless pest pressure is intense).
 - b) Row covers can also help “jump start” warm-season crops such as peppers early in the season and protect frost-sensitive crops at the end of the season
 - c) Nutrient needs: In spring, heat-loving crops growing in cool, wet soils may require supplemental fertility, as nutrients may not be readily available in these conditions. Supplements may include granular fertilizer (e.g. blood meal, feather meal) or liquid fertilizer (e.g., fish emulsion, liquid kelp) applied as a foliar spray or soil drench.

Demonstration 1: Garden-Scale Transplanting & Direct Sowing

for the instructor

OVERVIEW

The following demonstration outline covers the basic skills and concepts used to direct seed and transplant crops for garden-scale production. Following the outline below, discuss and demonstrate the tools and techniques used in garden-scale transplanting and direct seeding, as well as post-planting considerations (irrigation, pest control, etc.).

PREPARATIONS AND MATERIALS

- Recently prepared garden bed at 65–80% of field capacity, including a section prepared as fine/particulate surface soil for direct sowing of seeds and a section of less particulate surface soil for transplanting
- Flats of plants at transplanting maturity with well-developed root system (allium and broad-leaf crops)
- Cell tray at seedling maturity and immaturity
- Hand trowel and hand fork
- Watering wand
- Dibble (see Appendix 3, Transplanting and Irrigation Equipment)
- Measuring tape
- Rose and hose
- ½” poly line and micro-sprinklers (pre-assembled)
- String, string jig, and stakes (see Appendix 3)
- Large and small seed (e.g., peas/beans and carrots)
- Push seeders: Show different models, if available
- Bed end markers and indelible marker
- Appendices 7 and 8, Garden Sowing Log and Garden Transplanting Log

PREPARATION TIME

1.5 hours

DEMONSTRATION TIME

1.5 hours

DEMONSTRATION OUTLINE

A. Assess Plant, Soil, and Environmental Conditions Prior to Transplanting

Briefly review and assess the compatibility of the following environmental conditions and seedling maturity with the planned tasks, then demonstrate the following:

1. Seedling development necessary for successful transplanting
 - a) Shoot development
 - b) Root development
2. Seedling pre-treatments necessary for successful transplanting
 - a) Soil/media moisture
 - i. Cell-grown seedlings with media at field capacity
 - ii. Flat-grown seedlings with media at 75–80% of field capacity
 - b) Hardening-off period: A minimum of three days of full exposure to field conditions
3. Soil conditions favorable for successful transplanting or direct sowing
 - a) Soil moisture: Should be 75-80% of field capacity (see Appendix 5, Estimating Soil Moisture by Feel)
 - b) Degree of secondary cultivation: Smaller seeds require greater secondary cultivation
4. Optimal physical environment conditions favorable for successful transplanting of flat-grown seedlings
 - a) Low light levels
 - b) Low temperature
 - c) Low wind speed
 - d) High humidity
 - e) Steps to take if environmental conditions are not optimal (see Lecture)

B. Demonstrate Transplanting

1. Plant spacing: Talk about the way the following factors influence crop spacing
 - a) Pre-irrigation and cultivation considerations
 - b) Root and shoot size at maturity: Include depth and spread
 - c) Disease prevention/air circulation
 - d) References: See Appendix 2, Common Transplant Spacings; Common Seeding Rates and Thinning Distances of this unit, and Resources section of Unit 1.3, Propagating Crops from Seed, and Greenhouse Management
2. Tools used to assure uniform plant spacing: Demonstrate tools used to guide planting
 - a) Parallel lines of string between stakes
 - b) String jig
 - c) Transplant marker, e.g., dibble
 - d) Triangulation
 - e) One's hand
3. How to plant: Demonstrate the following
 - a) Knowledge of crop being planted
 - b) Plant selection criteria (development and vigor of seedling)
 - c) Plant handling technique
 - d) Depth of planting (see Appendix 4, Seedlings at Transplant Maturity; Planting Depths)

4. Watering in: Demonstrate why, how, and irrigation options
 - a) Why? To assure even soil moisture between transplant and surrounding soil in order to assure uninterrupted regrowth
 - b) Options for how to irrigate after transplanting (water in)
 - i. Basal application with watering wand
 - ii. Overhead sprinkler and considerations of scale
 - iii. Microsprinkler
 - iv. Overhead sprinkler, transition to drip irrigation
5. Documenting
 - a) Demonstrate documenting as learning tool
 - b) Where to document?
 - i. Field or bed marker
 - ii. Garden log book with crop seeding and transplanting dates, variety, and seed company (see Appendices 7 and 8)
6. Post-transplant follow up
 - a) Irrigation
 - i. Method of irrigation: Microsprinklers, oscillators, hand watering
 - ii. Monitoring root zone for 50–60% of field capacity: At the depth of the root ball (usually 2–4 inches deep) soil should be at the edge of “balling up.” It’s better to apply water earlier than needed than to wait until the plant is stressed.
 - b) Observations of subsequent growth. Discuss the following considerations:
 - i. Predation: Monitor seedlings for insect or pest damage. Replace as needed. Use remay or other floating row cover to protect seedlings from insects (e.g., flea beetles on brassicas and eggplants, cucumber beetles on cucurbits) and from bird and mammal damage.
 - ii. Nutrient needs: In spring, heat-loving crops growing in cool, wet soils may require supplemental fertility such as granular fertilizer (e.g. blood meal, feather meal) or liquid fertilizer (e.g., fish emulsion, liquid kelp) applied as a foliar spray or soil drench
 - iii. Root development: Carefully digging up seedlings to observe root development provides information for depth of irrigation requirements
 - c) Excess/replacement seedlings
 - i. Management of excess seedlings in propagation area: If necessary, pot up “extra” plants to maintain/extend their viability
 - ii. Treatment: Supplemental fertility may be required to sustain replacement seedlings

C. Discuss and Demonstrate Direct-Sowing Techniques

1. Briefly review optimal environmental considerations for seed germination
 - a) Soil moisture should be 65–80% of field capacity
 - b) Degree of secondary cultivation: Describe here, talk about differences between needs of small vs. large seeds
 - c) Soil temperature: For warm-season crops, surface soil temperature should exceed 60° in the top 6 inches for majority of daylight hours
 - d) Depth of planting: General rule is to plant seeds twice as deep as the seeds are long. Refer to seed packets or seed catalogs as reference

