

# Tomatoes: Fresh Market and Processing

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## Culture

Tomatoes are a warm-season crop and are one of Ohio's most important vegetables. Ohio ranks second nationally in processing tomatoes, with about 7,000 A producing an average yield of 29 t/A and a crop farmgate value of more than \$16 million. Fresh-market tomatoes are for the wholesale, retail and supermarket trade.

### Fresh Market

Most fresh-market tomatoes are produced from locally grown transplants or from southern-grown plants.

The key to good transplant production is sufficient space. Adequate spacing produces a short, stocky plant with a good root system for early production. Do not transplant too early unless trying for an early market. Start and grow plants at 60°F nights for smooth fruit and early clusters. Sow seeds about 7 weeks before plants are to be set in the field.

Cell sizes of 1.5-2.0 inches produce better plants than smaller cell sizes. A more popular and widely used tray size is the 96 square plug flat. Some growers are even using smaller plugs such as a 200 square plug flat. Harden plants slightly by decreasing temperature and water. Overhardening by exposure to very low temperatures and excessive starving results in plants that take off slower and produce lower yields.

Set plants no more than 1 inch deeper than in the flats. Otherwise, roots do not grow and vegetative growth is retarded, while new roots develop on the stem.

Ground tomatoes on plastic and "San Diego" stringtype trellis systems are the most common training methods. Tomatoes for the supermarket trade, the semi determinate types, are well suited for ground culture. Disease control is difficult during wet, humid periods and is one disadvantage to ground culture. String trellis systems provide more air circulation, but there is more danger of sunscald on the fruit. Trellis tomatoes produce earlier fruit when pruned to one or two stems, in comparison with ground culture systems.

### Processing

Select well-drained soils or provide surface and subsurface drainage systems. A 3-year rotation is preferred, with a crop other than corn planted the previous growing season. Avoid fields with residual nitrogen and where triazine herbicides may present a carryover problem.

Locally grown or southern transplants are used for field establishment. Use only certified plants from southern states. Transplants give earlier maturity than direct seeding, and nearly all processing tomato acreage in the Great Lakes region is established using transplants. Twin-row plantings with small bush-type varieties are now more common and can increase yields by 25%. Field planting starts in late April and continues until June 15.

The advantages of direct seeding are lower cost per acre; reduced chances for disease introduction; and flexibility in planting time, variety selection and plant population.

It is important to prepare plant beds for direct seeding or transplants as early as possible, regardless of soil type. Well-formed beds help surface drainage whether the beds are made in late fall or early spring. Fall bed making is preferred with clay loams and some silt loams. Beds generally are spaced 60 inches between centers (66 inches for some harvesters). Bed shape is determined by harvesting equipment.

Additional information about processing tomatoes is available from Ohio State University Extension Bulletin 647, *Guidelines for Machine-Harvested Tomatoes for Processing*. The bulletin is available through local county Extension offices or from the Publications Office of Ohio State University Extension.

# Varieties

Fresh Market							
Early	Main Season	Yellow	Roadside stand	Mature Green	Plum	Cherry	Grape
Early Sun Leaper	Sunbrite	Carolina Gold	Jet Star (VF)	Sunny (674) (VF)	Daquiri	Mountain Bell	Mini Charm
Sunshine	Florida 47		Market Pride	Count II (VF)	Mariana	Sugar Snack	Jolly Elf
Mountain Spring	Florida 91		Mountain Pride	Floradade (908)	BHN 411	Sun Gold (yellow)	
Pik Red (Semi-Det, F1F2, V)	Mountain Fresh Plus		Celebrity	Florida 47	El Dorado (yellow)		
Applause	Sunbeam			Florida 91			
	Indy						
	Sunguard						
	BHN 586						

Several varieties have been developed that have the jointless character. This allows the fruit to be harvested without the stem. Examples are Freedom, Revolution and Count II.

Processing Varieties Suited for the Production of Peeled, Whole-canned, and Diced Tomato Products						
Variety	Type	Plant Size	Maturity	oz/Fruit	Color	Color Uniformity
Ohio 7983	OP	Med	Early	2.5	good	good
OX52	H	Med	Early	2.1	good	good
OX88	H	Med	Early	2.3	good	good
OX150	H	Med-Lg	Early	2.1	excellent	good
PS 2196	H	Med-Lg	Early	2.5	good	good
TR12	H	Med	Early-Main	2.2	excellent	excellent
Heinz 9423	H	Med	Main	2.5	excellent	excellent
PS213015	H	Med-Lg	Main	2.3	excellent	good
Ohio 9242	OP	Med	Main	2.7	excellent	excellent
PS 696	H	Med-Lg	Main	2.5	good	poor
Ohio 8245	OP	Med	Main	2.5	good	poor
Heinz 9422	H	Med-Lg	Late	2.5	excellent	good

**Plant and Fruit Characteristics:** All varieties have Jointless pedicel (j2), uniform ripening fruit, and are suitable for once over machine harvest. Recommended harvest is at 80% ripe fruit.

**Disease Resistance:** All varieties are resistant to Verticillium Wilt (race 1) and Fusarium Wilt (race 1). Ohio 8245 has field resistance to bacterial spot. Early varieties are more susceptible to foliar pathogens and exhibit poor field holding.

**Yellow Shoulder Disorder:** Fruits affected by yellow shoulder are characterized by yellow or green sectors, under the fruit peel. Discolored sectors range from a few millimeters to the top 1/3 of the fruit. Yellow shoulder disorder (YSD) is sometimes called internal white tissue, yellow eye, yellow shoulder, or green shoulder. YSD begins early in fruit development and cannot be reversed by delaying harvest. Yellow shoulder affects both the appearance and nutritional quality of tomatoes, reducing efficiency and return on investment for growers and processors.

By paying attention to variety choice and field fertility, growers can potentially reduce the risk of YSD incidence by 50%. At the same time, weather conditions and/or a combination of all factors that are not under human control are a major determinant of YSD incidence in the field. Some varieties are less susceptible to yellow shoulder disorder than others and are said to have “uniform” color. Recommendations for color uniformity are based on a multi-year analysis of yellow shoulder disorder for the Midwest (Indiana, Michigan, and Ohio). Fields that are prone to yellow shoulder disorder should be planted to uniform varieties such as OX23, Heinz 9423, and Ohio 9242. PS696 and Ohio8245 should be avoided in fields that have a history of yellow shoulder disorder or that are not within the fertility guidelines described below.

Adequate soil fertility plays an important role in decreasing the incidence of yellow shoulder. However, massive application of fertilizer (mainly K) is unlikely to eliminate the problem due to soil fixation of nutrients by clay, leaching and nutrient imbalance. Foliar application of potassium is not an effective approach to fertility and will not prevent YSD. Growers should try to avoid soils

with pH below 6.0 since the availability of K, Ca, and Mg to the plant is reduced. Liming to achieve a pH above 6.8 can lead to a cation imbalance and ultimately reduce the levels of K in the soil solution. At alkaline pH (above 7.0) the fixation of K tends to increase, affecting the amount of K readily available to the plant. Organic matter has a positive effect on the nutrient holding capacity of soil (CEC), the pool of nutrients available to the plant, the water holding capacity and aggregation of the soil. Increased organic matter helps diminish losses of plant-available nutrients due to leaching or soil fixation. Adequate levels of available phosphorus in the soil are also important to reduce risks of YSD. However, growers are advised not to exceed soil test recommendation due to eventual water pollution by excess application of phosphorus.

