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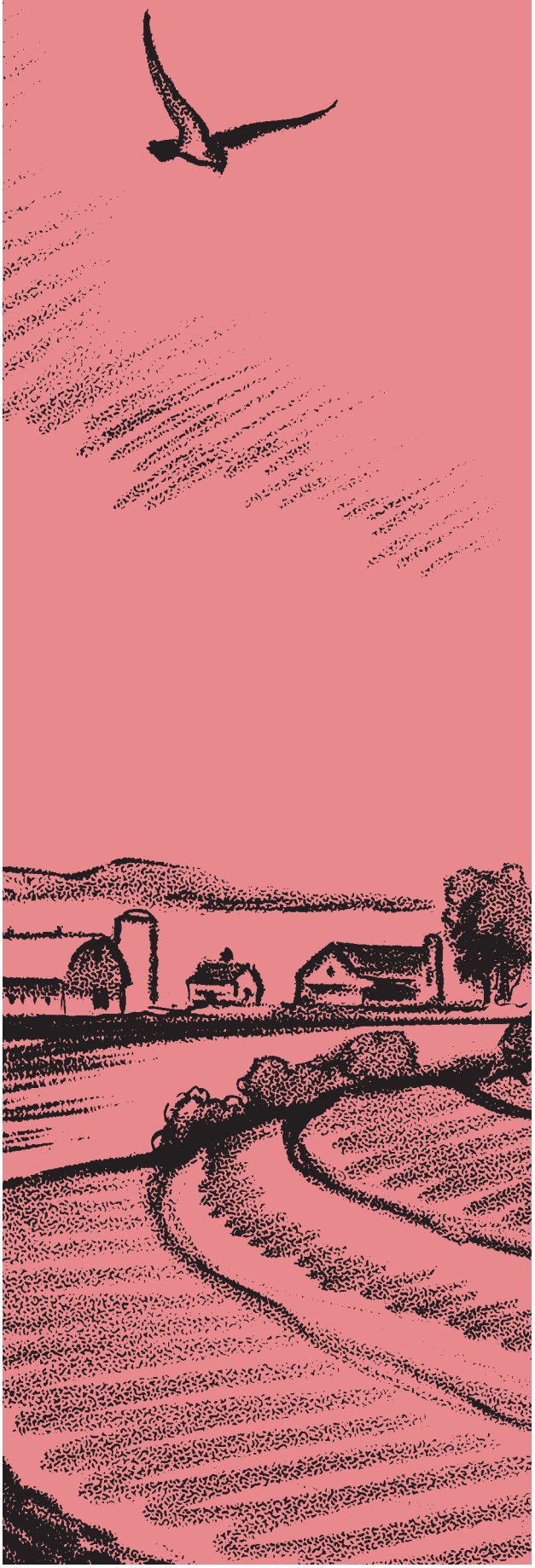

Growing tomatoes, peppers, and eggplants in Wisconsin

A guide for fresh-market growers

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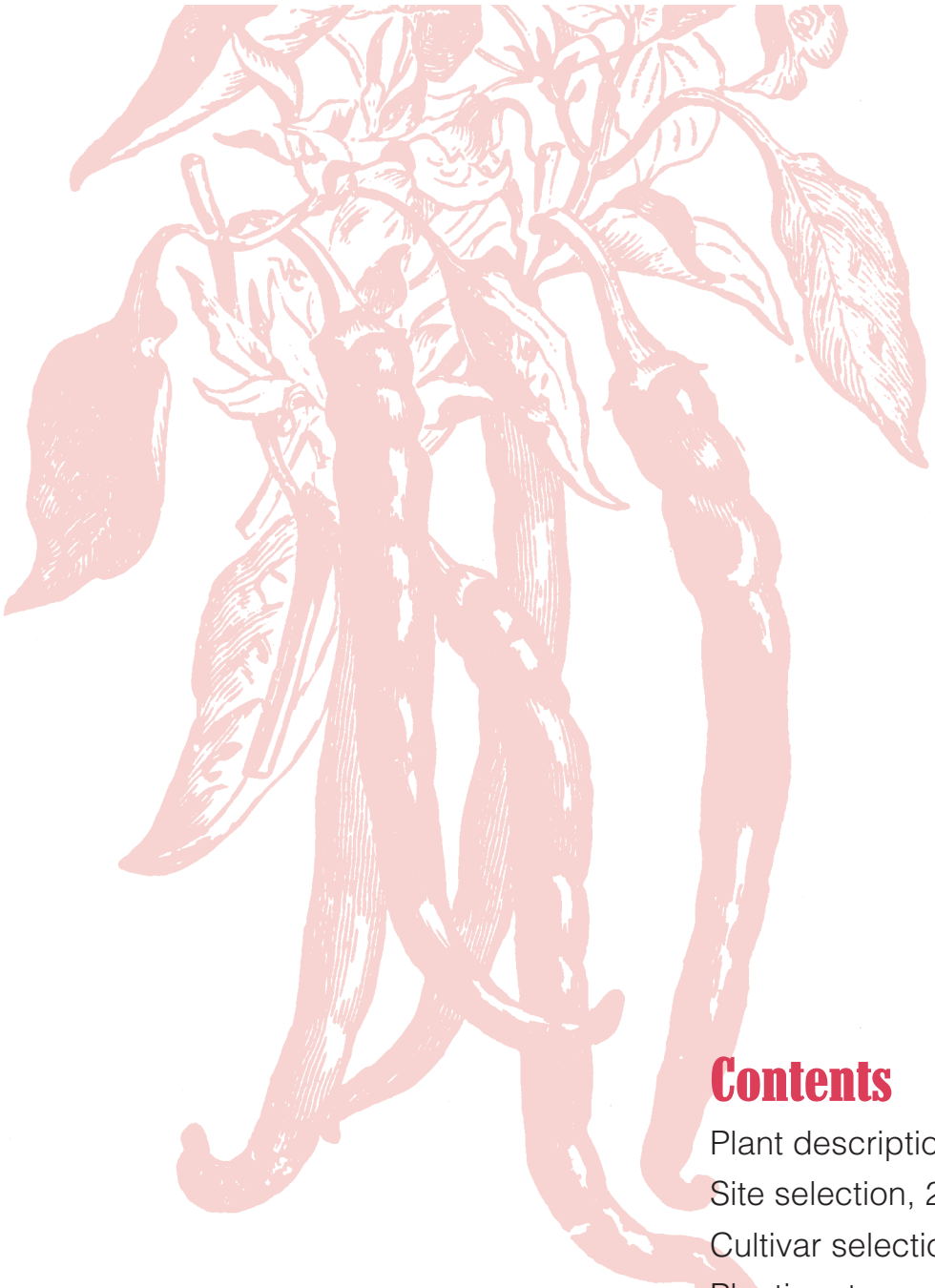

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Successful fresh-market gardening involves more than just a talent for growing high-quality vegetables. You also need to find a market for them. Before you start, visit other growers, develop a marketing plan, and evaluate the feasibility of your proposed business. Think about what is unique about your product. Are you promoting the product for taste, freshness, health benefits, value-added, or time of availability? For assistance determining your market, consult with your county Extension agent or refer to Extension publication *Direct Marketing of Farm Produce and Home Goods* (A3602).

Tomatoes have become the second-most popular vegetable, behind potatoes, in the United States. And salsa, which uses tomatoes and peppers liberally, has become the most popular condiment in the United States, surpassing even ketchup. Consumers expect fresh, flavorful, vine-ripened tomatoes to be available each summer to supplant the hard, bland tomatoes commonly available from the supermarket. Tomatoes and peppers contain significant amounts of the vitamins A and C. With the many varieties of sweet and hot peppers available, market gardeners can easily find a niche market for their product. Value-added products such as dried pepper wreaths command a high price. Specialty eggplant varieties such as the elongated Asian eggplants or varieties with white-skinned fruit are often more marketable than the traditional oval eggplant.

Plant description

Tomatoes, peppers and eggplants belong to the plant family Solanaceae, the nightshade family.

Tomatoes

The tomato, *Lycopersicon esculentum,* is native to the Andes mountain region of South America. Tomatoes were introduced to Europe in the 1500s, although until the 1700s they were believed to be poisonous if eaten. The foliage and some other green tissues of tomato plants do contain a toxic chemical, tomatine. Although tomatine is present in unripe tomato fruit, the levels are low enough to be nontoxic.

Tomatoes are tender, warm-season, herbaceous perennials grown as annuals in Wisconsin and other cold climates. Plants may be determinate, semi-determinate, or indeterminate in habit. Determinate varieties are compact plants which are often smaller than the indeterminate varieties. Each shoot on a determinate plant ends in a flower cluster, and consequently a fruit cluster. Determinate tomato plants tend to produce fruit all at once. Indeterminate cultivars are vining or sprawling in habit. The shoot tips continue to grow and flower clusters are borne in the leaf axils of the expanding shoot. Indeterminate tomato plants yield fruit over a long time. Determinate tomatoes, which grow on the ends of branches, tend to ripen earlier than indeterminate tomatoes because the fruit receives more heat and sun.