2. Demonstrate and discuss the pros/cons of the various direct-sowing techniques
 - a) Drills/sowing into furrows by hand
 - b) Push seeder: Demonstrate multiple types, if available
 - c) Broadcast sowing
3. Irrigation
 - a) Objective: For small-seeded crops (e.g., lettuce, salad mix, carrots), maintain even soil moisture until seed germination, when the oscillation between wet and dry can be stretched gradually. Larger-seeded crops (e.g. peas, squash, seed potatoes) can tolerate more of a wet-dry swing from the time they are planted; overwatering can lead to rot.
 - b) Techniques and frequency used
 - i. Micro sprinklers
 - ii. Overhead sprinklers
 - iii. Dripline
 - iv. Discuss flow rates of each system in regards to frequency
4. Thinning established stand
 - a) Stage of development: Discuss when to thin
 - b) Density: See Appendix 1, Field-Scale Transplanting Guide
5. Questions and answers

Demonstration 1: Garden-Scale Transplanting & Direct Sowing

step-by-step instructions for the students

A. Assess Plant, Soil, and Environmental Conditions *Prior* to Sowing or Transplanting

1. Seedling development
 - a) Shoot development
 - i. Second set of true leaves (cell format)
 - ii. Filling out allotted space and second set of true leaves established (flat format)
 - b) Root development
 - i. Root knit (cell format)
 - ii. Filling out allotted space (flat format)
2. Seedling pre-treatments
 - a) Soil/mix moisture
 - i. Field capacity (cell format)
 - ii. 75%–80% of field capacity (flat format)
 - b) Hardened-off
 - i. 3–21 day range (minimum of 3 days with 24 hours at field conditions)
 - ii. Hardening-off period should increase in duration with increased differential between field and greenhouse conditions
3. Field or garden soil conditions
 - a) Soil moisture
 - i. 75–80% of field capacity
 - b) Degree of secondary cultivation
 - i. Extensive secondary cultivation for small-seeded, direct-sown crops and transplants with small, weak, or inefficient root systems (e.g., carrots)
 - ii. Slightly less secondary tillage for large, vigorous, and resilient transplants (e.g., tomatoes, peppers)
4. Optimal environmental conditions favorable to successful transplanting from flat format
 - a) Low light levels
 - b) Low temperature
 - c) Calm winds
 - d) High relative humidity
 - e) Late afternoon and early evening

Note that you will seldom have all of these conditions in place; see information in lecture outline for ways to compensate for less-than-ideal transplanting conditions

B. Transplanting

1. Gather necessary tools and materials
 - a) Seedlings at transplant maturity
 - b) Hand trowel and hand fork
 - c) Watering wand
 - d) Dibble or other transplant marker

- e) String jig
 - f) Measuring tape
 - g) Ross and hose
 - h) Micro-sprinklers
 - i) String and stakes
 - j) Seed
 - k) Push seeders (if available)
2. Plant spacing considerations: Consider how the following factors influence crop spacing
 - a) Irrigation and cultivation considerations
 - i. Rows should be straight and between-row crop spacing should be large enough to accommodate drip irrigation line and cultivation tools
 - b) Root and shoot size
 - i. How large is the root system and vegetative portion of the plant at maturity?
 - c) Stem length and stem number in cut flowers
 - i. By increasing crop density in certain cut flowers, flower stem lengths may be increased.
 - d) See Appendix 2, Common Transplant Spacings; Common Seeding Rates and Thinning Distances, for recommendations
 3. How to plant
 - a) Know the crop being planted
 - i. Review the crop culture information on the back of the seed package, in seed catalogues, online, or in books on crop culture
 - b) Plant selection criteria (seedling vigor): Select for vigor
 - c) Plant handling
 - i. Crops grown in a flat format should be handled carefully by the rootball, attempting to disturb the root system as little as possible during the transplanting process. Crops grown in a flat format should only be transplanted during the late afternoon/early evening or on cloudy days.
 - ii. Crops grown in a cell tray format may be planted throughout the day and with less concern for disturbance of the root system during planting
 - d) Depth of planting
 - i. Most crops should be planted to the depth of the cotyledons (see Appendix 4, Seedlings at Transplant Maturity, Planting Depth)
 - ii. Crops in the Solanaceae family (tomatoes, peppers, eggplants, etc.) and Brassicaceae family (broccoli, cabbage, cauliflower, etc.) are adventitious rooters and may be buried to the bottom of the first set of true leaves
 4. Watering in
 - a) Seedlings should be immediately irrigated following transplanting
 - b) Bring the root zone of the crop to saturation (all pore spaces filled) using drip irrigation, overhead sprinklers, micro sprinkler, or basal soaking with a watering wand or rose
 5. Documenting
 - a) Transcribe the information on the horticultural label (including the transplanting date) to a bed-end stake and the garden record log book (see Appendix 8)
 6. Follow-up
 - a) Determine the type of irrigation to be used and set up any necessary irrigation equipment at this time

- b) Return remaining seedlings to the propagation area. Refill flats with propagation mix and water thoroughly
- c) Over the following approximately 2–5 days, monitor soil moisture in the root zone of the recently transplanted crop. Irrigate once the soil in the root zone has reached 50–60% of field capacity; at the depth of the root ball (2–4" deep) the soil should be right on the edge of not "balling up" when squeezed. Note that it is better to water too early than to stress new transplants by underwatering.
- d) Periodic, light overhead irrigation will raise the relative humidity around the seedlings, reduce the rate of evapotranspiration, and help minimize transplant shock
- e) Observe the growth and development of the roots and shoots of the seedlings, noting the following: Rates of growth, changes in color, and damage due to predation
- f) Replace seedlings lost to predation. Use remay or other floating row cover to protect seedlings from insect damage, as appropriate

C. Direct Sowing

1. Consider the optimal environmental conditions for seed germination in terms of:
 - a) Soil moisture
 - i. 75%–80% of field capacity
 - b) Degree of secondary cultivation
 - i. Extensive secondary cultivation is necessary for small-seeded direct-sown crops and transplants with small, weak, or inefficient root systems
 - c) Soil temperature
 - i. Compare the existing soil temperatures with the optimal germination temperatures found on the back of the seed package, in Knott's Handbook for Vegetable Growers, or in Appendix 2, Seed Viability Chart, of Unit 1.3, Propagating Crops from Seed, and Greenhouse Management
2. Direct-sowing techniques
 - a) Sowing into furrows with hands
 - i. Open furrow with fingers or hand tool to a depth of approximately 2 times the diameter of the seed to be sown
 - ii. Sow seed at 2–3 times the density desired at maturity (seedlings are later thinned to desired spacing when the first set of true leaves have developed)
 - iii. Cover seed by pinching furrow together
 - iv. Gently tamp soil with head of rake to assure soil-to-seed contact
 - b) Sowing into furrows with push seeder
 - i. Consult the seed plate chart for use of push seeder
 - ii. Test seeder output on hard, flat surface to confirm desired seed rate/spacing
 - iii. Periodically check to assure seed output and seed supply in hopper
 - c) Broadcast sowing
 - i. Broadcast evenly over surface of soil
 - ii. Cover lightly with a mixture of 50% garden soil and 50% mature compost
3. Irrigating seed beds
 - a) Using Ross, oscillator, or mist/micro-sprinklers, maintain surface soil moisture with light, frequent applications of water each time 50%–100% of the surface of the soil has dried and discolored (see Appendix 6, Garden-Scale Seed Bed Irrigation)
4. Thinning direct-sown crops
 - a) Thin directly seeded crops to desired spacing, if necessary, once the first set of true leaves has developed (see crop-spacing chart in Appendix 2 and in seed packages and catalogues)