Fields at a lower risk of producing fruit with YSD have the following soil properties:

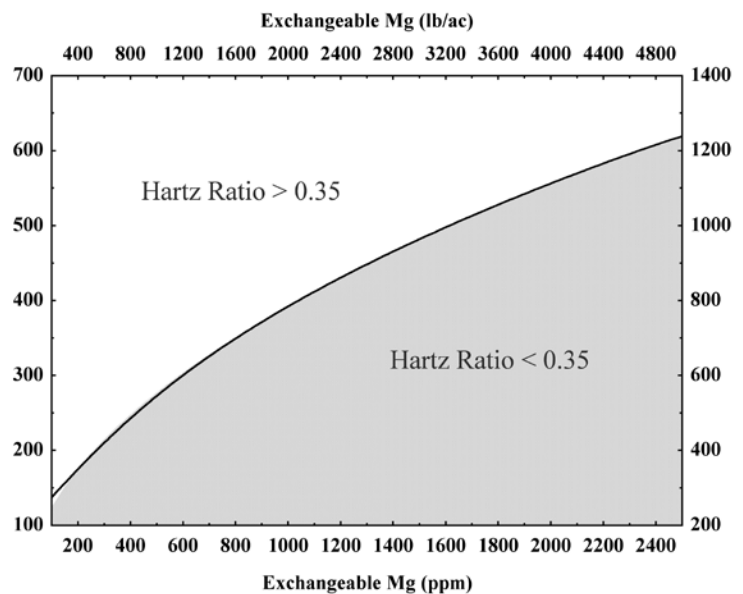
- pH between 6.0 and 6.8;
- organic matter above 1.5%;
- exchangeable potassium above 400 lbs/ac (or 200 ppm);
- ratio of K (meq/100g)/ $\sqrt{\text{Mg}}$  (meq/100g) above 0.35;
- available P above 30 ppm; and
- % of CEC occupied by K above 4.

Overall, soil fertility in the Great Lakes region falls, on average, well within these guidelines. However, soil fertility variability within a field is not uncommon. Growers should pay attention to the soil sampling guidelines in order to obtain a representative sample of the field. With the latest soil test results at hand, growers can compare their field fertility with the guidelines above by accessing the following website: <http://www.oardc.ohio-state.edu/tomato/HartzRatioCalculator.htm>. Current research in California and the Midwest suggest that the Hartz ratio [= Exchangeable K (meq/100g)/ $\sqrt{\text{Mg}}$  (meq/100g)] of your soil is an important tool to select soil at lower risk of yellow shoulder. Note that the Hartz ratio is estimated using meq/100gm as units, but most laboratories present the soil tests results as lbs/ac or ppm. If using the website or the diagram below, you do not need to convert the units of your soil test.

Follow these steps to estimate the Hartz ratio using the diagram below:

- Find the values of exchangeable K and Mg in your soil test (in ppm or lbs/acre, note that the graph has both units).
- In the diagram, plot these two values in their respective axes.
- Draw straight lines (vertical lines for Mg and horizontal lines for K) from both axes until both lines meet. At the crossing point you will have the Hartz ratio. The line crossing the diagram defines two classes of Hartz Ratio, that is, above and below the critical value of 0.35. Soils with values of Hartz ratio > 0.35 are at lower risk of yellow shoulder.

Growers should note that it is important to keep a good fertility balance of the soil. Over fertilization of soil will create a nutrition imbalance to the plant, that will ultimately affect the overall quality of the tomato fruit. Following the soil test recommendation is still the wisest management practice.



## Lime and Fertilizer Fresh Market

Tomatoes prefer a soil pH range of 6.0-6.8. Blossom-end rot can be caused by a calcium deficiency and occurs frequently on acid soils or during stress periods on soils with seemingly sufficient calcium.

Broadcast 60-80 lb N/A prior to planting. Apply P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O according to soil test. Sidedress with an additional 30-60 lb N/A with a material such as calcium nitrate or other fertilizer whose nitrogen source is mainly from the nitrate form. This helps to reduce the incidence of blossom-end rot. Sidedress at the appearance of the first fruit cluster.

Regardless of other fertilizer applications, apply a starter solution at the time of transplanting.

## Processing

Maintain soil pH between 6.5-6.8.

The nitrogen fertilization program is dictated by the harvest method. It is important to confer with the company's field person to determine the amount of nitrogen required. Twenty-25% less nitrogen is needed with direct seeded tomatoes than with transplants. Some guidelines are:

<b>Machine Harvest (N lb/A)</b>			
	<b>Sandy Loams</b>	<b>Silty Loams</b>	<b>Multiple Harvest</b>
Field seeding	60	60	70
Transplants	90	70	100

Apply 50% of the recommended N prior to planting and the remainder in a sidedress application shortly after the plants are established. On sandy soils or when leaching rains occur, an additional 30 lb N/A may be needed as a sidedress application after the first clusters have set fruit.

Apply per acre according to soil test: 100-175 lb P<sub>2</sub>O<sub>5</sub> and 200-350 lb K<sub>2</sub>O. Phosphorus and potassium can be applied prior to planting or prior to bed formation.

Apply a starter fertilizer at transplanting.

## Starter Fertilizers

Upon setting in the field, apply a starter solution to each transplant. Starter solutions are water-soluble fertilizers high in phosphorus. Select starters that have the highest level of phosphorus available, such as 21-53-0, 10-52-17, 10-58-6 or 10-34-0. Follow label directions for mixing and application rates. Usually, 3 lb are mixed in 50 gal of water and 1/2 pt applied per plant. Liquid fertilizers such as 10-34-0 are usually made by mixing 1 qt in 50 gal water (11 lb/gal). Be sure to follow label directions, because burning and stand reduction can result from excess application.

## Spacing, Seeding and Planting

### Transplants

Spacing is variety dependent.

Rows: 5 ft.

In-row: 9-16 inches.

### Twin row

Rows: 16-18 inches apart. In-rows: 12-18 inches apart. Twin-row centers: 5-6 feet apart.

Plants required: single row, 8,000-10,000 plants/A; twin row, 10,000-16,000 plants/A; most common, 12,000-14,000 plants/A.

The use of pregerminated seed in a plug mix probably is the best method to establish field seedings, but it is time-consuming and labor-intensive. Raw seed is the most popular method currently in use. Soil crusting and weed control are major concerns, but the use of anticrustants such as vermiculite and activated charcoal have reduced these problems.

Precision seeders, such as John Deere, International Harvester, Dahlman or Stanhay, are used to deliver clumps that are 8-10 inches apart. Each clump should have 3-5 plants. Direct seed provides two rows (twin-row system) per bed. Field seeding usually is between April 20 and May 20. Planting depth is 0.5-1 inch, and temperature should be at least 55°F at the 1 inch depth. Cold, dry soil can delay emergence as long as 20-30 days.

Seed required: 1-1.5 lb/A of raw seed or 8-12 oz of de-fuzzed seed.

## Fresh Market

### Large vined (indeterminate)

Rows: 5-6 ft apart, plants 20-30 inches apart in the row.

### Small vined (determinate and semideterminate)

Rows: 3-5 ft apart, plants 18-24 inches apart in the row.

# Harvest

## Ethephon for Ripening of Processing Tomatoes

Ethephon (Ethrel) is a growth regulator that, when applied to tomatoes, results in an increase in ethylene and triggers the ripening action of mature green fruit. Advantages to its use are (1) hastening and increasing ripe fruit accumulation so that once over, harvest can begin 5-7 days earlier than normal, (2) spreading out the total harvest period; (3) permitting late plantings to be harvested before frost, (4) increasing yields from split-set conditions (two fruit-ripening periods with uneven maturity); and (5) overcoming delayed ripening in fields with excessively vigorous plants.

