Crop Profile for Tomatoes in Michigan

General Production Information

- California produces 98% of processing tomatoes in the U.S.A.(2)
- Florida and California are the top producers of fresh market tomatoes(2)
- In Michigan tomatoes are produced for fresh market and processing
- Michigan ranks 10th in the country in fresh tomato production(6)
- Michigan ranks 4th in the country in processing tomato production (6)
- Production of processing tomatoes is down sharply from last year, according to the Federal/State Michigan Agricultural Statistics Service. The 47 percent drop in production is a result of fewer processing companies.(6)
- Processing tomato production is forecast at 66,000 tons, down 47 percent. The projected yield of 30 tons per acre is 2.5 tons per acre less than last year.(6)
- Processors contracted 2,200 acres of tomatoes this year, down 42 percent from 1997.(6)
- Tomatoes for processing are produced in:
  South Central District, St. Joseph county
  Southeast District, Monroe and Lenawee counties
- Tomatoes for fresh market are produced in:
  East Central District, Bay county
  Southwest District, Berrien county
  South Central District(6)

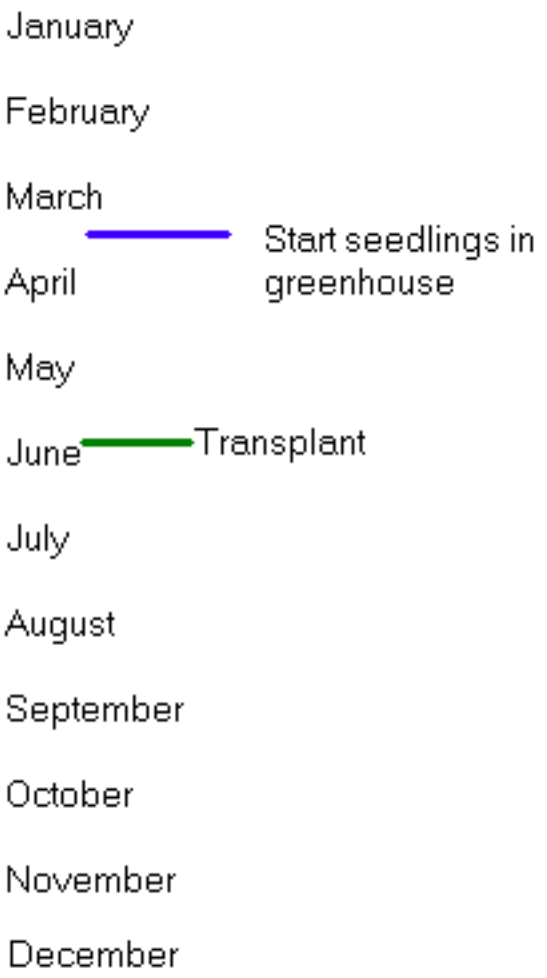
	Tomato (Processed)	Tomato (Fresh)
Michigan Ranking	4	10
Percent of U.S. Production	1.3	1.4
Area Planted (5 year average)(ac)	5,300	2,650
Area Harvested (5 year avg.)(ac)	5,100	2,450
Value of Production (thousands) (5 year average)($)	11,054	11,385
Production (thousands)	143	432

	Counties	District	Acres Planted	Yield (lb/acre) / district	Production/District
Fresh Market tomatoes (from 1995-96 MASS, MRS statistics)	Bay	East Central	95	20,000	2,600
	Berrien	Southwest	1,050	15,000	24,000
	all	Southcentral	120	14,000	1,550
	Macomb	Southeast	110	13,000	6,250
	Monroe	Southeast	180		
Tomates processing	St. Joseph	South Central	1200	63,000	107,000
	Lenawee	Southeast	1600	58,000	163,000
	Monroe	Southeast	1300		

Cultural Practices

Tomatoes are a warm-season crop. They develop best in temperatures between 70 and 75° F. They are damaged by frost if left unprotected. Tomatoes are grown both in greenhouses and in fields. Fresh market tomatoes are transplanted into the field and either staked or caged.(23) Processing tomatoes are grown without the use of supports. Transplants are usually started 6 to 10 weeks before planting, which generally occurs at the middle of May. Warm soil speeds tomato growth and increases production. Tomatoes require a regular water supply to avoid damage. Tomatoes are used in crop rotation practice.

Fresh market tomatoes are harvested by hand, up to 10 times at 2-3 day intervals during the "breaker" stage, an early stage of ripeness when fruit shows some red color.(23) Tomatoes harvested for processing are harvested by machine. harvesting can begin in July and peaks in August. Fungicides are used as protectants, applied early and frequently.



Chemical Controls: Critical Use Issues

- Over 9% of the yield nation-wide would be lost with the removal of Chlorothalonil in fresh market tomatoes and 4% in processing tomatoes even when alternatives are used. The loss of use of Chlorothalonil would devastate fresh market tomato production in Michigan.
- The estimated yield loss associated with the loss of trifluralin for use in fresh market tomatoes would be approximately 1.2% and 3.5% in processing tomatoes
- Loss of sethoxydim would cause an estimated 15% loss in fresh market tomatoes in Michigan
- The estimated yield loss associated with the loss of pebulate for use in processing tomatoes would be approximately 16.9%.
- The loss of ethephon would have a significant impact in Michigan, estimated 18% yield loss.
- The loss of use of metribuzin would devastate fresh market tomato production in Michigan.
- For all bacterial diseases resistance to copper is a primary concern (24)
- It is estimated that a loss of all fungicides would cause a 44% loss in yield for processing tomatoes. Fungicides are used on 90% of the fresh market and 92% of the processing tomatoes grown in Michigan.
- Nationwide loss of 6% fresh-market production is estimated from a loss of the use of copper

compounds. The loss of use of copper would devastate fresh market tomato production in Michigan.