Leaves of the tomato plant are covered with fine hairs that emit the characteristic tomato smell when crushed. Plants have a deep taproot system with many secondary side roots. In loose soils, vigorous root systems may extend down 10 feet.

Tomato flowers are largely self-fertilized and are primarily wind pollinated. Individual flowers are borne in clusters of 4–8 flowers, and a single plant may produce 20 or more flower clusters. Depending upon the variety, the resulting fruit may be red, yellow, orange, pink or purple, and may be oblong, round, or pear shaped.

Peppers

The peppers grown commercially belong to two species: *Capsicum annuum* which includes all sweet peppers and hot chili peppers, and *Capsicum frutescens,* the tabasco pepper. Many people confuse the black and white pepper used as a seasoning with the pepper fruit grown for fresh market; those peppers belong to the species *Piper nigrum.*

Figure 1. Determinate plants (left) form flowers at the ends of branches while indeterminate plants (right) produce flowers in leaf axils.

Peppers originated in Mexico and Central America. It is believed that peppers were domesticated in Mexico as early as 7500 B.C. Most cultivars contain varying amounts of capsaicin, the chemical responsible for the heat, or pungency, of peppers. Capsaicin is more concentrated in the seeds and internal walls (placenta) where the seeds are attached. Removing these tissues can reduce the pungency of hot peppers.

Peppers are tender herbaceous perennials and are more susceptible to cold weather injury than tomatoes. In Wisconsin and other northern regions, peppers are grown as warm season annuals. The root system is shallow and fibrous.

Pepper flowers are self-pollinated by insects, although about 12% will cross with other plants. A mild variety can become hot because of cross pollination with a pungent cultivar. Pepper fruit may be borne on the plant pointing either up or down.

Pepper fruit may be green, yellow, red, purple, or brown. As peppers ripen, the carotenoid capsanthin is produced and green peppers develop into other colors. This process depends on the fruit being in the proper stage of ripening and temperatures being between 65° and 75°F. Temperatures below 56°F will inhibit coloring of the fruit. Capsanthin is absent in peppers that are picked when unripe and still green.

Eggplants

The eggplant, *Solanum melogena,* is native to India and China. As with tomatoes and peppers, the eggplant is a tender perennial grown as a warm-season annual in Wisconsin. The plant is an indeterminate, erect bush that reaches 2–4 feet tall when fully grown.

Eggplants have an extensive, fibrous root system. Flowers are borne singly or in clusters in leaf axils. Flowers are self-fertile but cross pollination does occur. Eggplant is pollinated by insects. The fruit may be oval, oblong, or round. Fruit color may be purple, purple-black, brown, green, pink, white, red, or yellow.

Site selection

Tomatoes, peppers, and eggplants require full sun. Choose light, warm, well-drained, fertile soil. Soil pH should be between 5.5 and 7.5. Tomatoes are not grown on muck soils because high soil organic matter results in too much foliage at the expense of fruit production.

Cultivar selection

Choose cultivars according to your own situation and needs. Table 1 lists some recommended tomato, pepper, and eggplant cultivars. When deciding what to grow, consider market demands, the length of your growing season, your soil, pests, diseases, irrigation, cultivars other growers like, and cultivars you personally like. If trying a new cultivar, do not use it exclusively. Grow new trials next to old standbys so you may compare the characteristics objectively.

Tomatoes

Tomato cultivars for Wisconsin are categorized by use: early crop, main crop, paste, and small fruited (cherry).

If a field has a history of problems with *Verticillium* wilt and *Fusarium* wilt, consider planting a cultivar that is resistant to these diseases. Resistant varieties are indicated by the letter following the cultivar name. “V” indicates resistance to *Verticillium* wilt, “F” indicates resistance to *Fusarium,* and “N” indicates resistance to nematodes.

Table 1. Recommended cultivars for Wisconsin

Tomatoes

Early crop

indeterminate
Early Girl (V)

determinate
New Yorker (V)
Wayahead

Main crop

indeterminate
Beefmaster (VFN)
Better Boy (VFN)
Burpee's Big Boy
Jet Star (VF)
Pink Girl (VF)

indeterminate, heirloom
Brandywine
Yellow Brandywine

determinate
Campbell 1327 (VF)
Celebrity (VFN)
Floramerica (VN)
Heinz 1350
Siletz (V)
Ultra Sweet (VF)

Cherry

indeterminate
Gardener's Delight
Sweet 100
Yellow Pear

determinate
Patio (V)
Pixie
Small-Fry (VF)
Tiny Tim

Paste

determinate
Roma VF
Viva Italia

Peppers

Hot
Flash
Habañero
Hot Portugal
Hungarian Yellow Wax
Ortega
Spanish Spice
Super Cayenne
Super Chili

Sweet (early)
Ace
Canape
Early Crisp
Early Niagara Giant
Gypsy (yellow)
Lipstick
Yellow Belle

Sweet (midseason)
Bell Boy
Golden Bell
Hybelle
Islander (purple)
Ivory
Lady Bell
Ma Belle
North Star
Portos Yellow
Purple Beauty
Sweet Cherry (pickling)
Ultra Set
White Lamuyo
Yolo Wonder B

Other
Biscayne (cubanelle)
Giant Yellow Banana
Ivory Banana
Sugar Banana
Super Shepherd (ramshorn)

Eggplants

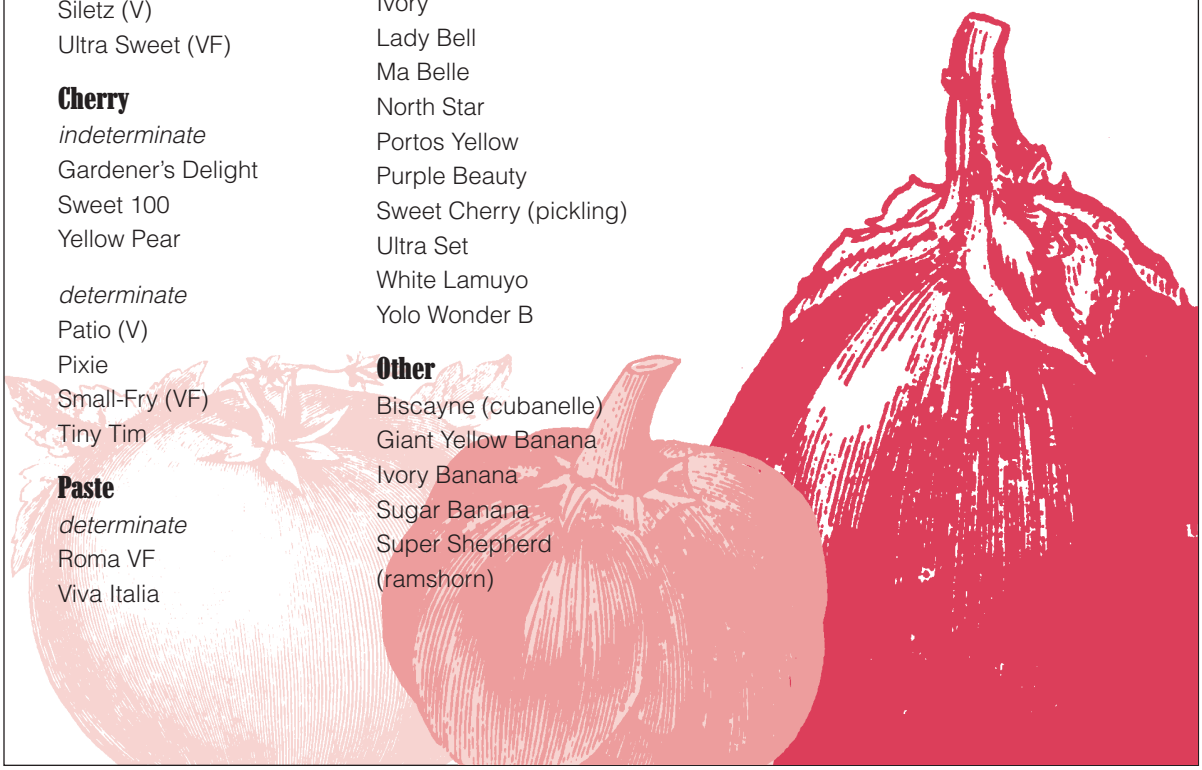
Asian
Agora
Ichiban
Orient Express

Oval (standard)
Black Beauty
Black Magic
Dusky
Early Beauty
Ghostbuster (white)
Machiaw (pink)
Neon (pink)
Rosita (pink)
Tango (white)

Miniature
Bambino

F_1 hybrids

Many cultivars have the designation "F_1 hybrid." An F_1 hybrid is created when two purebred strains of plants are crossed, producing identical offspring. F_1 stands for "filial 1," the first generation of hybrids after the cross was made. Seeds of F_1 hybrids will not produce true to form—the cross between the original parents must be made each time.



Older open-pollinated cultivars known as heirloom varieties have become increasingly popular. Heirloom varieties often offer better flavor and sometimes unusual characteristics. Growers can save genetically identical "true" seed from open-pollinated plants, whereas seed from hybrid plants is not true to the genetic make-up of the parent plant. Many heirloom varieties have no disease resistance and are often more susceptible to physiological disorders such as catfacing.