Apply ethephon only to mature green fruits. There is little or no effect on immature fruits. The best time for application occurs when 5%-15% of the fruits by count on the plants are pink or red. Plants with over 40% ripe or turning do not show a beneficial response to ethephon.

To determine the mature green stage, cut several fruits with a sharp knife. If the seed cavities are filled with gelatinous pulp, and the seed coat is tan or brownish, the fruits are considered mature. Such fruits also show a slight change from green to a light green or white color. Work with company representatives, because newer varieties vary in internal characteristics. The average time of harvest is 14-18 days after treatment.

Rate: Apply per acre 1.5-3.5 pt ethephon (2 lb/gal formulation) in 40-80 gal (ground application) of water. Late in the season, under cooler conditions, use 4.0 pt/A. Absorption decreases at lower temperatures. For early maturing varieties, 1.0-2 pt/A may be sufficient under normal or high temperatures.

Rates above 4.0 pt/A are not recommended due to excessive defoliation and reduced fruit quality. Do not apply ethephon under stress conditions such as moisture, disease, insect, hail, low vigor or root damage, because this will increase defoliation and lower fruit quality. High temperatures (80-90°F and above) increase foliar injury. **Do not apply at or above 90°F or when high temperature is expected.** Do not tank mix with other pesticides or hold overnight.

Ethephon initiates ripening but has little effect on the rate of ripening. Temperature has the greatest effect on the ripening rate. Therefore, do not increase the rate of application expecting to increase the rate of ripening.

Rainfall effects: 3 hours is the minimum time for adequate absorption.

## Fresh Market

### Supermarket and wholesale market

Pick tomatoes when they reach the mature green stage. Generally, only US #1 quality fruit is acceptable on this type of market. The fruit usually is clean and packed in 20- or 25-lb boxes. Ohio State University Extension offices or produce buyers can provide more information on acceptable grades and containers.

## Roadside Market

Tomatoes for roadside retail sales are picked at a more mature stage and should be in the breaker stage preferably as exhibiting at least 30%-60% red color. The type of container depends on local marketing trends, with the 10-lb handle basket or display box being popular. Bulk displays, where consumers choose their own tomatoes, are popular in some areas.

## Tomato Problems

**Catfacing:** Large scars at the blossom end of the fruit are known as catfacing. Plants exposed to low temperatures—below 50°F for 2 or more days or nights at the time of fruit initiation—are prone to catfacing. Certain varieties also are more prone to catfacing than other varieties. Herbicide injury and wind damage also cause catfaced fruit.

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# Disease Control

## Note on the Use of Strobilurin Fungicides

Products containing fungicides in this group (e.g., Amistar, Flint, Cabrio, Quadris) must not be used in consecutive sprays to avoid development of fungi resistant strains to strobilurins. They must be alternated with fungicides having different modes of activity (see pages 59-60).

## Damping off

Buy commercial fungicide-treated seed, if available. If Pythium has been a problem, apply **Ridomil Gold EC** (46EC) 1-2 pt/A. See label directions, or **Ridomil Gold GR** (2.5 GR) 20 lb/A; 40 lb maximum per season. (see label).

**Aliette** WDG 2.5-5.0 lb/A. Apply as a foliar spray at 2-4 leaf stage; continue at 7-14 day interval if conditions are favorable for disease development. **DO NOT USE IN WILLIAMS COUNTY, OHIO.**

## Early Blight (*Alternaria*), Late Blight (*Phytophthora*) and Anthracnose

Follow a regular fungicide application program. Start 2-3 weeks after transplanting or after emergence of seedlings. Apply one of the following at 7-10 day intervals:

\***Quadris** 5-6.2 fl oz/A (0 days-PHI) anthracnose and early blight; 6.2 fl oz/A for late blight (see label for restrictions).

\***Cabrio** EG 8-12 oz/A (0 days-PHI). Maximum use of 64 oz/A/season.

**Bravo Ultrex** 1.8-2.7 lb/A (0 days-PHI).

**Bravo Weather Stik** 1.5-3 pt/A (0 days-PHI).

**Equus** DF 1.3-1.5 lb/A (0 days-PHI).

\***Flint** 3.0 oz/A for early blight; 4.0 oz/A for late blight (3 days-PHI).

**Mancozeb** 4F 1.2-2.4 qt/A (5 days-PHI).

**Mancozeb** 75DF 1.5-3.0 lb/A (5 days-PHI).

**Ziram** 76 DF 3-4 lb/A (7 days-PHI) anthracnose and early blight only.

\***Tanos 50DF** 8 oz/A (3 days-PHI). Must be tank-mixed with a protectant fungicide.

**Gavel** 1.5-2.0 lb/A (3 days-PHI). Begin applications at first sign of disease or when late blight is found in the area.

See the table on page 58 for recommendations and restrictions on the use of EBDC fungicides, such as Mancozeb. Ziram 76 has controlled anthracnose as well as EBDC fungicides in Ohio field tests when applied to processing varieties before first green fruit is more than 1.5 inches in diameter. Do not use Ziram after pink fruit forms; do not use on cherry tomatoes.

## For Late Blight Only

When conditions are favorable for late blight, follow a 7-day schedule for all fungicides.

\***Aliette/Maneb 2 + 2** 4 lb/A (14 days-PHI) (see label). **DO NOT USE IN WILLIAMS COUNTY, OHIO.**

\***Acrobat** (50 WP) 6.4 oz/A (4 days-PHI). Do not exceed 32 oz/A per season.

Use only when disease is present.

\***Ranman** 2.1-2.75 oz/A (0 days-PHI).

## Buckeye Fruit Rot (*Phytophthora*)

\***Ridomil Gold EC** 1 pt/A 4-6 weeks after planting (4 weeks-PHI). See label.

\***Ridomil Gold GR** 10 lb/A, 4-6 weeks after planting. 10 lb/A additional up to 4 weeks before harvest.

\***Ridomil Gold/Bravo** 2lb/A (14 days-PHI) (see label for restrictions).

\***Quadris** 5.0-6.2 fl oz/A (0 days-PHI) (See label restrictions for resistance management).

\***Gavel** 75 DF 1.5-2.0 lb/A (5 days-PHI) (See label).

\***Tanos 50DF** 8 oz/A (3 days-PHI). Must be tank-mixed with a protectant fungicide.

## Septoria Leaf Blight

The important time to control this disease is mid-July to early August. During this time period, apply one of the following fungicides weekly:

**Bravo Ultrex** 1.3-2.75 lb/A (0 days-PHI).

**Bravo Weather Stik** 1.5-3 pt/A (0 days-PHI).

**Echo 720** 1.4-2.0 pt/A (0 days-PHI).

**Equus** DF 1.3-2.6 lb/A (0 days-PHI).

\***Cabrio** EG 12-16 oz/A (0 days-PHI). Maximum use of 64 oz/A/season.

\***Quadris** 5.0-6.2 fl oz/A (0 days-PHI).

\***Flint** 3.0-4.0 oz/A.

\***Tanos** 8 oz/A (3 days-PHI). Tank mix with mancozeb or other protectant fungicide.

## Botrytis Gray Mold

This disease is serious on stake tomatoes when workers cause extensive leaf and stem damage during picking, especially during periods of moist weather. Apply one of the following fungicides weekly when disease appears:

**Bravo Ultrex** 1.8-2.5 lb/A (0 days-PHI).

**Bravo Weather Stik** 3-4 pt/A **Echo 720** (6F) 2-3 pt/A (0 days-PHI). 15.1 lb a.i./A/year total.

**Echo 720** 1.4-2.0 pt/A (0 days-PHI).

## Powdery Mildew

\***Nova** 2.5-4.0 oz/A. Spray interval depends on disease pressure but should not exceed 21 days (0 days-PHI). See label.