Demonstration 2: Field-Scale Transplanting & Tractor-Mounted Seeding

for the instructor

INSTRUCTOR OVERVIEW

This field demonstration outline introduces the tractor-mounted equipment and skills used to transplant and direct seed crops. It first covers the sequence of techniques and equipment used to prepare the soil for both transplanting and direct seeding. The outline then introduces the range of equipment and techniques used to transplant and direct seed crops, followed by irrigation techniques.

PREPARATION AND MATERIALS

- Bed shaper/marker
- Tractor-mounted seeder
- Push seeder
- Plate planter
- Tractor-mounted transplanting equipment
- Hand trowels
- Irrigation equipment: Drip and sprinkler
- Record sheets for recording crops sown, and planted (see Appendices 7 and 8)
- Labels for marking bed
- Shovels for single row plantings

GROUND PREPARATION

This demonstration requires access to an area of ground that has received primary and secondary tillage, pre-irrigation, and weed cultivation. These techniques should be included in the demonstration if not covered previously in Unit 1.2, Garden and Field Tillage and Cultivation.

PREPARATION TIME

1 hour

DEMONSTRATION TIME

1 hour

DEMONSTRATION OUTLINE

A. Review and Discuss Tools and Sequence Used to Prepare Ground

1. Review field soil conditions prior to tillage
 - a) Soil moisture range: 50%–60% of field capacity (see Appendix 5 in this unit, and Unit 1.5, Irrigation—Principles and Practices, for discussion of field capacity)
2. Review steps involved in incorporation of cover crop residue through primary tillage
 - a) Mowing (flail or rotary)
 - b) Apply compost prior to residue incorporation, if necessary
 - c) Incorporate cover crop residue with spader or off-set wheel disc (see Unit
3. Establishment of seedbed through secondary tillage techniques
 - a) Rototill or disc field to improve surface uniformity following residue breakdown
4. Review steps involved in bed formation
 - a) Form beds with lister bar and shovels or rolling cultivator
 - b) Shape bed with bed shaper
 - c) Pre-irrigate to germinate weed seed; if using drip tape, pre-irrigate one week in advance
 - d) Cultivate unplanted beds with sweeps, knives, or rolling cultivator to minimize weed pressure and exhaust seed bank
 - e) Ensure good tilth: Important for roots of transplants to have access to water held in soil pores; large clods don't hold water
 - f) Plant beds with seeder, transplanter, or by hand

B. Demonstrate Bed Shaper/Seeder for Direct-Sown Crops

1. Review attachment of implement(s)
2. Demonstrate adjustment of bed shaper height
3. Demonstrate adjustment of seeder shovels' height for seeding various crops
4. Demonstrate using markers on bed shaper to pull scratch lines for guiding straight planting
5. Review examples of crops that are directly sown and why

C. Demonstrate Implements Used to Prepare Beds for Single-Line Plantings

1. Review attachment and adjustment of implement(s) used
2. Review examples of single-line crops

D. Review Planting Plan

1. Prepare planting map: Calculate how many feet of which crop will be planted (and where), and have map ready for planting crew
2. Prepare list of plants to pick up from hardening-off area

E. Review Preparation for Transplanting

1. Transplant preparations: Irrigation and hardening off (see Unit 1.5, and discussion of hardening off in this unit)
2. Ensure that transplants are ready: Knit together root plug, hardened off for one week, firm stems, roots that are not wrapped
3. Planting considerations to minimize transplant shock
 - a) Plug trays should be saturated (dripping wet) prior to planting
 - b) Soil should be pre-irrigated

- c) Plant in cool of the day, or going into cool; e.g., in Central Valley, plant late afternoon
- d) Leave trays in shade if not planting immediately
- e) Reschedule planting if extremely hot or windy
- f) Have irrigation ready to turn on as soon as planting is done and before plants stress; note that for sprinkler irrigation, planting block is equal to irrigation block

F. Review Hand Transplanting Techniques

1. Review of transplanted crops
 - a) Single line crops (tomatoes, peppers, eggplant, squash, melons, cucumbers)
 - b) Double line crops (brassicas, lettuce, celery, onions, leeks)
2. Handling and placement
 - a) To remove plants from plug trays, grasp stem firmly or drop tray on flat ground to loosen plugs
 - b) Work in teams: one person drops plant in furrow, one person plants
 - c) Drop and plant one line at a time (i.e., don't try and cover both lines of a raised bed)
 - d) Pay attention to designated spacing (i.e., 8", 12", etc.) and stay in scratch line so plants don't later get cultivated out during mechanical cultivation
 - e) Don't leave plugs on soil surface for longer than 3–5 minutes
 - f) Planting depth: Cover plug entirely (Note: Sometimes, plants are placed on their side if stems are leggy, e.g., tomatoes, sunflowers; or plant up to cotyledons, e.g., broccoli)
 - g) Avoid planting plug above air pockets

G. Demonstrate the Use of Mechanical Transplanter

1. Review attachment of implement(s)
2. Demonstrate adjustment of transplanter
3. Transplant preparations: Review irrigation and hardening off
4. Demonstrate handling and placement of transplants
5. Review examples of crops that are mechanically transplanted and why
6. Demonstrate adjustment of transplanter

H. Review Irrigation Techniques Used Immediately Following Transplanting and Direct Seeding

1. Drip irrigation
2. Sprinkler irrigation: Irrigation pipe is ready to hook up, pump is tested, etc.
3. Note that if block is mixed between direct sown and transplanted crops, direct sow first so that water can be turned on as soon as transplants are in the ground

I. Demonstrate Clean Up

1. Wash out plug trays and sun-sterilize

J. Review Record Keeping

1. Record information on bed-end stakes (cultivar, planting date)
2. Record information in field logs (see Appendices 9 and 10)

Assessment Questions

- 1) List three physical environmental conditions favorable for successful transplanting of flat-grown seedlings.
- 2) What is the optimal range of soil moisture for transplanting or direct seeding of crops?
- 3) Describe how the size, root nature, and vigor of transplants and the size of seeds influence the degree of secondary cultivation needed.
- 4) List two characteristics of seedlings at transplanting maturity.
- 5) List two necessary steps in preparing seedlings for transplanting.