Peppers

There are many different types of peppers grown in the United States (table 2). Peppers can be classified based on their relative hotness. The Scoville Heat Unit is a measure of pepper pungency. Pure capsaicin is approximately 16,000,000 Scoville units. Habañero type peppers are the hottest with 300,000 Scoville units. The units will vary for each type of pepper based on variety, maturity, and whether the pepper is fresh or dried. Typically, pungent peppers require hot, dry conditions to fully develop their flavor and may not produce a suitable harvest in cool, wet summers.

Eggplant

Eggplant breeding programs have focused on the production of compact plants, cool temperature tolerance, and the production of varieties that ripen in a shorter growing season. Resistance to cucumber mosaic and tobacco mosaic viruses have been bred into many cultivars currently available.

Table 2. Descriptions of various pepper types

Type	Size	Shape	Color at maturity	Scoville Heat Units	Uses
Ancho	2–3" W x 3–6" L	heart-shaped	red or brown	1,000–1,500	chili rellenos, moles, dried as poblanos for decoration
Bell	3–4" W x 4" L	blocky bell	red, yellow, orange, brown	100–600	fresh in salads or baked
Cayenne	1" W x 10" L	thin and tapered, slightly curved	red	30,000–50,000	dried powder
Habañero	1–2" W x 1–2" L	irregularly spherical	orange	150,000–300,000	fresh in salsas
Jalapeño	1" W x 3" L	blunt and tapered	red	2,500–5,000	fresh in salsas
Pimento	2–3" W x 2–4" L	flattened	bright red	0	fresh in salads, pickled, dried as paprika
Pequín	¼–½" W x ¼–½" L	round to conical	dark red	50,000–100,000	dried and used in soups and sauces
Serrano	½" W x 1–4" L	tapered	green or red	10,000–20,000	fresh or canned
Thai	½–¾" W x 1½" L	tiny, bullet-shaped	dark red	30,000–100,000	fresh in stir fry dishes or dried as a powder
Wax	1" W x 2–8" L	thin and tapered	yellow	0–40,000	pickled or mild varieties can be used fresh in salads

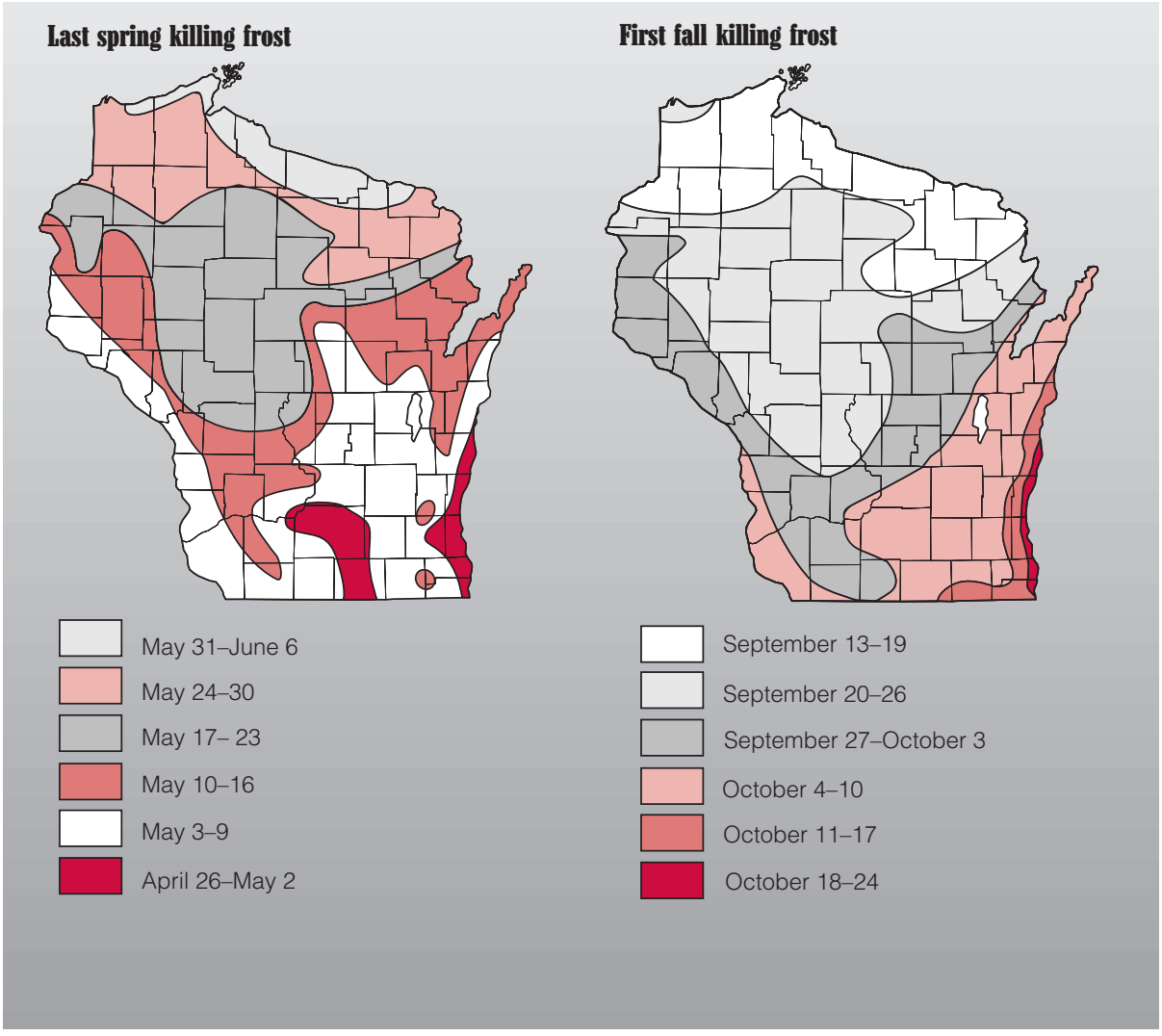
Planting, transplanting, and culture

Starting seeds

Tomatoes, peppers, and eggplants all require a long, warm growing season and therefore are typically started in the greenhouse in Wisconsin and transplanted outside after all danger of frost has passed. Tomatoes are started 4–6 weeks before they are transplanted to the field. Peppers should be started 6–8 weeks prior to field transplanting and eggplants should be started 10–12 weeks before the frost free date for the area. The best transplants are between 4 and 6 inches tall without flower buds.

You can buy or mix your own sterile potting mix for starting transplants. The mix should include peat, sphagnum, or compost to retain moisture; vermiculite or perlite for aeration; and mineral and nutrient sources to encourage growth after the first roots form. Fill plastic or polystyrene cell trays with media, or make individual blocks with a soil blocker. Cells that are 2 inches in diameter work well. Prevent bacterial and fungal infections by sterilizing transplant trays in a 10% bleach solution before you plant. Plant seeds ¼-inch deep. Label transplant trays with cultivar and planting date. Keep media moist but not wet. Germination will occur within 10 days. Maintain soil temperature at 80°–90°F with a heating mat or cable. After germination, soil temperature can be maintained at 70°F. Keep daytime temperatures in the greenhouse at 70°–75°F and 60°–62°F at night.

Figure 2. Approximate dates for first and last killing frosts.



Thin seedlings to one plant per cell or plug, or one plant every 2½ inches if grown in undivided flats. Ten days before transplanting to the field move plants into a cold frame where lower temperatures will harden them off. These plants cannot tolerate any frost or cool temperatures, so be sure to bring them inside the greenhouse if the temperature threatens to dip below 40°–45°F. Pepper fruit set later may be limited by cool temperatures at this stage.

Reduce watering and withhold fertilizer while plants are in the cold frame to help harden off transplants and acclimate them to field conditions. If left in the cold frame too long, plants become over-hardened and require more time to resume growth when transplanted to the field.

Soil preparation

Control weeds prior to planting the bed. Work beds 7–8 inches deep to promote deep rooting. Raised beds are an alternative to the conventional field planting method. They improve soil drainage and allow access to the crop without causing soil compaction. Raised beds are typically 4–5 feet wide and 100 feet long. The width is determined by the type of equipment used and by the crop. Leave a 1-foot aisle on either side of each bed to accommodate foot traffic.

Transplanting

Transplants are set out after all danger of frost has passed (see figure 2). Tomato transplants may be set out after May 20 in southern locations while peppers and eggplants should be held back until June 1. Growers along Lake Michigan should delay planting an additional week while northern growers should wait 2 weeks before transplanting. Tall tomato plants will form roots along their stem and can be planted in shallow trenches with their roots and some of the lower portion of the stem covered with soil. Don't plant the transplants too deep since soil temperature drops the further down you go. Do not bury pepper and eggplant stems deeper than the transplant soil line. Transplants can be planted with a tractor-pulled mechanical transplanter or by hand.

Tomato culture

Tomatoes grow best when daytime temperatures average 75°F and nighttime temperatures average 68°F. A 10°F difference between day and night temperatures gives optimum fruit production. Temperatures below 60°F or above 80°F impair growth and fruit set, although a few determinate varieties can set fruit at temperatures as low as 40°–50°F.

Plant tomatoes 18–24 inches apart in rows 3–4 feet apart. Determine your staking, trellis, or caging system before you plant.