\***Cabrio** 8-12 oz/A (0 days-PHI). Maximum use of 64 oz/A/season.

## Bacterial Spot, Bacterial Speck and Bacterial Canker

Bacterial spot is caused by a bacterium that can be carried as a contaminant on the surface of infested seed. Bacterial speck is caused by a different bacterium. Although there is speculation that this also is seed-borne, it has not been conclusively demonstrated. However, it can overwinter on plant debris in soil and on roots of many perennial plants.

Both organisms may exist at low populations on leaf surfaces of symptomless plants. At the onset of favorable warm, moist conditions, these low populations can increase rapidly, and bacteria then can enter plants through stomata or small wounds and begin infection. Bacteria can spread rapidly with spattering rain, and widespread epidemics may develop. Penetration of tomato fruit occurs through wounds created by wind-blown sand, breaking of hairs or by insect punctures.

The third disease, bacterial canker, is caused by bacteria that colonize and multiply in waterconducting tissues throughout the plant. Seed also can be infected and usually is the manner in which the disease is introduced. Serious losses to canker have occurred in Ohio in recent years. The organism can persist in soil on plant debris for at least one year and may survive in dried soil, crevices of wooden stakes or machinery. Stakes should be fumigated before reuse.

Control of bacterial diseases generally is difficult because of the high multiplication rate and the absence of effective bacteriocides. Crop rotations of at least 3 years, coupled with the use of disease-free transplants, is basic for disease control. However, transplants may carry bacteria and show no symptoms.

Planting certified disease-free seed, preferably acid treated, will minimize introduction of these organisms into transplant beds. After the crop is established, bacteria are spread mechanically and by wind-blown rain. Overhead irrigation should be regulated to minimize the time foliage is wet. Efforts should be made to avoid working in wet fields to further minimize spread.

Under warm, wet conditions, bacterial diseases are very difficult to control.

Fixed copper fungicides may be of some benefit if applied regularly, beginning soon after transplanting. A tank mix of **Manzate (200 DF) at 1.5 lb/A plus 4 lb fixed copper/A** may be effective in reducing the spread of bacterial diseases. See the table on page 58 for restrictions on the use of EBDC fungicides.

**Actigard** 50 WG 0.33-0.75 oz/A (14 day-PHI). See label for application schedule.

**Tanos 50DF** 8 oz/A (3 days-PHI) may suppress development of bacterial diseases. Tank mix with fixed copper fungicide plus mancozeb.

## Tobacco Mosaic Virus (TMV)

This disease is more a problem in fresh market tomatoes due to extensive handling. The best control is to use a TMV resistant cultivar. There is no chemical control. If only a few plants are showing symptoms, remove them carefully so as not to touch other plants. Control weeds around fields, as some weeds are known to harbor the virus.

## Tomato Spotted Wilt Virus

This virus is carried by thrips and can cause major losses to peppers and tomatoes if the virus infects young plants. If southern-grown transplants are used, growers should be certain they are from inspected, disease-free fields. Northern-grown transplants should be grown in isolation from ornamental crops. Control of thrips may slow spread of virus in the field and greenhouse. (See "Thrips" in the Insect Control section.)

# Postharvest Bacterial Soft Rot

Bacterial soft rot of fruit that develops after harvest is caused by bacteria that enter fruit through wounds or calyx scars during harvesting and packing operations. Although these bacteria are always present in the fields, their populations increase greatly in warm, wet weather and generally more disease will occur then.

Good field drainage and avoidance of excessive nitrogen fertilization will help minimize field infection. During harvest, avoid bruising fruit, as the bacteria enter through wounds. Make sure harvested fruit do not sit in the sun, but are moved to the packing shed quickly.

A major source of postharvest infection is the dump tank water, which is often contaminated with soft rot bacteria. It should be changed often and chlorinated by a system that keeps the levels between 100-150 ppm. Dirt or organic debris in the water quickly inactivates chlorine, so it must be constantly replenished. Chlorination is also most effective at a water pH of 6.0-7.5. The dump tank water must also be kept at least 10°F warmer than the pulp temperature of the fruit to minimize contaminated water being sucked into tiny wounds. It is also important that the fruit is not submerged any deeper than 24 inches or longer than 2 minutes to minimize hydrostatic pressure forcing contaminated water into wounds.

After removal from the tank, fruit should be run through a chlorinated spray wash of fresh water and then dried before packing. Each of these procedures is an important part of a total program to minimize postharvest soft rot. Use of only some of them will not be sufficient.

\*Follow guidelines for fungicide resistance management on the product label (see pages 59-60).

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## Insect Control

### Processing Tomato Insect Pest Management Tomato Pest Monitoring

Monitoring pest abundance is an essential component of an effective pest management program. Field scouting and pheromone trapping are two methods of monitoring insect pest abundance in a tomato field. When the abundance of insect pests is minimal, then applications of insecticide can be reduced to save money and satisfy consumers. When insect pest pressure is great, insecticide applications should be made to prevent damage to the crop. Careful monitoring of insect pest populations can also be used to better time insecticide applications when pest populations are most vulnerable. Field scouting both before and after a spray helps evaluate the efficacy of an insecticide application. Fewer and more effective insecticide applications can prolong the life of these valuable agricultural tools by reducing both environmental concerns and pest resistance.

### Field Scouting

Proper field scouting should accurately reflect the pest population or damage potential in a tomato field. One or two infested plants out of thousands does not warrant an insecticide application to an entire tomato field. Conversely, plants may superficially appear healthy, while an irreversible pest problem is developing. Objective, thorough field scouting of tomato fields is very important.

We presently recommend weekly sampling of a minimum of 40 plants per tomato field. If the field is larger than 20 acres, then add two additional plants per acre. Plants should be randomly selected while walking a “V” or zigzag pattern through the field. These sampling patterns ensure that a few plants are examined in each area of the field. A good way to randomly select a plant is to walk a set number of steps and then sample the plant that is nearest your lead foot. For aphid sampling, select leaflets randomly from the upper two-thirds of the tomato plant canopy.

Carefully examine each plant and record the *presence* or *absence* of:

- variegated cutworm caterpillars
- recent caterpillar (fruitworm or cutworm) feeding damage on fruit
- tomato fruitworm caterpillars
- stink bugs
- stink bug feeding damage on fruit
- hornworm feeding damage on fruit or leaves
- hornworms

and the *number* of:

- cabbage loopers



- Colorado potato beetle adults
- aphids on ten leaflets (individual tomato leaves are actually compound leaves composed of many leaflets)
- flea beetles (optional)

Insect counts should be converted to a per plant basis for comparison to guidelines if more or less than 40 plants are sampled per field. To convert, add up the number of insects found of each pest species and divide each by the number of plants or leaflets sampled. An infested plant is any plant that has 1 or more of a given insect pest present, or the presence of any feeding damage to foliage or fruit.

## Scouting Tips

- Variegated cutworms can be found inside fruit, on plant foliage, or curled-up underneath the plant canopy.
- Frass (moist-green pellets) and holes chewed in foliage are an excellent indicator that caterpillars are feeding in the area. Large frass pellets (> 1/4 inch) and defoliated stems are indicators of hornworms.
- Shaking foliage lightly will often dislodge cutworms and cabbage loopers, but save this for last.
- Stink bug feeding causes white or yellow blotches on tomato fruit. Finding damage to green fruit by stink bug requires close inspection. Stink bugs are often difficult to find on tomato plants and may hide when the plant is disturbed or the scout approaches. Shaking the plant may help dislodge them, or if you wait a few moments after searching the plant then stink bugs might come out of hiding.
- Colorado potato beetle problems are sometimes concentrated along field edges that border a previous year's potato or tomato field. Scouting for this pest should also be conducted specifically along these vulnerable edges. Insecticide applications can be applied just to an affected edge if this area alone exceeds the Colorado potato beetle treatment threshold.

