Commercial Vegetable Recommendations

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Peppers

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Production

The average state yield of green bell peppers is 4 tons (286 bushels) per acre. Yields of 10 to 13 tons (700 to 900 bushels) per acre can be obtained under optimum growing conditions.

Yield of processing peppers varies with type and number of harvests. Multiple hand harvests should yield roughly the following: sweet and hot banana—7 to 8 tons per acre; sweet and hot cherry—5 tons per acre; jalapeno—4 tons per acre.

Use

Approximately 60% of the green bell peppers grown in Michigan are sold on the fresh market, 20% are pickled, and 20% are diced and frozen. Virtually all of the other types of peppers are pickled.

Types and cultivars

All peppers grown in Michigan, including sweets and hots, belong to the genus and species *Capsicum annuum* L.

Green bell peppers account for about 75% of the pepper acreage in Michigan. Acceptable green bell cultivars produce large, blocky, thick-walled fruit with 3 to 4 lobes; continue to produce large fruit throughout the season; and set fruit under all conditions, especially during adverse growing seasons. Popular cultivars are: Staddons Select, Bell Boy, Big Belle, Hybelle, Lady Bell, Sweet Bell, Keystone Resistant Giant, Yolo Wonder B, and Yolo Wonder L.

Processing pepper cultivars are normally designated by processors. Some commonly grown cultivars are Sweet Banana, Sweet Cherry, Hot Cherry, Gold Spike, Santa Fe Grande, Hungarian Yellow Wax, Jalapeno and Rumanian Wax. All these processing types are open pollinated.

As a rule, hybrids set fruit earlier and are more consistent producers than non-hybrid cultivars, but hybrid seed is much more expensive. Peppers are very susceptible to environmental stress, so cultivars perform differently in different locations and during different years. Therefore, to obtain consistent production, plant at least 3 cultivars, one of which should be a hybrid.

Climatic requirements and irrigation

Peppers are a warm season crop—that is, they grow best in warm weather and do poorly in cool weather. Pepper seeds germinate at 60 to 85°F but germinate best above 80°. Plants grow best in soils above 65° and in air temperatures of 70 to 80°. Peppers are killed or seriously injured by frost. They also can be injured by long periods of temperatures below 50°. Because of their heat requirements, the majority of peppers in Michigan are grown in the southern half of the Lower Peninsula.

Both high and low temperatures have an adverse effect on flowering and fruitset. Blossoms often drop if day temperatures are above 90°. Fruit will not set well when night temperatures are below 55° or above 75°. Plants growing at temperatures below 70° develop very slowly and usually do not set flowers. Thus maximum production will usually be obtained during a moderately warm summer with day highs in the 80s and night lows in the 60s.

Transplanted peppers root only to a depth of about 2 feet but use soil moisture quite efficiently. Young pepper plants can take a fair amount of water stress without severe injury, but plant development will be slowed and ultimately yields reduced. Water stress during flowering and fruitset can cause flower and young fruit drop. Water stress during fruit development can cause poorly developed, small, misshapen fruit, or blossom end rot. During the growing season, peppers should receive 1 to 2 inches of rainfall or irrigation per week, depending on soil type and stage of growth. Sufficient water during fruiting will result in more numerous large fruit.

Soil requirements

Peppers grow well on any type of well drained soil. Sandy loam with good water retention is ideal. Sandy soils dry out and warm up faster in the spring but require more irrigation during the growing season. Clay soils hold moisture better than lighter soils and are well suited for production later in the season.

Peppers should not be grown on low-lying fields and muck soils because of the danger of frost, low temperatures during flowering and fruitset, and (in muck soil) excessive foliar growth due to high nitrogen levels in the soil.

Transplant production and handling

All peppers grown in Michigan should be established by transplanting. Therefore, a supply of healthy plants of the desired variety and age is essential for a good crop. Most pepper plants used in Michigan come from the South, where they are grown in the field and then pulled and shipped north. Several problems with Southern-grown plants make them less than desirable: disease infection, over-age, overhardening as a result of poor growing conditions, deterioration during shipping, poor storage conditions after arrival in the North, and rapid loss of viability if not planted within 2 weeks of pulling. Therefore, many farmers find it desirable to grow their own plants or to have them grown locally.