Assessment Questions Key

- 1) List three physical environmental conditions favorable for successful transplanting of flat-grown seedlings
 - *Low light levels*
 - *Low temperature*
 - *High relative humidity*
 - *Calm winds*
- 2) What is the optimal range of soil moisture for transplanting or direct seeding of crops in the garden? In the field?
 - *Garden: 75–80% of field capacity*
 - *Field: Between 50%–60% of field capacity (lower in order to minimize compaction from equipment)*
- 3) Describe how the size, root nature, and vigor of transplants and the size of seeds influence the degree of secondary cultivation needed
 - *Directly sown crops (especially small-seeded crops) require extensive secondary cultivation in order to reduce the surface soil particle size and produce a quality seed bed. Small, inefficient, weak, or shallow-rooted crops (e.g., onions, leeks, lettuce) also respond favorably to being transplanted into soils having received extensive secondary cultivation.*
 - *Large, vigorous transplants may be transplanted into more coarsely tilled soils*
- 4) List two characteristics of seedlings at transplanting maturity
 - *Second set of true leaves initiated*
 - *Root knit*
- 5) List two necessary steps in preparing seedlings for transplanting
 - *Pre-moistened to 75–80% and 100% of field capacity (flats and cell tray transplants respectively)*
 - *Hardened-off for 3–21 days*

Resources

PRINT RESOURCES

Coleman, Elliott. 1995. *The New Organic Grower: A Master's Manual of Tools and Techniques for the Home and Market Gardener, 2nd Edition*. White River Junction, VT: Chelsea Green Publishing.

The classic introduction to small-scale organic vegetable production. Includes sections on direct seeding, transplanting, and using soil blocks.

Maynard, Donald M., and George H. Hochmuth. 2006. *Knott's Handbook for Vegetable Growers, 5th Edition*. Hoboken, New Jersey: John Wiley & Sons.

A widely used reference book designed for commercial vegetable growers. Includes basic information on planting rates, schedules, and spacing of myriad vegetable crops.

Fortier, Jean-Martin. 2014. *The Market Gardener: A Successful Grower's Handbook for Small-Scale Organic Farming*. Gabriola Island, BC: New Society Publishers.

Includes a section on starting seeds indoors and direct seeding.

Volk, Josh. 2009. *Tools That Make Direct Seeding Easier*. Growing for Market. www.growingformarket.com/articles/20090428_6

WEB-BASED RESOURCE

USDA, Natural Resources Conservation Service. 1998. Estimating Soil Moisture by Feel and Appearance. Program Aid Number 1619.

www.ext.colostate.edu/sam/moisture.pdf

Describes techniques for using the “feel and appearance” method to estimate soil moisture content and schedule irrigation.

SUPPLEMENT 1

Genetic Engineering & Seed Diversity: Impacts on Farmers & Agricultural Communities

Seed saving has been an integral component of agriculture throughout history. Starting with humankind's earliest efforts to domesticate wild plants, farmers around the world grew crops by saving and replanting seeds from the previous season. Almost universally viewed as a shared resource entrusted to the public, farmers have always enjoyed the freedom to save, breed, replant, and exchange seeds, resulting in the great diversity of plants we rely on for food and fiber around the world.

Genetic diversity among seeds is vital not only to the resilience of plants, but also to the resilience of communities that depend on plants for their livelihoods.

Both crop diversity and farmers' freedom to grow crops of their choice have been severely diminished in the last eight decades, as production agriculture's focus on high yield intensified and as patent law gave agrichemical companies private patent rights to seeds. Today, global crop diversity is shrinking as the worldwide adoption of patented, genetically engineered (GE) seeds accelerates. GE varieties are quickly becoming dominant in commodity crop agriculture in many countries. As of 2009, 90 percent of corn, 84 percent of soybean and cotton, and 64 percent of canola grown in the United States is from GE seed.¹

As a consequence of changes to U.S. patent law in 1980, seeds were, for the first time, subject to patents and ownership by individuals or corporations. Nearly all GE and hybrid seeds are now patented and owned by the companies that sell the seeds commercially. As of 2009, five companies (Monsanto, DuPont, Dow, Bayer, and Syngenta) accounted for 58% of global commercial seed sales.²

Dramatic increases in seed prices have accompanied seed industry consolidation, due in part to technology fees on GE seeds that companies can charge with their increased market share. Farmers who buy

GE seeds are also required to sign technology use agreements (TUGs), essentially legally enforceable contracts, limiting how the seed is used, to whom it is sold or transferred, and what it can be used for. Most TUGs prohibit research trials using GE seed or comparing yield performance between GE and other seed. Nearly all TUGs prohibit seed saving, requiring farmers to purchase new seed each year.

To enforce the restriction on seed saving, one company in particular, Monsanto, employs 75 or more investigators with a budget of \$10 million to aggressively patrol and sample crops from farmers' fields to test for unauthorized use of their GE seeds.³ Any unauthorized use of its seed—intentional or not—is considered patent infringement, thus giving Monsanto a financial incentive to police farm communities. Indeed, the company has sued nearly 150 farmers in several U.S. states for infringement, resulting in 72 recorded judgments totaling \$24 million and an estimated \$80–160 million more in out-of-court settlements against farmers⁴ (see also Unit 3.2, Social Issues in Current U.S. Agriculture, Lecture 2). The other seed companies mentioned above engage similar tactics against farmers who save their patented seeds.

India has also seen drastic impacts on farmers as a result of GE seed use. GE cotton was introduced to Indian farmers in 2002 as part of new development policies aimed at stimulating economic growth. By 2009, nationwide adoption of GE cotton reached 85 percent, with rates as high as 95 percent in some states. While crop yields initially rose, the new varieties, owned and licensed by Monsanto, increased monetary and resource costs for cash-strapped Indian farmers with limited access to water.