## Pheromone Traps

Pheromone traps are useful for monitoring the adult (moth) form of variegated cutworm and tomato fruitworm. Weekly trap counts can be used to time insecticide applications or alert growers to the presence of these pests in the area. Place 3 traps for each species of moth in or around a field or group of nearby fields. Space traps as far apart as is practical to monitor the field and access traps easily. Count and record the number of moths in each trap once per week and remove all moths from traps after counting.

## Insecticide Decision Guidelines

The following insecticide treatment thresholds are based on pheromone counts and field scouting from on-going research on commercial farms and in research plots at Ohio State University. The guidelines are tentative and could be changed pending additional research. They are sufficiently conservative that they should eliminate insecticide applications that are obviously unnecessary while minimizing the risk of crop damage.

### Colorado Potato Beetle

- more than 20 adults per 40 plants sampled (0.5 per plant), **for transplants less than 8 inches high only**. Feeding on larger plants by adults or larvae, regardless of apparent severity, does not reduce fruit yield.

### Flea Beetles

- more than 160 adults per 40 plants sampled (4 per plant), **for young direct-seeded plants less than 4 inches high only**.

### Variegated Cutworm

- more than 1 infested plant (caterpillar, or fresh feeding damage on any fruit) per 40 plants sampled, **for plants with fruit only**.
- Spray a field for variegated cutworm within 4 to 8 days (4 days if weather is hot, 8 days if cool) after pheromone trap counts average more than 10 moths/trap per week, **for plants with fruit only**. In our research to date, pest problems have not been associated with counts less than 10. Also, not all fields that have trap catches above 10 moths will have a problem, but spraying based on trap counts will minimize the risk. As trap counts approach and exceed 10, field scouting as described above should be intensified.

### Hornworms

- more than 2 infested plants (caterpillars or plants with fresh feeding damage) per 40 plants sampled, **for all plant stages**.

## Tomato Fruitworm

- more than 1 infested plant (caterpillar, or fresh feeding damage on any fruit) per 40 plants sampled, **for plants with fruit only**.
- We have no data correlating damage levels with trap counts for this pest. Scout fields more frequently when pheromone trap counts begin to increase. Tomato fruitworm caterpillars are seldom a problem in early planted tomatoes in northern Ohio.

## Cabbage Looper

- more than 20 caterpillars per 40 plants sampled (0.5 per plant), **for plants with fruit only**.

## Stink Bugs

(Guideline only for wholepack processing tomatoes, once plants have fruit.)

- more than 1 stink bug infested plant per 40 plants sampled **or**
- Because old and new stink bug damage looks alike, spray when an *increase* over the previous week of at least 1 plant with stink bug damaged fruit per 40 plants sampled is observed.

## Aphids

- more than 0.5 aphid per leaflet, **for all plant stages**.

# Insecticides

See the table on the next page for overview of insecticides used to control tomato pests.

## • Preplant broadcast treatment

### Diazinon

For cutworms and wireworms.

Diazinon 14G: 14-28 lb/A.

Diazinon 50WP: 4-8 lb/A.

Diazinon AG500 (4EC): 2-4 qt/A.

Diazinon AG600: 51-102 fl oz/A.

## • At-planting or sidedress treatment

Note: If **cutworms** are a problem at planting time, carbaryl, methamidophos, or methomyl may be used; see rates under sections on foliar and bait treatments.

### Bifenthrin (1 day-PHI)

For wireworm, maggot, grubs.

Brigade 10WSB: 8-12.8 oz/A. Apply in-furrow with transplants.

### Dinotefuran (21 days-PHI)

For aphids (suppression), whiteflies, thrips, flea beetles, Colorado potato beetle.

Venom 70SG: 5-6 oz/A as transplant drench. Limit 12 oz/A per season.

### Imidacloprid (21 days-PHI)

For aphids, whiteflies, Colorado potato beetle, flea beetles, thrips.

Admire 2F, Alias 2F: 16-24 fl oz/A. Apply at-planting or a sidedress. Limit 24 fl oz/A per year.

Admire Pro (4.6F): 7.0-10.5 fl oz/A.

### Thiamethoxam (30 days-PHI)

For aphids, flea beetles, Colorado potato beetle, whiteflies, thrips, tomato pinworm.

Platinum 2SC: 5-11 fl oz/A.

## • Bait treatment

### Carbaryl (0 days-PHI)

For cutworms, crickets, grasshoppers, armyworms.

Sevin 5B: 20-40 lb/A or 7.3-14.7 oz/1,000 sq ft.

Prozap Sevin 10% Bait Granules: 10-20 lb/A.

## Insecticides for Use on Tomatoes in Ohio

(E = excellent; G = good; F = fair; P = poor; ✓ = pest listed on label but efficacy uncertain; - = pest not on label; rating in parentheses = pest not on label but product known to provide some control)