Supports for tomatoes. Tomatoes can be staked or allowed to sprawl depending on the variety and the inclination of the grower. Staking requires time, effort, and trellis materials but you can fit more plants in a smaller area and the fruit is larger, cleaner, earlier, and easier to harvest than if plants are left to sprawl. Indeterminate varieties are usually trellised in a basketweave system in smaller fresh-market operations. Determinate varieties can be left unstaked, tied to one stake, or trellised.

Choose stakes 1 inch square and 4–7 feet long depending on tomato cultivar height. Drive stakes 12 inches into the ground between every other plant for the length of the row. Leave a path to carry fruit out of the field. Strengthen the framework with an additional stake on each end driven at an angle and tied to the end stake.

Remove lower tomato plant suckers or sideshoots when they are 2–4 inches long, up to the one below the first flower cluster. Do not smoke cigarettes or handle chewing tobacco while you work with tomato plants since viral diseases may be carried on your hands from the tobacco.

When the plants are about 12 inches tall, before they fall over, begin the basketweave at 8–10 inches above the ground. Using strong, durable "tomato twine" which comes in a box that attaches to your belt, tie the twine to an end stake and pass the twine along one side of the plants and around each stake, pulling it tight as you go. At the end of the row, go to the other side of the plants and loop twine around each stake until you are back where you started. Tie the twine to the first stake. To make the string easier to handle, you can thread it through a 12–36 inch stick with a hole at the end.

As the plants grow, add strings 6–8 inches above the previous string until you have a trellis of 4 strings. If you stake your plants, be sure to set the stakes at the time of transplanting to avoid damaging the root system during the staking process.

Caged plants do not require pruning and will produce more fruit than the same variety which has been staked. Caged plants ripen later because of the lack of pruning but the incidence of sun scald is also reduced by the shading effect of the foliage.

Greenhouse tomatoes. Tomatoes are becoming more popular as a greenhouse crop to extend the short Wisconsin growing season. Typically, early spring and fall crops are produced in a plastic hoop house, avoiding the dark months of December, January, and February. Read about the details of greenhouse tomato production in *Commercial Greenhouse Production: Tomatoes,* from Kansas State Extension. This publication covers costs, returns, construction, heating, ventilation, tomato varieties, growth, training, watering, fertilizer, pests, and diseases. As with garden culture, temperatures between 70°–80°F and night temperatures of 65°F favor the best development. When the fruits are ripe, they are harvested by hand. The tomatoes should be at the firm, red stage before harvesting. Wisconsin greenhouse growers can expect tomato yields of 3 lb per square foot for the fall crop and 5–6 lb per square foot in spring.

Pepper culture

Peppers grow best at temperatures of 70°–80°F during the day and 65°–70°F at night. Pepper fruit set only occurs at temperatures of 75°–86°F. Night temperatures below 72°F will result in poor fruit set. Temperatures greater than 90°F or less than 55°F result in heavy blossom drop.

Peppers can be planted in twin rows 14 inches apart and 40 inches from the center of one double row to the center of the next double row. Plants are 12–18 inches apart in the row. This planting configuration increases shading and decreases sun scald. Peppers do not require support.

Eggplant culture

Optimum temperatures for eggplant growth are between 75°–85°F during the day and 65–75°F at night. Allow 30–36 inches between rows and 18–24 inches between plants. If the field has a history of problems with potato beetles or flea beetles, consider protecting the plants with row covers at transplanting. Eggplants do not require support.

Season extenders

You can lengthen the growing season by protecting plants from late spring frosts and early fall frosts. There are a variety of ways to prolong the growing season, including planting on a southern slope, creating a warmer microclimate using floating row cov-

Table 3. Planting guide

Vegetable	Planting time in southern WI[a]		Plants needed for 100 ft of row	Spacing (inches)[b]		Days to first harvest[c]	Estimated yield (lb/ft of row)[d]
	Indoors	Outdoors		Between rows	Between plants		
Tomato	April 15	May 20 (plants)	34–60	36–42	18–36	65–80	2.00–4.00
Pepper	April 1	June 1 (plants)	50–60	30–36	18–24	60–70	2.00
Eggplant	March 15	June 1 (plants)	50–60	30–36	18–24	70–80	1.75

[a]Plant about 1 week later along the lower lake shore and in the central part of state and about 2 weeks later in northern counties.

[b]If using a plate-type seeder, spacing between plants will be determined by plate configuration.

[c]Cultivars vary greatly in time needed to reach harvest stage; extend the harvest season by planting cultivars of different maturity dates or by making successive plantings of the same cultivar.

[d]Estimated yields under less than ideal growing conditions; actual yields will vary widely with weather, soil fertility and cultural practices.

ers, dark plastic mulch to warm the soil, clear plastic tunnels, cold frames, or using windbreaks to shield plants.

Floating row covers. Floating row covers of spunbonded polypropylene allow sunlight and water to pass through the fabric, but prevent insects from reaching the plants. Row covers can be used to cover low-growing crops and protect them from frost. They also serve as windbreaks and protect crops against insect pests. Depending on the fabric weight, row covers can provide 4°–8°F of frost protection.

Row covers are not typically used for warm-season crops such as tomatoes, peppers, and eggplants, but they may serve as a temporary emergency frost protection blanket. Row covers on eggplants will prevent flea beetles and Colorado potato beetles from defoliating plants.

Row covers may be draped over the crop or supported by wire hoops. If you gather the edges in a loose accordion-type fold and loosely bury them in soil along the crop row, then as the crop grows it will push up enough fabric to maintain a "floating" cover. With tender crops, or late fall crops which will grow to market maturity under row covers, consider supporting the row cover fabric to prevent abrasion damage to plants. Use 9-gauge wire hoops 6 feet apart buried 1 foot deep on each side on the row.

Row covers can be held in place by burying the edges or by weights such as reebar. Completely seal all four edges to the ground if you use row covers as an insect barrier. If not using row covers as an insect barrier, remove covers when the average daily temperature is warm enough for crop growth. Be sure to vent the beds on hot days and to let plants harden off for a few days to prevent burning before completely removing the row covers. Harden plants by removing covers on overcast days or for a few hours on sunny days.

Plastic mulch. Plastic mulch raises the soil temperature early in the season and can boost crop maturity by 1–3 weeks. Plastic mulch also suppresses weeds and reduces some disease problems by providing a barrier between soilborne pathogens and leaves. Lay wide strips of 1.25–1.5 mil black polyethylene plastic over the beds before planting, using a plastic mulch layer or by hand. Place soil along all the edges of the plastic to anchor it from wind. Clear plastic raises the soil temperature more than dark plastic, but it doesn't shade out weeds. If puddles form on top of the plastic, poke tiny drain holes to prevent a wet environment suitable for fungi.

Cut or burn holes (with a propane torch) into the plastic where you want to plant. Remove loose plastic flaps which might abrade tender stems. Plants grown on dark plastic need more water. Before laying plastic, consider placing drip irrigation tape along plant rows under the plastic.

Tunnels and cold frames. Slitted clear poly tunnels increase daytime temperatures 10°–30°F, and provide 1°–4°F of frost protection. Cold frames can be used to harden off crops before transplanting into the field. Consult the references listed at the end of this publication for more information on cold frames and tunnels.

Windbreaks. A grove of trees to block the prevailing winds can serve as a windbreak. Windbreak effects typically extend to 2½ times the height of the windbreak. For example, a 10-foot-tall windbreak will reduce air flow up to 25 feet away on the lee side. Less-permanent windbreaks include planting a tall cover crop such as grain rye upwind or between rows to reduce wind gusts or placing a semipermeable fabric or poly fence on the upwind edge of the field.

Soils and nutrient management

Obtain a soil test to determine the level of available nutrients before planting a field for the first time and routinely thereafter at least once every 3 years. After 3 years, soil conditions can change enough to make your current fertility management program obsolete. For information on how to collect good samples and where to send them for analysis, see Extension publication *Sampling Soils for Testing* (A2100).

Routine soil tests include pH, organic matter content, phosphorus, and potassium. Special tests are available on request for nitrate-nitrogen, calcium, magnesium, sulfur, boron, manganese, and zinc. You will receive the results of your soil test along with fertilizer recommendations based on your cropping history and planned use of the field.

Soil pH should be between 6.8 and 7.0 to maintain the availability of micronutrients. If the soil pH is below 6.0, apply aglime to raise the pH to the 6.8–7.0 range.

Fertilizer needs

Plants take up nitrogen as nitrate (NO_3^-) or ammonium (NH_4^+), phosphorus as phosphate (P_2O_5), and potassium as potash (K_2O). These chemicals, as fertilizers, can come from organic or inorganic sources. With adequate environmental conditions, soil microbes break down organic matter and supply the chemicals that plants need to their roots. Organic fertilizers can also improve soil tilth and health. Inorganic fertilizers can be used to supply a more readily available form of primary nutrients to plants.

Organic fertilizers can come from a variety of sources such as manures, compost, fish meal, and bone meal. Each material contains varying amounts of specific nutrients. Table 4 lists organic fertilizers and the amounts of nutrients in each. For more information on this subject, refer to Extension publication *Organic Soil Conditioners* (A2305). Table 5 lists guidelines for nutrient management to compare with your soil test results.