Ideal pepper transplants are 5 to 6 weeks old, have 5 to 6 true leaves, are 6 to 8 inches tall, have a stiff but not woody

stem strong enough to withstand transplanting, have an intact root system (but are not rootbound), and have not suffered shock from storage or holding. They should be slightly hardened but not to the point where they are slow to take off in the field.

The traditional method of growing pepper transplants requires about 8 weeks in the greenhouse. Plant seeds in germination trays containing vermiculite and place on a germination bench at 80 to 90°F. Sow about 1 ounce of seed per flat. Water the trays regularly so they do not dry out. After 3 to 4 weeks, when the first true leaves are just beginning to form, carefully lift the seedlings and transplant them into flats, cell trays or benches, on about a 1¼ x 1¼ inch spacing. Allow the plants to grow another 4 to 5 weeks before transplanting into the field. The plants can be hardened by drying them out slightly and exposing them to direct sunlight and air temperatures of 60 to 70°F for 3 to 5 days. This can be done by opening the greenhouse during the day or by placing flats on wagons and moving them outside during the day and in again at night (if temperatures drop below 50°F).

An alternative method of transplant production, which reduces time from seeding to transplanting, is to pregerminate the seed and sow the seeds directly into flats. To pregerminate, spread the seeds singly on a ¼ inch layer of gel (Viterra II or Laponite) in a dish or tray, cover the dish to avoid loss of moisture, and place in a warm (80 to 90°F) place for about 5 to 7 days, or until a number of the seeds have germinated and the radicles have just emerged. Then, using a small spatula, pick the seeds plus a small amount of gel out of the germination tray and place them into cells or holes punched into a flat or bed with a dibble. Cover the seeds with ⅛ inch fine vermiculite and water thoroughly. Be sure the mix in the flats is completely damp before sowing.

With this propagation method, each seed produces a plant. This is especially important when using expensive hybrid seed. Also, because the seedlings emerge rapidly and do not undergo transplant shock in the greenhouse, they are usually ready for transplanting in 4 to 6 weeks.

Pepper plants grow well in many soil or soilless mixes that are well drained. A mixture of 50% finely shredded sphagnum peat and 50% vermiculite (grade 3 or 4) plus lime and some nutrients works well. Be sure to use only pasteurized mix to avoid soil-borne disease problems. Wet the mix thoroughly at least 24 hours before seeding.

After germination at 80 to 90°F, grow the plants with day temperatures of 70 to 75° and night temperatures of 60 to 65°.

Use soil or soilless mixes that contain some fertilizer. Commercial mixes usually contain sufficient fertilizer to support plants up to the true leaf stage. When true leaves have formed, water once a week with a soluble complete fertilizer mix. Experience will teach you the rate to use. Generally, keep plants growing well, but do not overapply nitrogen to the point that plants become soft and leggy.

Plant size and root cell size have an effect on early yields in the field but usually do not affect total yields. Experiments at Michigan State University indicated that early yields (the first week of harvest) increased as the cell size increased to 1½ inches in diameter. But even very small plants with a cell diameter of ⅝ inch produced comparable total yields. Thus, growers must decide whether the greater early returns from larger plants are worth their greater cost (more space) in the greenhouse.

If fields or weather are not ready for planting when the plants are ready, pepper plants should be slowed down by reducing water, fertilizer and temperature. Over-aged pepper plants will normally grow when transplanted, but they usually take longer to overcome transplant shock than younger plants. Also, it is difficult to hold plants in small cells because they become rootbound quickly.

Southern bare-root plants can be stored up to 2 weeks by keeping them cool (50°F) and dry, and at a relative humidity of 80%. Crates containing the plants should be stacked so that all sides of the crates are exposed to air. If the plants have to be held longer than 2 weeks, they should be unpacked as soon as possible to increase air movement through the crates. However, pepper plants stored longer than 2 weeks often suffer severe stress when transplanted. Many die and most survivors will not produce maximum yields.

Pepper plants often lose many of their leaves in storage, but it is not a serious problem. If soft rot sets in and plants become soft and slimy, they should be discarded.

Pepper seeds should be hot-water treated (126°F for 30 minutes) if bacterial spot is a potential problem. This should be done by seed companies because of possible injury to seed. Bacterial spot can be controlled in the greenhouse by applying Agri-Strep every 5 days after the first true leaves appear. Some formulations of captan are registered for control of foliar fungal diseases and damping-off in the greenhouse.