Pest >>	Pre-harvest interval (days)	Flea beetle	Colorado potato beetle	Vari-gated cutworm	Tomato fruit-worm	Horn-worms	Stink bugs	Potato aphid	White-flies	Thrips	Grass-hoppers	Impact on beneficial insects
<i>How often an insecticide has been needed on Ohio farms for this pest in the past &gt;&gt;</i>												
<b>ORGANOPHOSPHATES</b>												
diazinon	1	-	-	-	-	-	-	F	-	-	-	moderate
dimethoate (Cygon)	7	(G)	-	-	-	-	-	G	-	(G)	-	disruptive
malathion (Cythion)	1	(G)	-	-	-	-	-	F	-	-	-	low/moderate
Monitor (methamidophos)	7	(G)	P	✓	G	G	(G)	G	-	(G)	-	disruptive
<b>CARBAMATES</b>												
Lannate (methomyl)	1	(G)	-	✓	F/G	G	-	G	-	(G)	-	disruptive
Sevin (carbaryl)	3	G	P/F**	✓	F	G	-	-	-	F	-	disruptive
Vydate (oxamyl)	3	-	-	-	-	-	-	✓	✓	-	-	disruptive
<b>PYRETHROIDS</b>												
Asana (esfenvalerate)	1	G	F/G*	G	G	G	-	F	✓	(F)	✓	disruptive
Baythroid (cyfluthrin)	0	G	F/G*	G	G	G	G	F	-	✓	-	disruptive
Capture (bifenthrin)	1	G	-	✓	✓	-	✓	✓	✓	✓	✓	disruptive
Danitol (fenpropathrin)	3	-	-	-	G	✓	✓	-	-	✓	-	disruptive
Decis (deltamethrin)	1	✓	✓	✓	✓	✓	✓	-	-	✓	-	disruptive
Hero (bifen. + zeta-cy.)	1	✓	✓	✓	✓	✓	✓	-	✓	-	✓	disruptive
Mustang (zeta-cypermethrin)	1	✓	✓	✓	✓	✓	✓	-	-	F	✓	disruptive
Pounce (permethrin)	0	-	F/G*	-	F	G	-	-	-	-	-	disruptive
Proaxis (gamma-cyhalothrin)	5	G	F/G*	✓	✓	✓	✓	✓	✓	✓	✓	disruptive
Warrior (lambda-cyhalothrin)	5	G	F/G*	G	G	G	G	-	-	-	✓	disruptive
<b>NEONICOTINOIDS (CHLORONICOTINYLS)</b>												
Actara (thiamethoxam)	0	✓	✓	-	-	-	✓	✓	✓	-	-	low/moderate
Admire (imidacloprid)	21	✓	G	-	-	-	-	✓	G	✓	-	low/moderate
Assail (acetamiprid)	7	G	G	-	-	-	-	G	G	✓	-	low/moderate
Platinum (thiamethoxam)	30	G	G	-	-	-	-	G	G	-	-	low/moderate
Provado (imidacloprid)	0	-	G	-	-	-	-	G	G	-	-	low/moderate
Venom (dinotefuran)	1, 21	✓	✓	-	-	-	✓	✓	✓	✓	✓	low/moderate
<b>OTHER INSECT NERVE POISONS</b>												
Agri-Mek (abamectin)	7	-	G	-	-	-	-	-	-	-	-	low/moderate
Avaunt (indoxacarb)	3	-	-	-	✓	✓	-	-	-	-	-	low/moderate
Beleaf (flonicamid)	0	-	-	-	-	-	-	✓	-	-	-	-
Fulfill (pymetrozine)	0	-	-	-	-	-	-	G	F	-	-	low
Proclaim (emamectin benzoate)	7	-	-	-	✓	✓	-	-	-	-	-	low/moderate
Pyronyl, PyGanic (pyrethrins)	0	✓	G	-	-	G	✓	✓	✓	-	✓	moderate
Radiant (spinetoram)	1	-	✓	-	✓	✓	-	-	-	✓	-	-
SpinTor (spinosad)	1	-	G	-	✓	G	-	-	-	✓	-	low
Thionex (endosulfan)	2	G	F/G*	-	G	G	G	G	✓	(F)	-	moderate
<b>INSECT GROWTH REGULATORS</b>												
Confirm (tebufenozide)	7	-	-	-	-	G	-	-	-	-	-	low
Courier (buprofezin)	7	-	-	-	-	-	-	-	✓	-	-	low/moderate
Intrepid (methoxyfenozide)	1	-	-	-	✓	✓	-	-	-	-	-	low
Neemix, Aza-Direct (azadirachtin)	0	✓	G	✓	✓	G	-	-	✓	✓	-	low/moderate
Trigard (cyromazine)	0	-	-	-	-	-	-	-	-	-	-	low/moderate
<b>MISCELLANEOUS</b>												
Acramite (bifenazate)	3	-	-	-	-	-	-	-	-	-	-	low
<i>B. thuringiensis</i> (B.t. coleoptera strains; Novodor)	0	-	G	-	-	-	-	-	-	-	-	very low
<i>B. thuringiensis</i> (B.t. lepidoptera strains; DiPel)	0	-	-	✓	F	G	-	-	-	-	-	very low
cryolite (Kryocide)	14	✓	G	-	-	-	-	-	-	-	-	low
Kelthane (dicofol)	2	-	-	-	-	-	-	-	-	-	-	low/moderate
Oberon (spiromesifen)	7	-	-	-	-	-	-	-	✓	-	-	-
soap (M-Pede)	0	-	-	-	-	-	-	F	G	-	-	low
* some Ohio populations resistant.												
** most Ohio populations resistant.												

**Metaldehyde** (0 days-PHI)

For slugs.

Deadline MP (4B): 20-40 lb/A.

Prozap Snail and Slug AG (3.5B): 24-40 lb/A.

Metaldehyde 7.5G: 20 lb/A.

**Permethrin** (0 days-PHI)

For crickets, cutworms.

Ambush 0.5% Bait: 10-40 lb/A.

**• Foliar treatment**

Note: Use WP rather than EC formulations while tomato plants are setting young fruit to prevent possible spray injury.

Note: **Flea beetles** cause most injury to tomatoes when the young plants are becoming established in the field following transplanting. Treat plants in flats or beds before transplanting and repeat in field as necessary. If transplants have not been treated before setting out, treat the transplants as soon after setting out as possible.

Note: To prevent **grasshoppers** and **crickets** from damaging tomato fruits, treat the margins of tomato fields, roadsides, ditch banks, weed patches, and adjacent fields.

Note: For **Drosophila** fruit fly control by treating fruits in the field, make the first application when fresh, cracked fruits show fly eggs. Repeat at weekly intervals as necessary.

**Abamectin** (7 days-PHI)

For Colorado potato beetle, leafminers, spider mites, russet mite, pinworm.

Agri-Mek 0.15EC, Abba 0.15EC: 8-16 fl oz/A.

**Acetamiprid** (7 days-PHI)

For aphids, whiteflies, Colorado potato beetle, thrips, flea beetles.

Assail 30SG: 1.4-4.0 oz/A.

**Bacillus thuringiensis (B.t.)** (0 days-PHI)

For loopers, hornworms, armyworms.

Agree WG (3.8% a.i.): 0.5-2 lb/A.

Biobit HP WP (6.4% a.i.): 0.5-2 lb/A.

CryMax WDG (15% a.i.): 0.5-1.5 lb/A.

DiPel DF (10.3% a.i.): 0.25-1 lb/A.

Javelin WG (6.4% a.i.): 0.25-1 lb/A for loopers; 0.25-0.5 lb/A for hornworms.

Lepinox WDG (15% a.i.): 1-2 lb/A.

XenTari WDG (10.3% a.i.): 0.5-2 lb/A.

**Bacillus thuringiensis (B.t.)** (0 days-PHI)

For Colorado potato beetle **larvae**. Apply when 30% of eggs hatch or larvae are 1/4 inch or smaller.

Novodor FC (3% a.i.): 1-4 qt/A.

**Bifenazate** (3 days-PHI)

For spider mites.

Acramite 50WS: 0.75-1.0 lb/A. Limit one spray per season.

**Bifenthrin** (1 day-PHI)

For aphids, caterpillars, flea beetles, grasshoppers, stink bugs.

Limit 4 applications per season.

Capture 2EC, Discipline 2EC, Fanfare 2EC, Sniper 2EC, Tundra 2EC: 2.1-5.2 fl oz/A.

Brigade 10WSB: 5.3-12.8 oz/A.

**Bifenthrin + zeta-cypermethrin** (1 day-PHI)

For hornworms, tomato fruitworm, fall armyworm, beet armyworm, cabbage looper, stink bugs, flea beetles, Colorado potato beetle, grasshoppers, whiteflies.

Hero 1.24EC: 4-10.3 fl oz/A.

**Buprofezin** (7 days-PHI)

For whiteflies.

Courier 0.7EC: 6-9 oz/A.

**Carbaryl** (3 days-PHI)

For flea beetles, Colorado potato beetle, fruitworm, hornworms, cutworms.

Carbaryl 4L; Sevin XLR Plus (4EC); Sevin 4F: 0.5-1 qt/A for flea beetles, leafhoppers; 2 qt/A for cutworms; 1-2 qt/A for other pests.

Sevin 80S: 1.25 lb/A for flea beetles, leafhoppers; 2.5 lb/A for cutworms; 1.75 lb/A for other pests.

Carbaryl 50WP; Sevin 50WP: 2 lb/A for beetles; 3 lb/A for fruitworm, hornworm; 4 lb/A for cutworms.

Carbaryl 90DF: 0.62-1.12 lb/A for beetles; 1.12-2.25 lb/A for fruitworm, hornworm.

**Cryolite** (14 days-PHI)

For flea beetles, loopers, hornworms, fruitworm, Colorado potato beetle larvae.

Kryocide (96% a.i.): 8-16 lb/A.

Prokil Cryolite 96 (96% a.i.): 10-16 lb/A. Not for cherry tomatoes.

**Cyfluthrin** (0 days-PHI)

For variegated cutworm and other caterpillars, Colorado potato beetle, potato aphid, stink bugs, thrips.