Table 4. Nutrient composition of various organic fertilizers

Material	N	P_2O_5	K_2O
Alfalfa hay	2.0–3.0	0.2–0.6	2.0–3.2
Bone meal	0.2–1.0	12.0–14.0	—
Compost[a]	0.5–3.5	0.5–1.0	1.0–2.0
Fish meal	9.0–11.0	5.0–8.0	0.0–3.0
Greensand	—	—	7.0
Manure, cow	0.5–0.7	0.2–0.4	0.5–0.8
Manure, sheep	1.0–2.0	0.7–1.0	0.5–2.0
Manure, poultry	1.1–1.7	1.0–1.3	0.5–1.0
Rock phosphate	—	20.0–30.0	—
Soybean meal	7.0	0.5	2.3

[a]Nutrient analysis of compost will vary based on the source.

Table 5. Annual nitrogen, phosphate (P_2O_5), and potash (K_2O) recommendations

	Nitrogen			Phosphate and potash				
	Organic matter	Amount to apply		Yield goal	Amount to apply[a]			
					P_2O_5		K_2O	
Vegetable	%	lb/a	oz/100 sq ft	tons/a	lb/a	oz/100 sq ft	lb/a	oz/100 sq ft
Tomato	<2	140	5.25	20–25	40	1.5	180	6.75
	2.0–4.9	120	4.5					
	5–10	100	3.75					
	>10	80	3.0					
Pepper	<2	100	3.75	8–10	10	0.4	50	1.9
	2.0–4.9	80	3.0					
	5–10	60	2.2					
	>10	40	1.5					
Eggplant	<2	140	5.25	10–12	40	1.5	180	6.75
	2.0–4.9	120	4.5					
	5–10	100	3.75					
	>10	80	3.0					

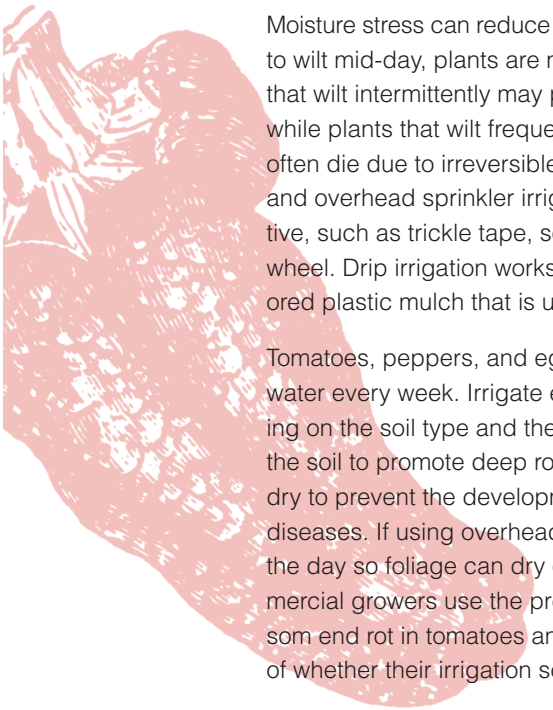
[a]Amounts of P_2O_5 and K_2O are for optimum soil test levels. Apply half the given rate if the soil test is high and omit if the soil test is excessively high. If soil test is low or very low, increase rates according to the soil test recommendations.

Fertilizing tomatoes. Apply phosphorus and potassium according to the soil test recommendations before planting, and work them into the soil. On fine-textured soils incorporate nitrogen fertilizer before planting. On coarse-textured soils, apply 20–40 lb nitrogen/acre (0.75–1.5 oz/100 square feet) before transplanting tomatoes and sidedress the remainder in one or more applications after the fruits set.

Fertilizing peppers. Peppers require high soil fertility early in the growing cycle. Apply phosphorus and potassium according to the soil test recommendations before planting. Use a starter solution high in nitrogen and phosphorus when setting out transplants and sidedress one or two applications of nitrogen later in the season. If foliage starts to turn from dark green to pale green or yellow, peppers may be low in nitrogen.

Fertilizing eggplants. Eggplants also use large amounts of nutrients. Apply phosphorus and potassium according to the soil test recommendations before planting. A high phosphorus fertilizer should be used at transplanting to prevent shock. Apply one-fourth of the total nitrogen as a sidedress at transplanting and again every 3 weeks for optimum growth.

Irrigation



Moisture stress can reduce crop yields. If leaves begin to wilt mid-day, plants are moisture stressed. Plants that wilt intermittently may produce smaller yields, while plants that wilt frequently or that wilt too long often die due to irreversible cell damage. Both drip and overhead sprinkler irrigation systems are effective, such as trickle tape, solid set, and traveler hose wheel. Drip irrigation works particularly well with colored plastic mulch that is used as a season extender.

Tomatoes, peppers, and eggplants require 1 inch of water every week. Irrigate every 5–10 days depending on the soil type and the frequency of rain. Soak the soil to promote deep rooting, but keep the foliage dry to prevent the development and spread of foliar diseases. If using overhead sprinklers, water early in the day so foliage can dry out quickly. Some commercial growers use the presence/absence of blossom end rot in tomatoes and peppers as an indicator of whether their irrigation schedule is adequate.

Blossom end rot is a physiological disorder that occurs when calcium uptake is inhibited by low soil moisture.

Irrigation scheduling software is available from the University of Wisconsin-Extension to help you determine your irrigation needs. For more information on this software, contact your county Extension agent.

Harvest, handling, and storage

Tomatoes

Tomatoes grown for local markets are harvested by hand when they are sweet and have reached the table ripe stage. Consumers list the vine-ripened flavor of fresh tomatoes as their strongest market attraction. Mature green tomatoes will ripen off the vine, but will not acquire their full flavor.

The USDA has developed a classification of tomato maturity (table 6). This information can be helpful for planning when you'll need additional harvest labor. Ten days elapse from the mature green state to table ripe tomatoes.

Handle tomatoes gently since they bruise easily. Tomatoes may be hydrocooled in a water bath to remove field heat, but do not chill the fruit, since tomatoes will not ripen further once chilled. Tomatoes may also be simply wiped clean. Do not stack them higher than two layers while harvesting and packing. Pack tomatoes in shallow cardboard boxes or trays.

Tomatoes are sensitive to cold temperature. If the temperature is above 55°F, tomatoes will continue to ripen and improve their flavor. Do not store tomatoes below 55°F. Also, never allow ice to touch tomatoes since chilling injury will occur. Symptoms of chilling injury include irregular ripening and off flavor.

Sell tomatoes within 2–3 days for best flavor and quality. Good quality can be preserved for up to 2 weeks if tomatoes are stored in a cool location, above 55°F and in 85–90% humidity. Mature green tomatoes may be stored for up to 6 weeks under similar temperature and humidity conditions.

Peppers

Harvest peppers by hand when they are firm, tasty, and crisp. The plant will set more fruit after each flush of harvest, so regular harvests maximize yields. Peppers grown for their red, purple, or yellow color must ripen on the plant. Hot peppers will produce the strongest flavor if allowed to remain on the plant until fully ripe.

Peppers may be hydrocooled in a water bath to remove field heat. Dry them on a screen table and pack into waxed cardboard boxes. Maintain high humidity and provide evaporative cooling by lining the box with a clean damp cloth. Store peppers at 45°–50°F with 90–95% relative humidity. Under these conditions, peppers will keep for up to 2 weeks. Temperatures less than 45°F can cause the same chilling injury as in tomatoes.

Peppers such as chili or cayenne can be dried on screen tables in a cool, dark, dry, well-ventilated area. Peppers can also be strung on thread through the stem and hung to dry. Dried peppers keep for up to 6 months at 60–70% relative humidity.

Eggplants

Harvest eggplants by hand when they are glossy and deeply colored, 25–40 days after pollination, before the skin toughens and seeds become large

Harvesting & packing tips

When you harvest tomatoes, peppers, and eggplants, change your position often to minimize stress and fatigue to your body. You might wear kneepads or sit on a small cart. Use garden carts and wagons as much as possible to minimize lifting and hand carrying heavy produce. Standardized vented plastic containers that stack are easy to load and unload, and clean.

With a smooth level floor in the packing area, a palletized packing and storage system can be designed to fit small-scale operations (small pallets moved with a hand-pulled pallet-jack) or large operations (pallets moved by forklift). Heavy boxes of produce can be moved from one area to another on roller tables.

Layout your washing and packing area to minimize stooping, lifting, and carrying. Set up screen tables or water baths at table height. Ideally, tables could be adjusted to match each worker, so that work is performed at a height between wrist and elbow.

Table 6. USDA tomato maturity classes

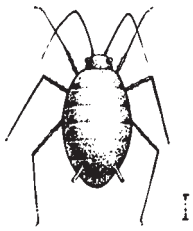
Classification	Description	Days to full color
Green fruit	gelatin around seed has formed, skin is a whitish green	9–13
Breaker	trace of color on blossom end	8
Turning	10–30% pink starting at blossom end	7
Pink	30–60% pink or red	6
Light red	60–90% pink or red	3
Red/firm ripe	>90% red	1
Table ripe	ready to eat, fruit somewhat soft	0
Canning ripe	deep red but still firm	0
Soft ripe	too soft to slice	0

and bitter. High quality fruit should feel heavy in relation to its size. Clip the fruit from the plant, leaving the cap and part of the fruit stem intact. Wipe fruit clean but do not hydrocool it, since eggplant is very cold sensitive and cannot tolerate temperatures below 50°F. Symptoms of chilling injury are pitted skin and internal flesh discoloration.