1 USDA Economic Research Service. Genetically engineered varieties of corn, upland cotton, and soybeans, by State and for the United States, from 2000–14. www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us.aspx#.VCzU_CldWyo

2, 3, 4 Center for Food Safety. Seed Giants vs. U.S. Farmers, February 13, 2013. www.centerforfoodsafety.org/reports/1770/seed-giants-vs-us-farmers#

GE cotton seeds cost farmers two to ten times more than non-GE varieties⁵ and, because of TUG requirements, had to be purchased each season, forcing many farmers to borrow money just to buy seed. Then, in order to secure the high yields these new, expensive seeds promised, farmers who traditionally relied on rainfall for irrigation borrowed more money for wells and irrigation equipment to provide the thirsty GE crops with a steady supply of irrigation water. GE seeds are genetically identical clones bred in closely monitored field trials under optimum conditions. As a result, they require optimum conditions to produce the increased yield they are advertised as capable of producing and that is necessary for farmers to be able to pay back the mounting debt from seed, pesticide, and irrigation purchases. In a year of poor rainfall or when a well pump fails, many farmers suddenly find themselves paralyzed by debt. In the years following India's adoption of GE cotton, farmers fell deeper and deeper into debt to recoup their investment in GE seeds, and scores of smallholder farmers eventually gave up trying. From 2002 and 2010, 153,727 farmers committed suicide in India.⁶

Many more farmers, in India and elsewhere, find themselves in a similar situation, heavily burdened by debt and pressured to cultivate more land just to make ends meet. In an effort to provide farmers with more options, organizations such as the Organic Seed Alliance and The Land Institute are researching and breeding organic seeds for commercial production and (in The Land Institute's case) for sustainable farming systems based on perennial crops. Unlike hybrid and GE seed, these are generally open-pollinated varieties that farmers can save from season to season. Still a minor source of seeds even for organic growers, more government-funded research is needed to develop commercially viable organic seeds for the wide variety of crops grown in the U.S. and abroad.

Although the debate about genetically engineered crops is likely to continue for the foreseeable future, it is important to recognize the serious impacts of this technology on the viability of farm communities around the world today. From public research to farmer sovereignty and suicides, the effect of corporate control and ownership of seed on a farmer's ability, and right, to save and replant seeds has far-reaching implications for the wellbeing of individuals and of agricultural communities.

5 Center for Human Rights and Global Justice, *Every Thirty Minutes: Farmer Suicides, Human Rights, and the Agrarian Crisis in India*; p.7 (New York: NYU School of Law, 2011). www.chrgj.org/publications/docs/every30min.pdf

6 Compiled from Crime Records Bureau, *Accidental Deaths and Suicides in India*, available at ncrb.nic.in/ (Scroll over "Publications", then click "Accidental Deaths & Suicides in India")

Appendix 1: Field-Scale Transplanting Guide

| Crop | VERY EASY TO TRANSPLANT | MODERATELY EASY TO TRANSPLANT | CHALLENGING TO TRANSPLANT | ALMOST NEVER TRANSPLANTED | COMMENTS |
|-------------------|-------------------------|-------------------------------|---------------------------|---------------------------|---|
| Broccoli | X | | | | |
| Cabbage | X | | | | slight stress in plant trays will result in premature flowering |
| Cauliflower | X | | | | |
| Chard | X | | | | |
| Collards | X | | | | |
| Kale | X | | | | |
| Lettuce | X | | | | |
| Tomatoes | X | | | | OK to overharden / handles stress well |
| Celery | | X | | | |
| Eggplant | | X | | | |
| Leeks | | X | | | |
| Onions (bulbing) | | X | | | can be planted in "nursery bed" in field |
| Onions (bunching) | | X | | | can be planted multiple seeds per cell |
| Peppers | | X | | | |
| Beets* | | | X | | |
| Cucumbers** | | | X | | |
| Melons** | | | X | | |
| Pumpkins** | | | X | | |
| Radishes* | | | X | | rapid seed emergence makes direct sowing desirable |
| Salad Mix* | | | X | | |
| Spinach* | | | X | | |
| Squash (Summer)** | | | X | | |
| Squash (Winter)** | | | X | | |
| Turnips | | | X | | rapid seed emergence makes direct sowing desirable |
| Beans | | | | X | |
| Carrots* | | | | X | |
| Corn | | | | X | |
| Peas | | | | X | |

* close spacings make transplanting uneconomical in most situations

** transplanting often results in reduced yield compared to direct sown

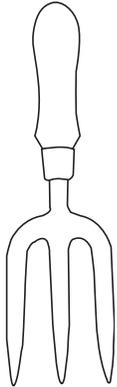
Appendix 2: Common Transplant Spacings: Common Seeding Rates & Thinning Distances

| CROP | Transplant (TP) or Direct Sow (DS) | Spacing / Thin to | Notes for Central Coast CA |
|---------------------------------------|---------------------------------------|-------------------|--|
| Arugula | DS | 20-50 seeds/ft | Seeding rate depends on seeder type/seed plate |
| Basil | TP | 8" | Plant out clusters from plug tray, 4-6 seeds/cell |
| Beans, bush | DS | thin to 3" | 1.5# per 300' row, plant 2 beds at a time, = 3#/sowing |
| Beets | DS | thin to 3" | 2 oz sows 300'; 4 oz per 2-line bed. Divide seed total between Red, Golden and Chioggia varieties. |
| Broccoli | TP | 12" | |
| Brussels Sprouts | TP | 16" | |
| Cabbage | TP | 12" | |
| Carrots | DS | Thin to 2" | 1 oz raw seed sows 600 feet |
| Cauliflower | TP | 14" | |
| Celeriac | TP | 8" -12" | |
| Celery | TP | 8" | |
| Chard | TP | 8-10" | Early and late season (break leaf miner cycle with summer gap) |
| Chinese Cabbage | TP | 12" | Cover well with remay for flea beetles |
| Cilantro | DS | 50 seeds/ft | 1 oz sows 275 linear feet. Good beneficial habitat when flowering. |
| Collards | TP | 12" | |
| Corn | DS | 10-12" | |
| Cucumbers | DS or TP | 12"-24" | |
| Dill | DS | thin to 3" | 20,000 seeds/oz 1 oz plants 2500 linear feet |
| Fennel | TP | 8" | |
| Garlic | DS | 6" | |
| Greens, Asian: baby Bok Choy | DS | thin to 6-8" | 1 oz seeds 830' (cover with remay) |
| Kale | TP | 10" | Plant early and late. Aphid problems in spring – use Red Ursa. |
| Kohlrabi | TP | 8" | |
| Leeks | TP | 4-8" | |
| Lettuce, full size | TP | 10" | |
| Lettuce, mini heads | TP | 6" | |
| Onions, storage | DS | thin to 5" | 1 oz plants 300 |
| Onions, "Purplette" fresh bunching | TP | 8" | Sow as clusters of 5 in TP trays |
| Onions, Cipollini | TP | 8" | Plant in mid-April from transplant for harvest mid-July. Plant in clusters. |
| Pac Choi | TP | 10" | |
| Parsley, Italian | TP | 12" | |