Under normal spacings in the field, about 10,000 plants are needed per acre. An ounce of seed contains about 4,500 seeds, so about 2½ to 3 ounces of seed are needed to produce enough plants for 1 acre. If each plant has 1½ square inches of bench space, about 110 square feet of bench space will be required for plants for 1 acre.

Establishment and culture in the field

Transplant peppers after soil temperatures are above 55° and danger of frost is past. In most areas of Michigan, this is May 20 or later. Peppers can be planted earlier on plastic mulch and/or covered by hotcaps or tunnels, which will normally shorten the time to harvest by 1 or 2 weeks.

Fields for pepper production should be free of perennial weeds and as free of annual weeds as possible. Weeds in the same family as peppers, such as nightshade and jimson weed, are especially troublesome. For this reason, rotation to other crops and other herbicides is important. Peppers can be safely grown on the same field every other year.

Before final field preparation, broadcast all preplant fertilizer. The final preparation with a disc or rotovator should make a firm but not overly smooth planting bed. Irregularities of the field surface will reduce sandblasting of the young plants during spring windstorms. In fact, on very sandy soils, it is wise to leave 5-foot strips of rye for windbreaks every 50 or 100 feet if sandblasting is a potential problem.

At transplanting, add a high phosphorus starter fertilizer to the transplant water. Use ½ cup of water per plant. Set pepper plants in the field so that no more than 1 inch of the stem above the roots is covered by soil. Pepper plants do not take off well if planted too deeply, because they do not root from the stem.

Peppers may be cultivated to control weeds and to sidedress fertilizers. Cultivate as shallowly as possible to

avoid injury to pepper roots, which are very shallow.

Fertilizer requirements

Land for pepper production should be limed to a pH of 6.5 to 6.8. Peppers require moderately high levels of phosphate (P_2O_5) and potash (K_2O) to produce maximum yields. About 250 lb P_2O_5 and 300 lb K_2O should be available per acre. Base fertilizer requirements on a soil test.

If a soil test is not available, broadcast and disc in about 75 lb nitrogen (N), 150 lb P_2O_5, and 150 lb K_2O before transplanting. For instance, apply 750 lb of 10-20-20 per acre. After the first fruit has set, sidedress with 40 lb N per acre (90 lb urea or 120 lb ammonium nitrate). On light, sandy soils and after heavy rains, a second sidedressing may be required to keep the peppers producing throughout the season.

Avoid overapplication of N before fruitset to prevent flower and fruit drop. High N causes pepper plants to grow too big and too fast, making them soft and brittle and therefore subject to structural damage from wind and heavy rain.

Spacing

Plant green bell peppers 18 to 24 inches apart in rows 30 to 40 inches apart. Early maturing cultivars tend to have smaller plants and can be safely planted at the closer spacing. Processing peppers can usually be planted at 12 inches. If pepper plants are planted too close together, they will have fewer fruit per plant, smaller fruit and fewer branches. Peppers should always have sufficient space between rows for good air movement and ease of harvest.

Harvest and postharvest

Peppers mature in 60 to 80 days from transplanting. The first, or "crown" set of fruit, at the first main fork of the stem, usually produces a large percentage of the large fruit. If the crown set is lost, early yield will be reduced. If harvested regularly (and maintained), pepper plants will continue to produce fruit until killed by frost.

Most Michigan peppers are harvested by hand. A mechanical harvester for processing peppers, which was developed by the USDA Agricultural Engineering section at Michigan State University, is being used by some growers.

Harvest green bell peppers when they are large and firm. Early maturing cultivars tend to have thinner walls and do not obtain the weight or firmness of later cultivars. Immature fruit do not hold up well after harvest, so it is important to recognize when fruit of each cultivar is ready for harvest.

After harvest, peppers for market are usually washed, waxed, graded by size and packed in 1 or 1⅑ bushel baskets, crates or boxes. U.S. Fancy grade green bell peppers are firm, well shaped and free from sunscald, frost injury, decay and scars from any type of injury. They are completely green, not less than 3 inches in diameter and 3½ inches in length. U.S. No. 1 grade is the same, except the peppers must be at least 2½ inches in diameter and 2½ inches in length. About 90 to 100 Fancy grade fruit and 100 to 110 U.S. No. 1 grade fruit are required to fill a 1⅑ bushel box.