Pack eggplant in waxed cardboard boxes. Maintain high humidity by lining the box with a clean damp cloth. Optimum storage conditions are between 55°–60°F at 85–90% relative humidity. Under these conditions the fruit will maintain good quality for up to 10 days. Otherwise, eggplants remain in top quality up to 2 days.

Insect management

Aphids



Description: Aphids are small, soft-bodied, pear-shaped insects that come in a variety of colors. They can be distinguished from all other types of insects by the presence of cornicles, or tailpipes projecting from the back end of the insect.

The green peach aphids and potato aphids commonly infest peppers. Both species can be winged or wingless. The wingless forms can be up to ⅛ inch in length. The green peach aphid has an elongated, smooth, soft, spindle-shaped body. Antennae are held to the side and are longer than the body. Coloration varies from green to reddish-pink. Winged forms are a pale green. Potato aphids have more slender bodies and longer legs and are more active. Both species have piercing/sucking mouthparts and feed by sucking on plant juices.

Life cycle: In Wisconsin, green peach aphids overwinter as black eggs on the bark of peach, plum, apricot, or cherry trees and potato aphids overwinter as eggs on wild and cultivated roses. During the summer, adult female aphids produce offspring without mating or laying eggs. In warm weather a female can give birth to as many as 12 nymphs per day. Nymphs mature in less than 2 weeks. Late in the season, the females mate and produce eggs which will overwinter. Individual generations may be completed within 1 week during the summer, and multiple generations overlap. Aphids produce winged offspring when colonies become overcrowded and when day length begins to shorten. Colonies live primarily on the underside of leaves, usually in the lower canopy.

Damage/Symptoms: Aphids feed by inserting a fine, needle-like stylet between plant cells into the vascular tissue. Typically, this causes little direct injury to adjacent tissues. Extremely large populations may extract enough sap to cause leaf curling and wilting or eventual plant death. Seedlings are most susceptible to aphid damage, although pepper plants of any size may be killed by heavy aphid feeding. Aphids excrete excess sap, honeydew, which falls onto leaves, giving them a sticky texture. Sooty mold fungi may grow on honeydew secretions, making affected pepper fruit unmarketable. Both aphid species transmit potato virus diseases.

Management: Scout weekly for aphids by removing leaves from the mid to lower half of 25 plants per sample site. Count the total number of adult and nymph aphids. Treat if you find more than 50 wingless aphids per 25 plants early in the season or 100 per 25 plants late in the season. Monitor whether populations are increasing or decreasing over time.

Natural controls such as heavy rains, predators, and diseases may help reduce aphid populations. Predators include ladybird beetles, lacewings, and syrphid flies. Often, though, aphids reproduce far faster than the parasites and predators can consume them.

Systemic and foliar insecticides provide good control. However, insecticides often also destroy the beneficial natural enemies, resulting in secondary aphid problems. In addition, many populations of green peach aphids have high levels of insecticide resistance. Insecticides should be applied for other insects only when needed, as determined by scouting.

Colorado potato beetle

Description: Adult Colorado potato beetles have bright yellow bodies with black stripes running the length of their backs and black spots behind the head. They are ⅜ inches long. Young larvae are small and blackish-brown. Older larvae are reddish-brown with black heads, legs, and spots along each side of their bodies. This beetle attacks potatoes primarily, but also causes severe damage to eggplant. Noncrop hosts include weeds such as nightshade, ground cherry, jimsonweed, horse nettle, and mullein. If left unchecked, Colorado potato beetle larvae and adults can completely defoliate plants, resulting in reduced yield or plant death. Once a garden has been infested, potatoes and eggplants will suffer progressively worse damage in subsequent years.

Life cycle: Colorado potato beetles overwinter as adults in the soil. Adults become active in the spring. Females lay clusters of bright yellow-orange eggs on the lower leaf surfaces. Larvae hatch 4–9 days later and begin feeding immediately. They frequently congregate on new growth on the ends of stems. Larvae soon turn brown-red, and although feeding damage on new growth is more evident, damage will not be severe enough to require treatment. Older larvae cause serious crop damage. Second-generation adults normally appear in mid-July and may cause severe defoliation. There are usually one to two generations per year in most of Wisconsin.

Damage/Symptoms: Both adults and large larvae are voracious leaf feeders, chewing holes larger than ⅛ inch in diameter. Often, entire leaves on the tips of plants are consumed. Larvae typically feed in groups and may completely defoliate plants. Older larvae do the most feeding damage. Heavy defoliation will severely reduce plant yields.

Management: Begin monitoring eggplants for Colorado potato beetles as soon as plants have been set out or when potato plants in nearby fields have emerged. Examine the lower leaf surfaces for clusters of the bright yellow eggs. In areas that were infested the previous year, look for adult beetles on plants near field edges in early May.

Several cultural methods will help reduce the number of Colorado potato beetles. This pest has a limited host range, so rotating out of solanaceous plants such as eggplant and potatoes, while also removing alternate host weeds, will effectively reduce beetle populations. Another technique is to plant strips of early-planted potatoes, trap crops, on field edges next to overwintering sites to attract beetles. When adults gather in these trap crops, use propane flamers or vacuum suction to remove the beetles. Watch populations on plants over several days. Control when populations appear to have peaked. A third strategy is to use physical barriers, such as row covers or plastic-lined trenches, to prevent adult beetles from finding plants and laying eggs. Cover plants with row covers immediately after transplanting and keep covers in place until mid-June. Or place plastic-lined trenches between fields and overwintering sites before transplanting. In small plantings, the large larvae and adults may be hand picked or removed with a net. Colorado potato beetles contain a chemical that can burn and blister sensitive skin, so be sure to wash your hands after handling the beetles.

Pesticide resistance is a serious threat to continued effective control of Colorado potato beetles. Certain races of this pest are resistant to every class of insecticide currently registered for control. Bacterial insecticides, such as *Bacillus thuringiensis* (Bt), are effective against young larvae only; eggs, older larvae, and adults will be unharmed. Bacterial insecticides only persist 1–2 days and should be applied weekly for 2–3 applications if used alone. Only *Bacillus thuringiensis-tenebreonis* (Btt) is effective against Colorado potato beetles. The more commonly available *Bt-kurstaki* (Btk), which is effective against lepidopterous larvae, will have no effect on beetles. Refer to *Commercial Vegetable Production in Wisconsin* (A3422) for a complete listing of available insecticides.

European corn borer

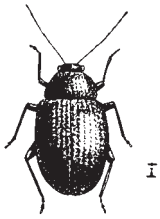
Description: European corn borers can cause significant damage to pepper crops. The adult European corn borer is a night-flying moth. Males are mottled brown and have a wingspan of about 1 inch. The females are lighter in color and slightly larger than the males but have the same markings. The larvae are ¾–1 inch at maturity and gray to cream-colored with many dark spots covering the body.

Life cycle: The European corn borer overwinters as mature larvae in corn stalks and stems of weed hosts. They complete development and pupate in the spring when temperatures exceed 50°F. Peak moth emergence for the overwintering generation is usually in June in southern Wisconsin. Shortly after emergence, females mate and lay eggs over the course of a few evenings. The eggs hatch in 3–7 days and the larvae begin feeding. There are two generations in southern Wisconsin and only one in the northern part of the state.

Damage/Symptoms: European corn borers damage peppers by tunneling into developing fruit and plant stems. The larvae feed inside the fruit for about 3 weeks. Infested fruit often ripen earlier than the rest of the crop. The second generation, which appears in late July and early August, poses the most serious threat to peppers.

Management: To help control corn borer infestations in peppers, keep pepper plantings as far away from sweet corn fields as possible and remove grassy weeds from field edges. If you plan to use insecticides, you'll need to time applications to coincide with the peak moth flight and egg-laying period. Once larvae burrow into the fruit, they are protected from insecticide sprays. The Department of Agriculture Trade and Consumer Protection (DATCP) provides weekly reports during the growing season on corn borer populations or you can monitor them through blacklight trapping. This information will help you know when to look for moths in the grassy areas. Corn borers can often be successfully controlled with three treatments made at 7-day intervals.

Flea beetles



Description: Flea beetles are small (1/10 inch), dark beetles with large hind legs for jumping. Common species in Wisconsin include the eggplant flea beetle, tobacco flea beetle, potato flea beetle, and the pale-striped flea beetle. All attack eggplant but the pale-striped flea beetle is most common on pepper while the eggplant flea beetle is most common on eggplant. Flea beetle feeding can severely damage eggplants. Tomatoes and peppers often tolerate feeding once they have passed the seedling stage.