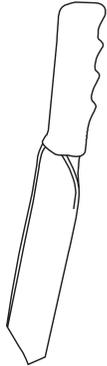
Appendix 2 (cont'd): Common Transplant Spacings: Common Seeding Rates & Thinning Distances

| CROP | Transplant (TP) or Direct Sow (DS) | Spacing / Thin to | Notes for Central Coast CA |
|---------------------------|------------------------------------|-------------------|---|
| Peppers, Sweet | TP | 12-18" | 4 peppers = about 1.15# |
| Peppers, Hot | TP | 12" | |
| Potatoes | DS | 10-12" | |
| Radishes | DS | 2" | |
| Salad Mix | DS or TP | TP: 4-6", DS: | |
| Spinach | DS | swath | |
| Squash, Summer | DS | Thin to 24" | Sow 1/ft and thin. Leave empty bed next to planted bed for ease of harvest/cultivation. |
| Squash, Winter & Pumpkins | DS | Thin to 24" | 30-40" between row spacings for bush type squash, 6"-80" for vining types |
| Strawberries | buy plants | 12" | Plant into plastic |
| Tomatoes, Dry Farm | TP | 24-36" | Skip a row for less water competition |
| Tomatoes, Heirlooms | TP | 24" | |
| Turnips, Tokyo type | DS | Thin to 3" | |

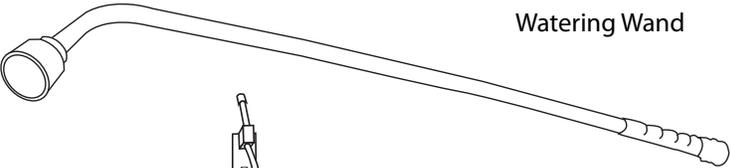
Appendix 3: Transplanting & Irrigation Equipment