Peppers should be stored at 45 to 50°F at a relative humidity of 90 to 95%. Under ideal conditions they will store for 3 weeks. At temperatures below 45°, peppers suffer chilling injury and begin to break down. At temperatures above 50°, they continue to ripen.

Soft rot of the stem is a common storage problem. It occurs when peppers are not cooled sufficiently before storage. To avoid the problem, test stem temperature with a probe thermometer and adjust cooling time so that internal temperatures are reduced below 50°. Rapid cooling will help avoid this problem and maintain fruit quality. Forced air cooling is probably the most efficient method of cooling peppers.

Keeping seed

Some growers keep their own pepper seed, especially of types or cultivars that are hard to find. It is possible to keep seed of non-hybrid cultivars. Seed of hybrids should not be saved because the resulting plants will not be the same as the parent plants.

Since the various types of peppers belong to the same species, they cross-pollinate easily. Peppers are primarily self-pollinated (i.e., flowers pollinate themselves), but usually about 17% are cross-pollinated by wind or insects. This is enough cross-pollination to make a batch of seed unusable. To avoid cross-pollination, separate pepper fields for seed harvest by at least 500 feet.

Harvest peppers when they are red (or brown) ripe and beginning to soften and shrivel. Earlier harvest will result in seed with poor viability. Remove the seeds from the peppers and spread them out in a warm place to dry. Avoid use of fans, or the seeds will blow away when dry. Cover them with a screen if birds or mice are a potential problem. When the seeds are dry, pack them in airtight containers and keep them cool (32-40°) and dry (30% relative humidity). Before seeding, treat the seeds with thiram (1 tablespoon per lb of seed) or captan (⅔ tablespoon per lb of seed).

Physiological disorders

Blossom end rot is a result of poor calcium movement into developing fruit during periods of rapid growth during hot, dry weather. Black, hard, sunken spots appear near the blossom and expand as the pepper grows. The spots often develop on a lower side of the fruit and can cover almost the entire side. Fungal or bacterial diseases may colonize the spot but are not the primary problem.

To avoid blossom end rot, do not overfertilize with nitrogen and avoid moisture stress during flowering and fruiting. Some cultivars are less susceptible than others to blossom end rot.

Corky stem appears regularly in some fields. It is a physiological condition that affects both peppers and tomatoes. The stem just above the soil line expands to about twice its normal diameter. The epidermis (skin) often splits open in one or more places. The cells of the water-carrying vessels (xylem) appear to grow and expand out of control. The inner tissue is white and very brittle so that young plants often break off in strong winds. As plants mature, the corky area becomes very woody and hard.

The cause of corky stem is unknown, but it may be caused by a combination of herbicide injury and cool, damp weather. Once the condition develops, the stems remain corky for the rest of the season. Some growers hill their plants with a cultivator to cover the corky area and give the plants some stability.

Sunscald occurs on fruit exposed to intense sunlight. Affected areas bleach out, turning light green, then yellow and finally white. The spots soon become papery and dry. Often fungi or bacteria colonize the affected tissue, and the fruit begins to decay.

Sunscald is only a minor problem in Michigan, because our cultivars usually have sufficient leaves to cover the fruit.

Individual exposed fruits may be affected.

Diseases

Six viruses affect susceptible pepper cultivars. These include tobacco mosaic (TMV), potato virus X (PVX), potato virus Y (PVY), cucumber mosaic (CMV), tobacco etch (TEV) and alfalfa mosaic (AMV). These viruses infect a wide range of cultivated plants and weeds.

Symptoms vary depending on the strain or virus involved, temperature and other environmental conditions, and plant stage when infected. Viral symptoms seen in peppers include mild to severe leaf mottling, puckering or curling, stem and petiole streaking and cracking, deformed or mottled fruit, plant stunting, and blossom and fruit drop. Some of these viruses are transmitted by aphids, whereas others are spread by mechanical means: during handling, by chewing insects, through infected debris in soil, on tools and by seed. Several of the viruses overwinter in infected plant material, especially in weeds belonging to the potato-tomato (*Solanaceae*) family, such as ground cherry, horsenettle, jimsonweed and nightshade. To avoid viruses, rotate away from fields of solanaceous crops (potato, tomato, eggplant), control weeds in and around fields, use a routine aphid spray control program, and use virus-free plant material.