Life cycle: Flea beetles overwinter as adults in leaf litter, hedgerows, windbreaks, and wooded areas. The beetles emerge in late April when temperatures reach 50°F. Adults begin laying eggs in the soil at the base of host plants (eggplants, peppers, tomatoes, potatoes) in May. Eggs hatch 7–14 days later and larvae feed on various plant parts until full grown. The larvae move below ground to pupate, emerging 11–13 days later as adults.

Damage/Symptoms: Characteristic flea beetle feeding damage is tiny holes or pitted areas scattered throughout the leaves. Eggplants can be totally defoliated if flea beetles are allowed to feed unchecked.

Conservation of natural enemies

Not all insects are pests. Beneficial insects prey on other insects, helping to keep populations in check. You can take advantage of this free natural resource by minimizing the use of broad-spectrum insecticides. For more information about biological controls, see Extension publication *Biological Control of Insects and Mites: An Introduction to Beneficial Natural Enemies and Their Use in Pest Management* (NCR481).

Management: Because flea beetles overwinter in plant debris, it is important to remove infested plant material or incorporate it deeply into the soil at the end of the growing season. Floating row covers can be used to protect eggplants. Row covers should be put into place when transplants are set out. Begin monitoring for flea beetles as soon as the plants are set out. Treat if flea beetle populations exceed the thresholds listed in table 7.

Table 7. Treatment threshold for flea beetles on eggplants

Plant size	Threshold (flea beetles/plant)
<3 inches	2
3–6 inches	4
>6 inches	8

Leafhoppers

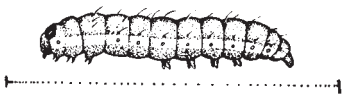
Description: Leafhoppers are small (⅛ inch), wedge-shaped, slender green insects that feed on many vegetable crops but primarily cause problems on snap beans, potatoes and eggplants. Adults are extremely active and jump, fly or crawl sideways or backwards when disturbed.

Life cycle: Potato leafhoppers don't overwinter in Wisconsin. Instead, they are blown north on wind currents each spring. Large influxes of migrants in June and early July cause populations to increase rapidly and seemingly "explode" overnight. Adult females insert white eggs into the stems or large leaf veins of susceptible crops. Each female lays approximately three eggs per day for about 1 month. Eggs hatch in 7–10 days. Nymphs develop in 12–15 days, maturing in late July. The second generation matures in early September. There are normally two generations per year in Wisconsin.

Damage/Symptoms: Like aphids, leafhoppers feed by sucking plant juices from the vascular tissue of the plant. Damage caused by leafhopper feeding is called hopperburn and results when the insect injects a toxin with its saliva while feeding. Early symptoms appear as a yellowing of the leaf margins. Affected tissue later becomes brown and dry.

Management: Leafhoppers are difficult to control because they are highly mobile. The best method of leafhopper management is exclusion. Floating row covers will prevent leafhoppers from reaching the plant. Row covers should be set out when transplants are set into the field. Monitor leafhopper activity in nearby field edges or other crops to determine when activity has dropped and row covers may be removed.

Tomato fruitworm (corn earworm)



Description: The tomato fruitworm is also known as the corn earworm. This pest poses a more serious problem in sweet corn production than in tomatoes or peppers where it is a sporadic pest. The adult fruitworm is a tan moth with dark spots on the outer edges of the forewings and a wingspan of 1½ inches. Newly hatched larvae are light green to brownish-black with splotches of pink, maroon, green, brown, or tan. Lengthwise stripes are characteristic on these larvae. Older larvae have the same coloration but take on a "greasy" appearance. They are 1¾ inches long at maturity.

Life cycle: Most tomato fruitworms overwinter as pupae in the south. Adults emerge in the spring and migrate northward. The moths fly mainly at dusk or during warm, cloudy days. The moths typically arrive in southern Wisconsin in late July although timing can vary depending on weather conditions. When susceptible sweet corn is not available, female moths are attracted to reproductively mature tomato plants. They lay eggs singly near the fruit. Each fertilized female can lay up to 1000 eggs during her lifetime. Larvae hatch as soon as 24 hours later in warm

weather. After feeding for approximately 2 weeks, the larvae drop to the ground and pupate. There is one generation per year.

Damage/Symptoms: Damage is more severe on late plantings of tomatoes and peppers. The larvae prefer green fruit and rarely enter ripening fruit. Feeding damage creates deep, watery cavities. These cavities are often colonized by soft-rot organisms making damaged fruit unmarketable.

Management: The tomato fruitworm can be monitored with the Hartstack pheromone trap. Growers with large plantings of tomatoes or peppers should set up and monitor their own traps. Small-scale growers may consult pest report newsletters late in the growing season to determine when the adult moths have reached the state and the activity of this insect in sweet corn. Control is recommended if tomato and pepper fruit is present at the same time as the moths are active. The bacterial insecticide, *Bacillus thuringiensis* (Bt) is recommended for controlling the early stages of this insect. Treat when you find young larvae on the fruit.

Tomato and tobacco hornworms

Description: Tomato hornworms and tobacco hornworms are large (3–4 inches), blue-green caterpillars with a characteristic horn on the tail end of the body. They feed on tomato leaves and occasionally on fruit. The adults are large, heavy-bodied hawk moths with a wingspan up to 5 inches, that become active in July.

Life cycle: Hornworms overwinter as pupae in the soil. Adults emerge in late June and mate. Female moths lay pale-green eggs singly on the lower leaf surface of tomato plants. Upon hatching, the larvae begin feeding immediately and may reach full size within a month. In late summer, the fully grown larvae drop from the plant to pupate in the soil. There is only one generation per year.

Damage/Symptoms: Infestations of the tomato or tobacco hornworm are usually localized and damage is rarely economically important in Wisconsin.

Management: Monitor fields frequently for damage. Fresh-market tomatoes should be treated if you find one or more caterpillars per two plants. Trichogrammid wasps offer natural control by parasitizing hornworm eggs. The bacterial insecticide, *Bacillus thuringiensis* (Bt), is recommended for control of young caterpillars.

Disease management

Early blight

Hosts and severity: Early blight is a potentially serious disease that affects the leaves, stems, and fruit of tomatoes and eggplant. It is caused by the fungus *Alternaria solani.* Early blight typically occurs along with Septoria leaf spot.

Disease cycle: The fungus overwinters on infected plant debris, on seed, or in the soil. It can survive for 1 year on infected debris. Periods of warm, wet weather in the spring favor infection. Early-maturing tomato cultivars are the most susceptible to infection.

Symptoms: Leaf spots appear first on the older leaves. The lesions spread out in concentric rings enlarging to ¼–½ inch in diameter. A yellow halo may surround the spots. In serious infections, entire leaves may yellow and drop off. As the plant defoliates, the fruit becomes exposed to the sun and is susceptible to sunscald. Infected fruit has dark, leathery, sunken spots near the stem end. Only green fruit is infected.

Management: Early blight can be managed by practicing crop rotations of 3–4 years out of any solanaceous crop or by using pathogen-free seed. Several tomato cultivars are tolerant of early blight, but only Jubilee is recommended for Wisconsin. Protective fungicides applied on a 7–10 day schedule will prevent the spread of infection.

Late blight

Hosts and severity: Late blight (*Phytophthora infestans*) is a fungal disease of tomatoes. It occurs sporadically in Wisconsin but can be serious when present.

Disease cycle: Late blight overwinters on infected plant debris. Under cool, wet conditions, the disease develops. Storms can carry spores of the fungus great distances, causing new outbreaks of the disease in previously disease-free areas.

Symptoms: Late blight can affect all above-ground parts of the tomato plant. Early symptoms include water-soaked spots that enlarge to cover the entire leaf. As the disease progresses, leaves become brown and shriveled. There may be a white, fuzzy growth on the lower surface of infected leaves in wet weather. Fruit lesions are dark, olive green, greasy spots that may enlarge to cover the entire fruit. Soft rots often follow late blight fruit lesions. One characteristic of late blight is the foul odor emitted by the decaying vines.

Management: To manage late blight, practice a 2–3 year rotation out of solanaceous crops. Destroy infected plants immediately, including any potato tubers which may be infected. Copper fungicides may be used as a protectant if conditions favor disease development. Tomato cultivars resistant to late blight include Johnny's 361, Red Currant, and Yellow Currant.

Septoria leaf spot

Hosts and severity: Septoria leaf spot is a serious disease that often occurs with early blight. This disease, caused by the fungus *Septoria lycopersici,* can infect tomatoes and ground cherries as well as jimsonweed and nightshade. Septoria often occurs along with early blight.

Disease cycle: Septoria overwinters on weedy hosts or on infected plant debris for up to 3 years. Wet weather favors infection. Infection begins on the lower part of the plant. It spreads upward as spores from infected leaves are splashed onto clean foliage by rain or irrigation water. Spores can also be spread if field work occurs while plants are wet.

Symptoms: Initially, small, circular spots appear on the upper surfaces of older leaves with water-soaked areas on the lower leaf surface. Infection does not occur until after fruit set has begun. As the spots enlarge, they develop dark brown margins with sunken gray centers. Tiny black fruiting bodies may be found in the center of these lesions. Infected leaves often drop from the plant, exposing the fruit to sunscald.