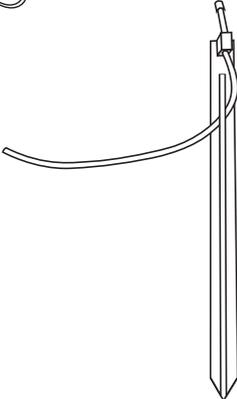
Hand Fork



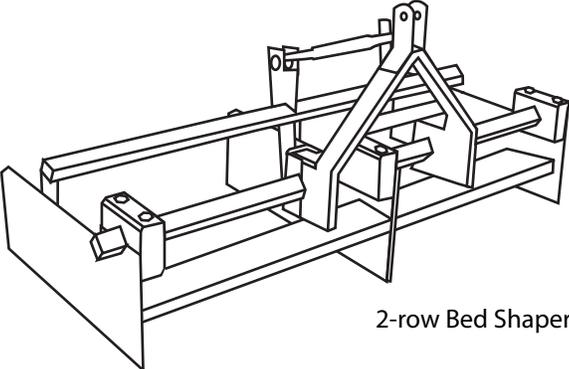
Hand Trowel



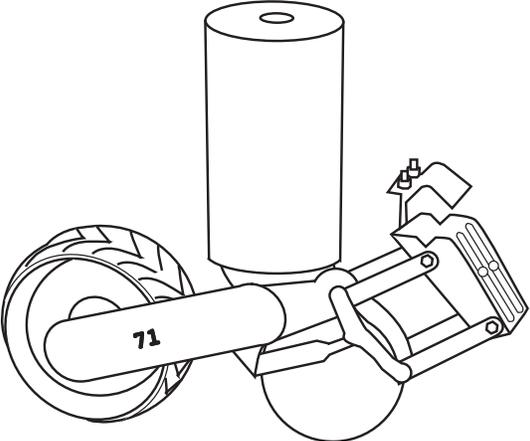
Watering Wand



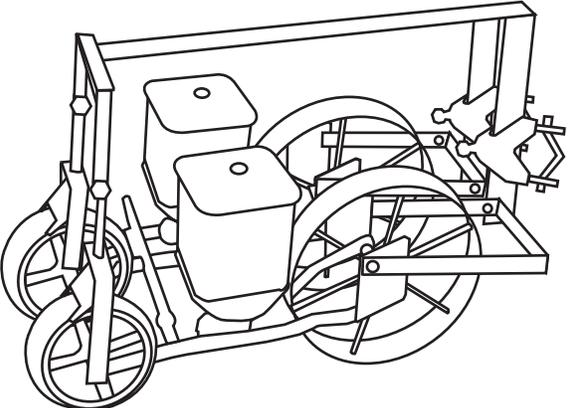
Micro-sprinkler



2-row Bed Shaper



John Deere Model 71 Plate Planter

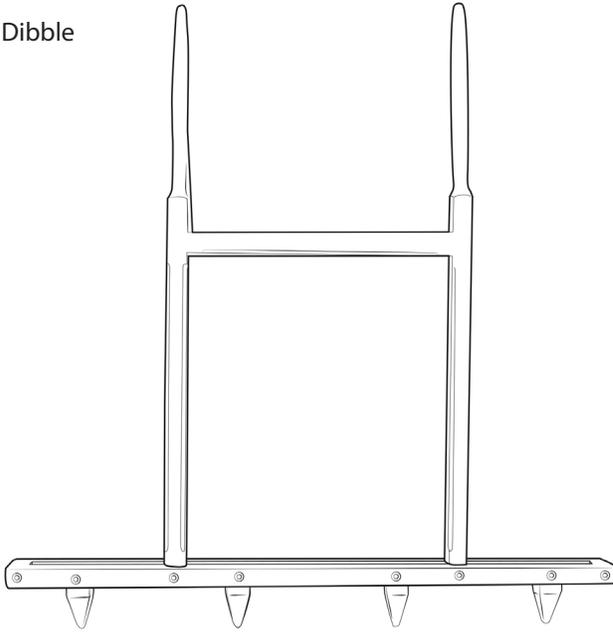


Planet Jr. Vegetable Planter

Illustrations by Cathy Genetti Reinhard; not to scale

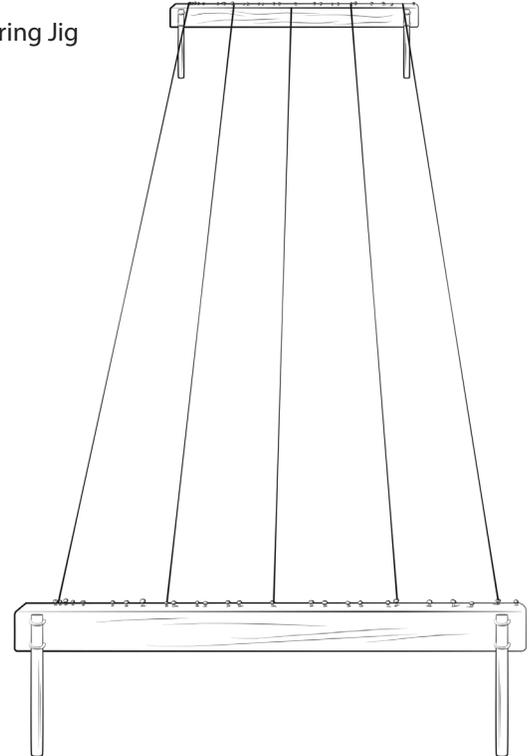
Appendix 3 (cont'd): Transplanting & Irrigation Equipment

Dibble

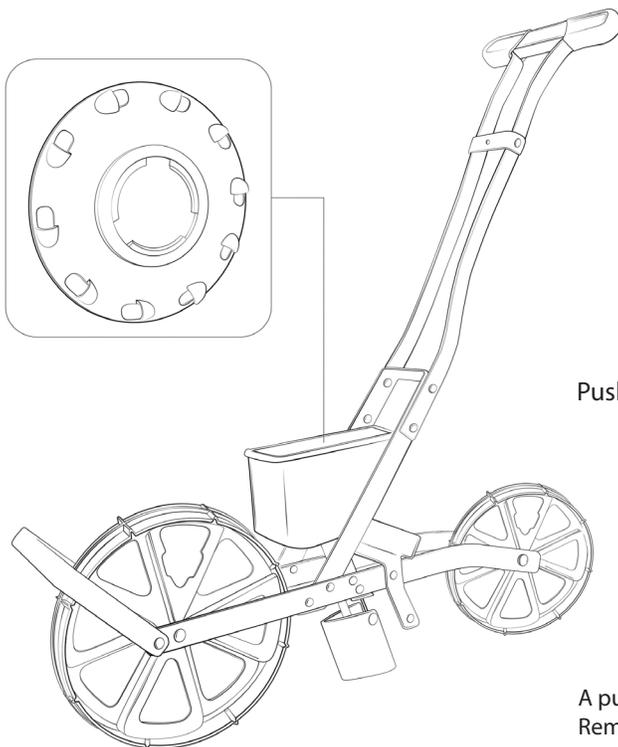


Dibble for creating lines of holes for transplanting. Note that the shape of the dibble creates a hole that fits transplant "plugs."

String Jig



String jig used to delineate rows for direct seeding and transplanting. The jig has screws set at different widths; string is wrapped onto the head of the screws to mark different row spacings.

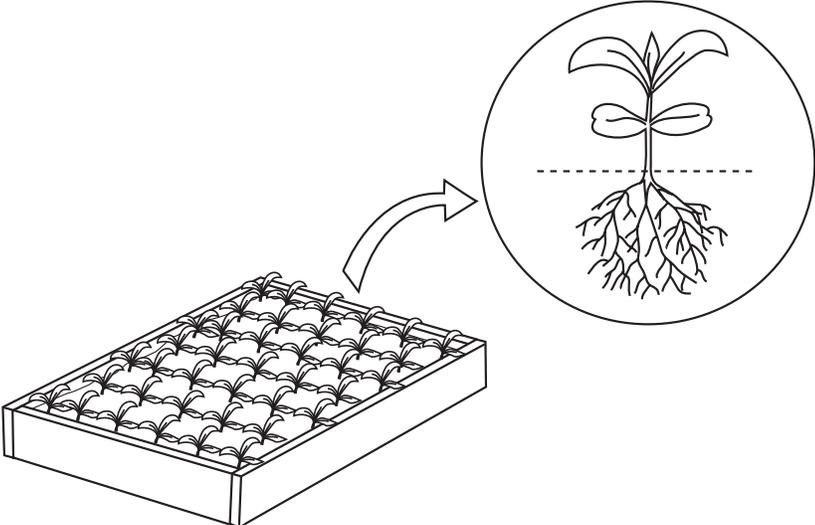


Push Seeder

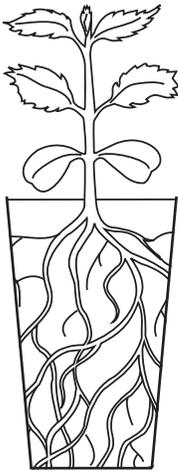
A push seeder used to seed garden beds. Removeable plates are used for different seed sizes.

Illustrations by José Miguel Mayo

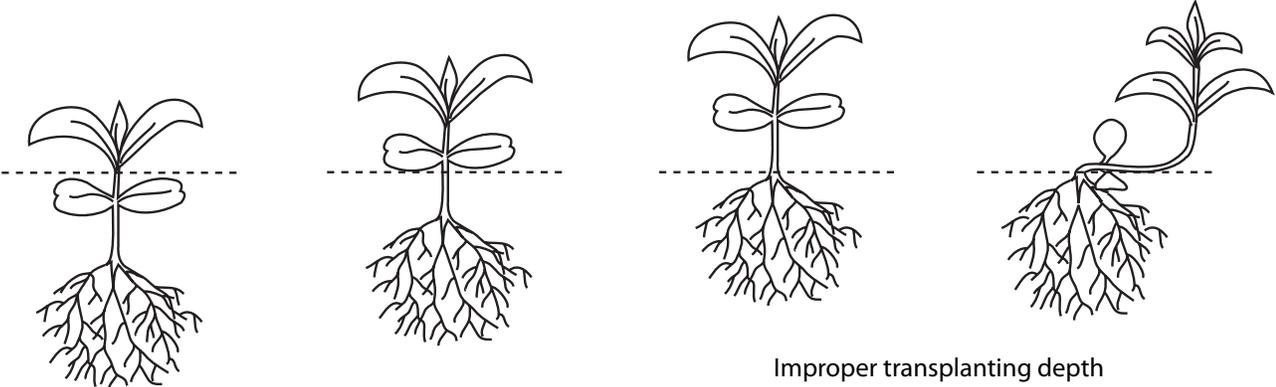
Appendix 4: Seedlings at Transplant Maturity: Planting Depth