Baythroid 2EC, Baythroid XL (1EC): 1.6-2.8 fl oz/A. Limit 16.8 fl oz/A per year.

**Cyromazine** (0 days-PHI)

For leafminers.

Trigard 75WP: 1/6 lb/A. Limit 6 applications.

**Deltamethrin** (1 day-PHI)

Decis 1.5EC, Delta Gold 1.5EC: 1.0-2.4 fl oz/A for leafhoppers, hornworms. 1.5-2.4 fl oz/A for Colorado potato beetle, cutworms, flea beetles, stink bugs, thrips, tomato fruitworm, tomato pinworm, variegated cutworm.

**Diazinon** (1 day-PHI)

For aphids, Drosophila fruit flies.

Diazinon AG500 (4EC): 0.5 pt/A for aphids; 0.5-1.5 pt/A for Drosophila.

Diazinon 50WP: 0.5 lb/A for aphids; 0.5-1.5 lb/A for Drosophila.

**Dicofol** (2 days-PHI)

For mites.

Dicofol 4EC: 0.75-1.5 pt/A.

Kelthane MF (4EC): 0.75-1.5 pt/A.

**Dimethoate** (7 days-PHI)

For aphids, leafminers.

Dimethoate 400, Dimate 4EC: 0.5-1 pt/A.

Dimethoate 267EC (2.67EC): 0.75-1.5 pt/A.

**Dinotefuran** (1 day-PHI)

For aphids (suppression), whiteflies, thrips, flea beetles, Colorado potato beetle, stink bug, grasshoppers.

Venom 70SG: 1-4 oz/A. Limit 6 oz/A per season.

**Emamectin benzoate** (7 days-PHI)

For beet armyworm, fall armyworm, looper, hornworm, pinworm, fruitworm.

Proclaim (5WDG): 2.4-4.8 oz/A. Limit 28.8 oz/A per year.

**Endosulfan** (2 days-PHI)

For flea beetles, Colorado potato beetle, aphids, thrips, cabbage looper, stink bugs.

Limit 6 applications (4 qt)/A per year.

Thionex 3EC; Endosulfan 3EC: 0.67-1.33 qt/A.

Thionex 50WP: 1-2 lb/A.

**Esfenvalerate** (1 day-PHI)

For hornworms, flea beetles, Colorado potato beetle, tomato fruitworm (corn earworm), whitefly, grasshoppers, crickets, leafminers.

Asana XL 0.66EC, Adjourn 0.66EC: 2.9-5.8 fl.oz/A for hornworms; 5.8-9.6 fl oz/A for beetles, fruitworm, whitefly, grasshoppers, crickets; 9.6 fl oz/A for leafminers.

**Fenpropathrin** (3 days-PHI if alone, 7 days-PHI if tank mixed with Monitor)

For fruitworm, hornworms, spider mites, stink bug.

Danitol 2.4EC: 10.7 fl oz/A. Limit 42.7 fl oz/A per season.

For thrips, potato aphid, fruitworms, pinworm; tank mix Danitol 2.4EC (10.7 fl oz/A) + Monitor 4EC (24-32 fl oz/A).

Note: Monitor is for use on fresh-market tomatoes only.

**Flonicamid** (0 days-PHI)

For aphids.

Beleaf 50SG: 1.2-2.8 oz/A. Limit 3 applications per year.

**Gamma-cyhalothrin** (5 days-PHI)

For caterpillars, flea beetles, Colorado potato beetle, stink bug, thrips; suppression of aphids, whiteflies.

Proaxis (0.5EC): 1.92-3.84 fl oz/A.

**Imidacloprid** (0 days-PHI)

For aphids, whiteflies, Colorado potato beetle.

Provado 1.6F, Pasada 1.6F: 3.75 fl oz/A. Limit 18.75 fl oz/A per year. Note: Do not apply Provado if Admire used at planting or as sidedress.

**Indoxacarb** (3 days-PHI)

For hornworms, loopers, tomato fruitworm.

Avaunt 30WG: 2.5-3.5 oz/A.

**Lambda-cyhalothrin** (5 days-PHI)

For cutworms, hornworms, other caterpillars, stink bugs, Colorado potato beetle, grasshoppers.

Warrior 1EC, Silencer 1EC, Taiga Z 1CS: 1.92-3.84 fl oz/A. Limit 2.88 pt/A per season.

**Malathion** (1 day-PHI)

For aphids, mites, Drosophila fruit flies.

Malathion 5EC, 57EC: 1-3 pt/A for aphids, mites; 2.5-3 pt/A for Drosophila.

Malathion 8EC: 1.5 pt/A for aphids, mites; 2 pt/A for Drosophila.

**Methamidophos** (7 days-PHI)

See Ohio 24c label; for use on fresh-market tomatoes only.

For Colorado potato beetle, cabbage looper, black and variegated cutworms, aphids, hornworms, fruitworm, thrips.

Monitor 4L: 1.5-2 pt/A. Limit 10 pt/A per season.

**Methomyl** (1 day-PHI)

For variegated cutworm, loopers, tomato fruitworm, hornworms, aphids.

Limit 16 applications/crop.

Lannate 90SP: 0.5 lb/A for cutworm; 0.5-1 lb/A for other pests.

Lannate LV (2.4WSL): 1.5 pt/A for cutworm; 1.5-3 pt/A for other pests.

**Methoxyfenozide** (1 day-PHI)

For fall armyworm, beet armyworm, fruitworm, hornworm.

Intrepid 2F: 4-16 fl oz/A.

**Oxamyl** (3 days-PHI)

For leafminers, Colorado potato beetle, aphids.

Vydate L (2SL): 2-4 pt/A. Limit 6 gal/A per season.

**Permethrin** (0 days-PHI)

For looper, Colorado potato beetle, hornworms, fruitworm, pinworm.

Do not apply to cherry tomatoes.

Pounce 3.2EC, Arctic 3.2EC, Permethrin 3.2EC: 2-8 oz/A. Limit 48 oz/A per year.

Pounce 25WP, Ambush 25WP: 3.2-12.8 oz/A.

**Pymetrozine** (0 days-PHI)

For aphid control and whitefly suppression.

Fulfill 50WDG: 2.75 oz/A. Limit 5.5 oz/A per season.

**Pyriproxyfen** (14 days-PHI)

For whiteflies.

Esteem 35WP: 2.5-3 oz/A. Limit 2 applications or 6 oz/A per season.

**Soap** (0 days-PHI)

For aphids, whiteflies.

M-Pede: 1 gal/A in 50 gal water per acre. Do not apply if temperature is above 90°F or if plants are under stress.

**Spinetoram** (1 day-PHI)

For tomato fruitworm, pinworm, hornworms, Colorado potato beetle, thrips.

Radiant 1SC: 5-10 fl oz/A. Limit 6 applications per year.

**Spinosad** (1 day-PHI)

For Colorado potato beetle larvae, hornworms, loopers, fruitworm, armyworms, thrips, pinworm, European corn borer.

SpinTor 2SC: 2.25-8 oz/A. Limit 29 oz/A/year.

Entrust (80WP): 0.5-2.5 oz/A.

**Spiromesifen** (7 days-PHI)

For two-spotted spider mite, whiteflies, psyllid.

Oberon 2SC: 7.0-8.5 fl oz/A. Limit 3 applications per crop season.

**Tebufenozide** (7 days-PHI)

For hornworms, cabbage looper, black cutworm, corn borer, fall armyworm.

Confirm 2F: 6-8 oz/A for small plants; 8-16 oz/A for larger plants and heavy infestation. Limit 64 fl oz/A per year.