Management: To manage this disease, plow under infected debris immediately after harvest in the fall. Do not compost infected plants. Rotate out of solanaceous crops for 3–4 years and control solanaceous weeds. Protectant fungicides may be applied to prevent the disease from spreading. There are no resistant cultivars commercially available.

Fusarium and Verticillium wilts

Hosts and severity: Two fungal pathogens cause wilting of tomato plants, *Fusarium oxysporum* f.sp. *lycopersici* and *Verticillium dahliae*. The fungus that causes *Fusarium* wilt is specific to tomatoes while *V. dahliae* may attack hundreds of plant species including peppers and eggplants.

Disease cycle: Both fungal organisms are soil-borne. High soil moisture and high temperatures favor initial infection.

Symptoms: The early symptoms of both diseases begin as a yellowing of the older leaves. Often, only the leaves on one side of the plant are affected. The symptoms progress up the stem until much or all of the plant dies. Cutting open an infected stem, where the leaf petiole is attached, will reveal a dark brown discoloration. If you suspect *Fusarium* or *Verticillium* infections, send or bring a sample to your county Extension office for diagnosis.

Management: These diseases are soil-borne and long-lived. Therefore, it is important to rotate out of solanaceous crops for at least 3–4 years. If planting in a field with a history of either disease, select a resistant variety. Resistant varieties include Beefmaster, Better Boy, Campbell 1327, Celebrity, Flash, Floramerica, Heinz 1350, Jet Star, Lemon Boy, New Yorker, Pole King Hybrid, Roma VF, Small Fry, and Viva Italia. Currently, no eggplant cultivars are resistant to *Verticillium* or *Fusarium* and very few peppers are resistant to *Verticillium*.

Bacterial speck and bacterial spot

Hosts and severity: These two diseases are often found together on the same plant but may occur separately. They may occur on both tomatoes and peppers.

Disease cycle: Bacterial speck is caused by *Pseudomonas syringae* and is often seed-borne. Bacterial spot is caused by *Xanthomonas campestris* and overwinters on infected plant debris. Both diseases are spread by splashing water. Working in the field while plants are still wet hastens spread of the diseases. Warm weather favors the development of bacterial spot while cooler weather tends to produce bacterial speck infections.

Symptoms: Bacterial speck produces small (less than ⅛ inch diameter), dark, round lesions on leaves. Initially, the lesions are surrounded by a yellow halo. As the disease progresses, the lesions may spread to stems, petioles, and flowers. On fruit, tiny dark spots develop. Fruit lesions are often sunken with a darker green halo surrounding the center of the lesion. Bacterial spot produces water-soaked, brown lesions on all above-ground plant parts. A yellow halo surrounds the lesions. As the disease becomes more severe, a generalized yellowing may occur on the leaves.

Management: Both bacterial diseases can be controlled by rotating fields out of solanaceous crops for at least 2 years. Using treated seed will prevent seed-borne infection. Reduce activity in the field when plants are wet. Copper-containing pesticides are available for use in controlling bacterial spot. There are a few resistant pepper cultivars, but they have not performed well in Wisconsin.

Anthracnose

Hosts and severity: Anthracnose is a common disease of tomato and pepper fruit. Infection occurs when the fruit is still green but symptoms don't appear until the fruit begins to ripen.

Disease cycle: Anthracnose overwinters in the soil and on infected plant debris. Warm weather along with free water favor infection. Fruit that comes in contact with soil is most likely to become the initial point of infection.

Symptoms: This disease produces small, round, slightly sunken spots that are surrounded by concentric rings. Leaves, stems and roots may be infected.

Management: Prevention is the best control. Crop rotations out of solanaceous crops for 2–3 years will reduce the incidence of disease. Weed management practices to control susceptible weeds will reduce reservoirs of the disease. Cultural practices such as mulching and staking to prevent the fruit from coming in contact with the soil will also reduce the chance of infection. Using drip irrigation, rather than overhead irrigation, will also reduce spread of the disease. In severe outbreaks, fungicides may be necessary to protect developing fruit.

Viruses

Hosts and severity: Several viruses can affect the production of tomatoes, peppers, and eggplant. Three common viruses are tobacco mosaic, cucumber mosaic, and spotted wilt viruses. All viruses can weaken infected plants and reduce yield and quality.

Disease cycle: Tobacco mosaic virus is spread primarily through infected seed and by human activity. Cucumber mosaic virus is transmitted by aphids and has a wide host range including carrot, celery, cucurbits, eggplants, legumes, lettuce, pepper, spinach, and tomato. Because the host range is so broad, cucumber mosaic virus is often difficult to control once it becomes established in weedy reservoirs. The tomato spotted wilt virus is transmitted by thrips and causes a bronzing of the young leaves.

Symptoms: Symptoms of each virus are characteristic of that virus. Tobacco mosaic virus produces mottled tissue on foliage and fruit. Affected leaves may become distorted, twisted or strap-like, mimicking symptoms caused by phenoxy herbicides. Fruits infected with tobacco mosaic virus usually ripen unevenly and are smaller in size and number than their healthy counterparts.

Cucumber mosaic virus also produces shoestring foliage. Early symptoms of the disease are yellow, bushy, and stunted foliage. The oldest and youngest leaves may show symptoms while the middle part of the plant appears normal. Severely infected plants have reduced yield.

In plants infected with tomato spotted wilt virus, leaves develop numerous small, dark spots. Shoots may wilt and die and infected stems are often streaked. On infected fruit, target-shaped lesions appear. These areas become more pronounced on ripe fruit.

Management: Virus diseases are best managed through prevention: use resistant cultivars and follow good sanitation practices such as planting clean seed and eliminating weed hosts. Do not smoke while you work with tomato plants since viral diseases may be carried on your hands from tobacco.

Environmental disorders

Blotchy ripening

Blotchy ripening of tomatoes is characterized by areas of the fruit that fail to ripen properly because of poor fertilization. This problem is more prevalent in cool years and is exacerbated by too much or too little water. The symptoms may also appear on virus-infected plants. Yellow or orange blotches appear on the surface of ripening fruit while the tissue inside remains hard and white. The affected area is usually on the upper portion of the fruit. Blotchy ripening is cultivar specific and appears more frequently on older cultivars.

Catfacing

Catfacing describes the presence of deep indentations in the blossom end of the fruit. This damage occurs when temperatures drop below 50°F during flowering and fruit set. In some cases, excess heat, 2,4-D injury, and erratic soil moisture can lead to catfacing. Large-fruited cultivars are most susceptible. Catfacing is cultivar specific and appears more frequently on older cultivars.

Growth cracks

Two types of growth cracks affect the stem end of tomatoes: concentric and radial. Concentric cracking produces circular cracks around the stem end of the fruit. Radial cracks spread outward from the stem scar. These cracks typically appear as the fruit matures. Growth cracks often appear when conditions drastically change the rate of growth, such as wide fluctuations in temperature and moisture. Dry weather followed by heavy rains typically causes radial cracking in many tomato cultivars. Cultivars vary in their ability to withstand cracking depending on the strength and “stretchability” of the skin. Proper plant nutrition and adequate, regular irrigation will reduce the likelihood of growth cracks.

Green shoulder

Green shoulder is similar to blotchy ripening, but only the shoulder region of the fruit remains unripe. It results when the chlorophyll in the affected area fails to break down as it does during the normal ripening process. Green shoulder is cultivar specific. If it occurs over several years, select a cultivar that is less susceptible to this disorder.

Large core or puffiness

This disorder produces angular tomatoes. If cut open, affected fruit have locules (chambers) that did not fill with gel, causing the fruit to become flattened. Poor pollination, excess nitrogen, and improper seed development can cause large core. Cold temperatures may worsen the disorder. Many cultivars are susceptible.

Physiological leaf roll

Physiological leaf roll can occur on any tomato cultivar and is most severe during excessively cold, wet years. High water pressure within the plant causes the margins of the leaves to curl upward. This disorder may be mistaken for leafhopper damage, although leaves do not have marginal browning. It has no affect on fruit production.

Sun scald

Sun scald is characterized by bleached, sunken tissue on the fruit. It occurs when the plant is defoliated by disease, exposing the fruit to direct sunlight. Peppers, staked tomatoes, and determinate tomatoes are more susceptible to sun scald. Secondary rot organisms often invade the affected tissue causing subsequent fruit rots.

Weed management

Weed management is essential for crops to produce maximum yields. Weeds compete with crop plants for sunlight, water, nutrients, and space. Before planting, reduce perennial weed populations by smothering with a cover crop (such as buckwheat), by solarization with black plastic, by hand removal, or by using herbicide sprays. Cultivate or hoe regularly to control annual weeds.

Black plastic mulch within rows makes a good weed barrier, helps warm the soil in the spring, and prevents the spread of some diseases. A thick straw mulch will prevent weed germination and growth by blocking sunlight from reaching the soil. Between the rows, cultivation and herbicides will control weeds not smothered by the plastic mulch. Some of the problematic weeds that occur in solanaceous crop plantings include nightshade, pigweed, lambsquarters, smartweed, morning glory, annual and perennial grasses, green foxtail, and nutsedge. There are commercially available cultivars of tomato that are resistant to the herbicide metribuzin allowing the use of this herbicide without injury to the plants.

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