Bacterial spot (*Xanthomonas vesicatoria*) causes fruit, stem and leaf spotting as well as defoliation and flower drop. Initial symptoms are small, circular to irregular greasy spots on the undersides of leaves. As the spots enlarge (up to ¼ inch) they may be surrounded by a narrow, yellow halo. The inside of the lesion ranges in color from brown to black. Eventually, centers of the lesions on the leaves dry out and frequently tear apart. Heavily infected leaves may be distorted and often turn yellow and drop off, exposing the fruit to sunscald. Fruit spots caused by the bacteria are ⅛ to ¼ inch in diameter, light to dark brown and raised. Fully developed lesions are rough and scabby. The causal bacterium can be brought in on infected seed or transplants. It is also known to overwinter in diseased plant residue for up to a year. Disease development is promoted by warm temperatures and abundant moisture.

Phytophthora blight (*Phytophthora capsici*) is seen occasionally on peppers in Michigan. The disease initially causes water-soaked spots on fruit, followed by the development of a large, irregularly shaped, soft, watery lesion. Often the surface of the lesion is covered by white mold growth. In addition to fruit rot, this organism can cause root rot, stem cankers and leaf blight. The organism is most active in wet weather and will usually be observed in the wettest areas of the field.

Bacterial soft rot (*Erwinia carotovora*) is not seen frequently in the field but often appears after harvest. The soft rot bacterium enters wounds and rapidly causes a soft, watery breakdown of fruit tissue. It also causes stem rot.

Alternaria rot (*Alternaria* spp.) may occur on fruit or leaves that have been wounded mechanically, chemically or by insects. Colonized wounds become covered with a black, velvety coat of spores.

Other diseases known to occur on pepper include Cercospora leafspot, downy mildew, Verticillium wilt and southern blight. These disorders are rarely seen in Michigan.

Insects

Consult Extension bulletin E-312, "Control of Insects, Diseases and Nematodes on Commercial Vegetables," for specific control recommendations.

Cutworms, especially the black cutworm, overwinter in the soil and become active about the time peppers are transplanted. They hide in the soil during the day and feed at night. The cutworms cut the plants off at the soil line but usually do not eat them. Growing peppers on plastic mulch may increase cutworm problems, because the higher soil temperature causes cutworms to be more active and attracts them to the plants.

Cutworms are difficult to control, but many will be killed by treating the soil around the plants with an insecticide. If a cutworm problem is anticipated, apply and incorporate a soil insecticide before transplanting. Fields should be checked daily for several days after transplanting, so that treatment can be applied, if needed, before damage becomes widespread.

Green peach aphids normally appear about the first week of June. They damage peppers by sucking sap from the undersides of the leaves. Aphids leave a sticky substance, called honeydew, on the leaves, on which sooty mold grows, discoloring the leaves and fruit. The plants may be stunted if the aphids are not controlled. Aphids also transmit mosaic viruses to peppers, which stunt the plants and may make the fruit unmarketable.

Apply insecticides for control as soon as aphids appear and continue as needed throughout the season.

European corn borer is a major pest of peppers. Adults of the second generation begin to appear in late July and lay eggs on the undersides of leaves. Eggs hatch in a few days and the larvae move into the fruit, usually entering under the cap (stem). The larvae are then inside the peppers, contaminating the fruit. Green bell peppers are much more susceptible to damage than non-bell types. However, strict quality standards for processing peppers make corn borer control mandatory for all cultivars.

Larvae must be controlled before they enter the fruit. Begin insecticide applications as soon as fruit begin to form, and repeat every 5 to 7 days until harvest. Sprays should be directed to cover all areas of the leaves and fruit.

Weeds

Several good herbicides are available for weed control in peppers. Devrinol and Treflan are most effective if incorporated before transplanting. Enide can be applied over the top after transplanting. These herbicides give good grass control and also control some broadleaves. Granular Amiben can be applied 3 days or more after transplanting, or later in the season after a clean cultivation. It will improve control of ragweed, smartweed and nightshade.

Cultivate peppers as needed to maintain good weed control. Cultivate shallowly to avoid injury to pepper roots.

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