**Thiamethoxam** (0 days-PHI)

For beetles, aphids, stink bugs, whiteflies.

Actara 25WDG: 2-3 oz/A for flea beetles, Colorado potato beetle, aphids; 3-3.5 oz/A for whiteflies, stink bugs. Limit 11 oz/A per season.

**Zeta-cypermethrin** (1 day-PHI)

For beetles, caterpillars, stink bugs, grasshoppers.

Mustang 1.5EW: 2.4-4.3 fl oz/A.

Mustang Max (0.8EC): 2.24-4.0 fl oz/A.

## • Treating fruits in bulk containers

Note: Handle fruits carefully to avoid cracking; most *Drosophila* eggs are deposited in fresh cracks that result from improper handling of the tomatoes during the picking, loading, and transporting operations. Picked tomatoes should not be allowed to remain in the field overnight because most eggs are laid in evening and early morning hours.

Note: For control of *Drosophila* fruit flies in the field before harvest, see listings for Azinphos-methyl, Diazinon, and Malathion.

**Pyrethrum/Pyrethrins** (0 days-PHI)

For *Drosophila* fruit flies.

Synergized pyrethrum 0.1%: Dust the fruits when containers are half full and again when full.

Pyrenone (6% a.i.): 1 pt per 150 gal water.

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# Weed Control

## Preplant Incorporated Transplanted Tomatoes

**Dual Magnum:** To control annual grasses, and eastern black nightshade prior to emergence. Apply Dual Magnum at 1 to 1.33 pt/A on coarse soils if soil organic matter is less than 3% or 2 pt/A if organic matter is 3% or greater. On medium soils apply 1.33 to 1.67 pt/A and on fine soils apply 1.33 to 1.67 pt/A if soil organic matter is less than 3% or 1.67 to 2 pt/A if organic matter is 3% or greater. Transplant with minimum soil disturbance. Observe all precautions upon the label.

**Trifluralin:** Controls germinating annual grasses and certain broadleaf weeds.

**Tri-4 HF, Riverside Trifluralin 4EC, Albaugh Trifluralin 4EC, Gowan Trifluralin 4EC, Treflan HFP, Trilin 4EC:** 1-2 pt/A.

**Gowan Trifluralin 5EC, Trilin 5EC:** 0.8-1.6 pt/A.

**Trific 60DF:** 0.875-1.66 lb/A.

**Treflan TR-10, Trilin 10G, Wilbur-Ellis Trifluralin 10G, Gowan Trifluralin 10G:** 5-10 lb/A.

**Tillam 6E:** Controls germinating annual grasses and broadleaf weeds and suppresses yellow nutsedge. Apply 2.6-4.0 qt/A Tillam 6 E preplant incorporated 2-3 inches deep.

**Devrinol 50 WP:** Controls germinating annual grasses and broadleaf weeds. Apply 2-4 lb/A Devrinol 50 WP preplant incorporated not more than 1 inch deep.

**Sencor 4:** Apply 0.5-1.0 pt/A. Controls germinating annual broadleaf weeds. Apply before transplanting and incorporate 2-3 inches into the soil. Usually used in combination with trifluralin, pebulate, or napropamide to improve preemergence broadleaf control.

## Direct-seeded Tomatoes

**Devrinol 50 WP:** Controls germinating annual grasses and certain broadleaf weeds. Apply 2-4 lb/A Devrinol 50 WP preplant incorporated not more than 1 inch deep. Sencor or Lexone and Tillam granules can be used as directed on label.

## Preplant

**Sandea:** After bed forming but before laying plastic mulch apply 0.5-1.0 oz/A. Tomatoes may be transplanted 7 days after application and laying of plastic. Do not apply Sandea over-the-top of plastic. Two applications per season are permitted; for instance a Preplant could be followed by a Postemergence row middle application. No more than 2 oz/A/season is permitted (30 days-PHI).

## Preemergence Transplanted Tomatoes

**Dual Magnum:** To control eastern black nightshade prior to emergence. Apply Dual Magnum as a preplant to the soil before transplanting at 1 to 1.33 pt/A on coarse soils if soil organic matter is less than 3% or 2 pt/A if organic matter is 3% or greater. On medium soils apply 1.33 to 1.67 pt/A and on fine soils apply 1.33 to 1.67 pt/A if soil organic matter is less than 3% or 1.67 to 2 pt/A if organic matter is 3% or greater. Transplant with minimum soil disturbance. Observe all precautions upon the label.



# Postemergence Transplanted Tomatoes

**Dual Magnum:** To control annual grasses, and eastern black nightshade prior to emergence. Apply Dual Magnum post-directed, post-over-the-top or between rows of plastic mulch. Apply 1 to 1.33 pt/A on coarse soils if soil organic matter is less than 3% or 2 pt/A if organic matter is 3% or greater. On medium soils apply 1.33 to 1.67 pt/A and on fine soils apply 1.33 to 1.67 pt/A if soil organic matter is less than 3% or 1.67 to 2 pt/A if organic matter is 3% or greater. Observe all precautions upon the label.

**Matrix:** Apply Matrix at 1 oz/A tank-mixed with Sencor 75DF at 2 oz/A to young (less than 1 inch tall), actively growing weeds. Always add a non-ionic surfactant to the tank at 2 pt/100 gal. Delay application until the tomato crop has reached the true two-leaf stage and has been acclimated in the field for 1-3 days. Controls certain grasses and broadleaf weeds in tomatoes. Temporary chlorosis may occur under environmental conditions that promote crop stress. Symptoms usually disappear within 5 to 15 days. Cultivation no sooner than 7 days after Matrix application to augment weed control. Can be tank-mixed with 1 oz/A of Sencor 75DF. Matrix has a 45 day PHI.

**Sandea:** Application should be delayed until 14 days after transplanting. Apply 0.5-1.0 oz/A over-the-top, or as a directed spray to weeds under the crop canopy or growing between rows of plastic mulch. Do not spray plastic with Sandea. For emerged weeds include nonionic surfactant at 1-2 quarts/100 g of spray mix. Processing tomato varieties vary in sensitivity to Sandea. Expect short-lived chlorosis. Research in Ohio and other states has not detected yield reduction when chlorosis occurred following Sandea application. Two applications per season are permitted, totaling not more than 2 oz/A/season (30 days-PHI).

## Seeded or Transplanted Tomatoes

**Metribuzin:** Controls germinating and emerged annual broadleaf weeds up to 1 inch tall. Apply postemergence as a directed spray after tomato seedlings have five or six true leaves or after transplants are well established. Varietal response can be critical. Cloudy weather immediately preceding application may result in injury to tomato plants. May be mixed with Treflan and applied preplant incorporated with transplants only.

**Sencor 4:** 0.5-1.0 pt/A.

**Lexone 75DF or Sencor 75DF:** 0.33-0.67 lb/A.

**Poast:** For postemergent control of annual and perennial grasses. Apply 1-1.5 pt/A Poast (20 days-PHI). Do not exceed 4.5 pt/A/season. Add 1 qt/A nonphytotoxic oil concentrate. Rate is dependent on grass species and stage of development.

**Select:** Controls emerged annual and perennial grasses. Apply 0.5-1.0 pt/A (20 days-PHI). Do not exceed 32 fl oz/A/season. Add a crop oil concentrate at 1% on a volume basis (v/v).

## Directed/Shielded Application

**Gramoxone Extra:** Controls emerged annual weeds and top growth of perennial weeds. Apply 1.5 pt/A Gramoxone Extra. For control or suppression of emerged weeds between rows after crop establishment. Prevent contact with crop otherwise crop injury will result. See the label for specific precautions.