Flat-grown seedling at transplant maturity—
note balance of roots and shoots



Cell-grown seedling at transplant maturity—
note balance of roots and shoots



Proper transplanting depth

Improper transplanting depth

Illustrations by Cathy Genetti Reinhard; not to scale

Appendix 5: Estimating Soil Moisture by Feel

Note: For garden beds, soil moisture should be at 75%–80% field capacity prior to transplanting or direct seeding. In the field, soil should be at 50%–60% of field capacity prior to transplanting or direct seeding. See also the Planting to Moisture information in Supplement 1 of Unit 1.10, Managing Weeds.

| SOIL MOISTURE LEVEL (% OF FIELD CAPACITY) | COARSE (SAND) | LIGHT (LOAMY SAND, SANDY LOAM) | MEDIUM (FINE, SANDY LOAM, SILT LOAM) | HEAVY (CLAY LOAM, CLAY) |
|--|---|--|---|---|
| 0–25% No available soil moisture. Plants wilt. | Dry, loose, single grained, flows through fingers. No stain or smear on fingers. | Dry, loose, clods easily crushed and will flow through fingers. No stain or smear on fingers. | Crumbly, dry, powdery, will barely maintain shape. Clods, breaks down easily. May leave slight smear or stain when worked with hands or fingers. | Hard, firm baked, cracked. Usually too stiff or tough to work or ribbon ¹ by squeezing between thumb or forefinger. May leave slight smear or stain. |
| 25–50% Moisture is available, but level is low | Appears dry; will not retain shape when squeezed in hand | Appears dry; may tend to make a cast ² when squeezed in hand, but seldom will hold together | May form a weak ball ² under pressure but will still be crumbly. Color is pale with no obvious moisture. | Pliable, forms a ball; will ribbon but usually breaks or is crumbly. May leave slight stain or smear. |
| 50–75% Moisture is available. Level is moderate to high. | Color is darkened with obvious moisture. Soil may stick together in very weak cast or ball. | Color is darkened with obvious moisture. Soil forms weak ball or cast under pressure. Slight finger stain, but no ribbon when squeezed between thumb and forefinger. | Color is darkened from obvious moisture. Forms a ball. Works easily, clods are soft with mellow feel. Will stain finger and have slick feel when squeezed. | Color is darkened with obvious moisture. Forms good ball. Ribbons easily, has slick feel. Leaves stain on fingers. |
| 75% to field capacity (100%) Soil moisture level following an irrigation | Appears and feels moist. Color is darkened. May form weak cast or ball. Will leave wet outline or slight smear on hand. | Appears and feels moist. Color is darkened. Forms cast or ball. Will not ribbon, but will show smear or stain and leave wet outline on hand. | Appears and feels moist. Color is darkened. Has a smooth, mellow feel. Forms ball and will ribbon when squeezed. Stains and smears. Leaves wet outline on hand. | Color is darkened. Appears moist; may feel sticky. Ribbons out easily, smears and stains hand, leaves wet outline. Forms good ball. |

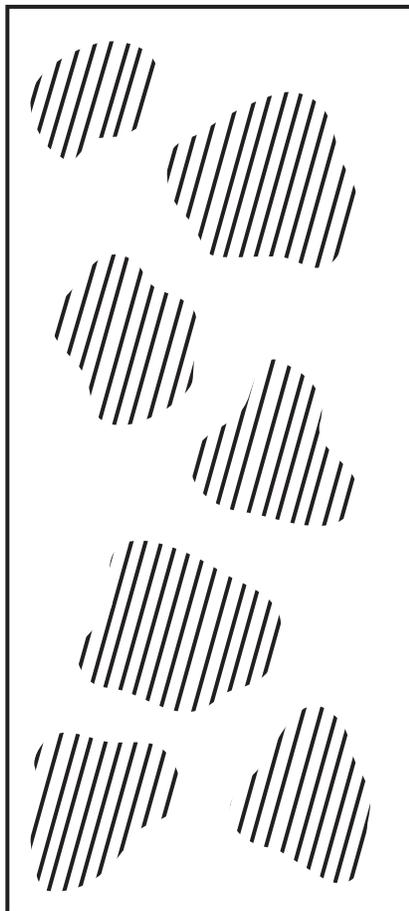
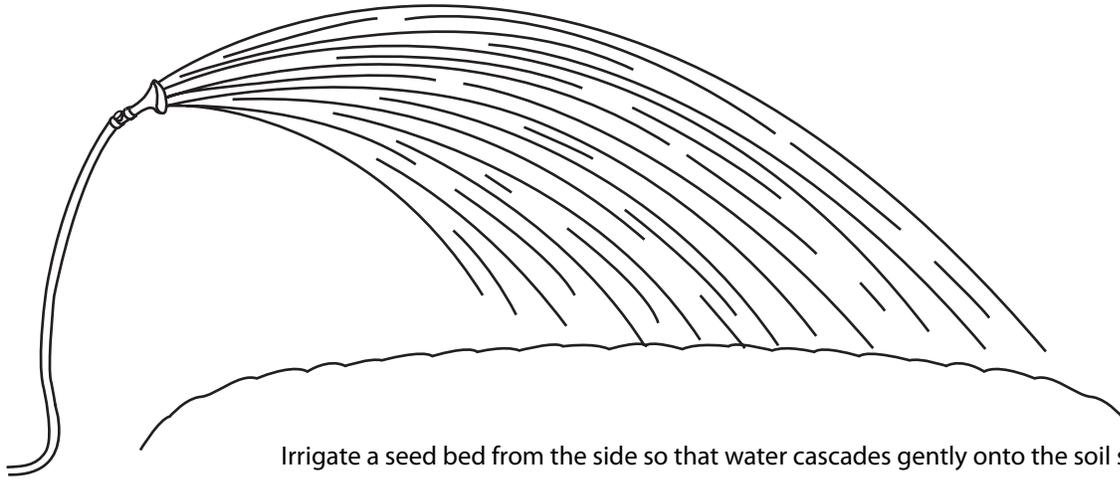
¹ Ribbon is formed by squeezing and working soil between thumb and forefinger

² Cast or ball is formed by squeezing soil in hand

See also:

USDA, Natural Resources Conservation Service. 1998. Estimating Soil Moisture by Feel and Appearance. Program Aid Number 1619. www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/newsroom/?cid=nrcs144p2_056492

Appendix 6: Garden-Scale Seed Bed Irrigation



Irrigate a seed bed each time 50% of the bed's surface area has dried

Illustrations by Cathy Genetti Reinhard