- The loss of Methyl bromide is estimated to cost over 800 million pounds of tomatoes.

Insect Pests

Colorado Potato Beetle (*Leptinotarsa decemlineata*)

Biology:
Colorado potato beetles are important pests in tomato crops, causing defoliation and crop loss. Colorado potato beetles overwinter in soil in fields and field borders. They emerge in the spring and begin feeding on tomatoes, mating and laying bright orange eggs. Nightshade and horsenettle are also hosts. Larvae also feed on foliage and sometimes injure tomato fruit. They may have from 1 to 3 generations per year in Michigan, depending on the length of the season. In mid-August, most egg laying ceases and adults begin to enter the soil for overwintering.(21)

Colorado potato beetles can cause 75% crop loss (quantity). They are more of a problem when it is hot and dry early in the season and when tomatoes are grown in one field without rotation. A field loss of only 25% can cause output to fall below input costs.(10)

Cultural Controls:
Crop rotation and **management of weed** hosts are important in reducing Colorado potato beetle populations and the need for insecticide treatment. Rotations are not always effective, since the Colorado potato beetles move from field to field. Tomatoes planted in or near fields previously planted with solanaceous crops may be heavily infested.

Chemical Controls:

- Azinphos-methyl – Guthion Solupak 50 WP, 3/4 lb or 2L (RUP), 1 ½ pt (0 days).
- Provado 1.6 R, 3 ¾ fl oz (0 days)
- Agrimek 0.15 EC, 8fl oz (7days)
- Asana XL, 5.8 to 9.6 oz (1 day)
- *Bacillus thuringiensis tenebrionis*
- Novodor FC, 1 to 4 qts (0 days).
- Baythroid 2, 1.6 to 2.8 fl oz (0 days)
- Carbaryl (Sevin) 80 S, 1 ¼ to 2 ½ lb or XLR B, Plus, l to 2 qt (3 days).
- Cryolite (Kryocide) 96 W, 18 to 15 lb. (14 days).
- Endosulfan (Phaser, Thiodan) 3 EC, 2/3 qt 50 WP, 1 lb (2 days).
- Penacap-M 2 F, 4 pt (15 days)
- SpinTor 2SC, 2.25 to 4.5 oz (1 day)
- **Warrior 1 E**, 2.6 to 3.8 fl oz (5 days)

Alternative Controls
The Colorado potato beetle has become extremely resistant to insecticides in many parts of Michigan. Methomyl and Naled are used as alternative chemical controls.

- Methomyl
- Naled

Predators such as stink bugs and egg endoparasitic wasps have been suggested for control of Colorado potato beetle

Tomato Looper (*Trichoplusia ni*)

Biology
Tomato loopers can be a serious late season pest of cole crops in Michigan. Loopers bore holes in fruit, causing up to 100% crop loss. They do not overwinter in Michigan, but migrate into the state during July and August. The adults are about 1 to 1 ¼ inches across, gray-brown, and fly and lay eggs mostly at night. The larvae are light green, with a white stripe on each side, about 1 inch long, and move by humping their back like an inch-worm (from which their get their name "looper"). There may be 2 or 3 generations per year. As the larvae grow, they become more difficult to control. They cause foliar injury and can be a contaminant at harvest for cole crops. Plant damage and product contamination are similar to that of imported cabbage worm.

Hosts of the cabbage looper include cole crops, celery, tomatoes and potatoes. Eggs are laid singly on the underside of the foliage.

Monitor fields regularly for eggs, larvae, and damage. Apply insecticides as needed for control. Tomato

loopers are much more tolerant of insecticides than imported cabbage worms. Identification must be certain, as higher rates or more toxic materials are used on loopers.

Buyers will refuse an entire load if a single looper is found. Even a 25% field loss will cause grower's output to fall below input.

Cultural Controls
No information available

Chemical Controls

- Methomyl – Lannate SP, 1/2 to 1 lb or EV, 1 1/2 to 3 pt (1 day)
- Esfenvalerate – Asana XL, 5.8 to 9.6 oz (1 day)
- Warrior 1 E, 1.9 to 3.2 fl oz (5 days)
- *Bacillus thuringiensis*: Agree, Biobit. Condor. Cutlass, Dipel, Javelin. MVP n or Mattch (O days)
- Baythroid 2, 2.1 to 2.8 fl oz (0 days)
- Endosulfan (Phaser, Thiodan) 3 EC, 2/3 qt or 50 WP, 1 lb (2 days)
- SpinTor 2 SC, 3 to 6 oz (1 day)

Alternative Controls

- Imidacloprid
- Oxamyl
- Sulfur and Chlorothalonil
- Azinphos-methyl

Loopers can be monitored visually, and adults can be monitored with pheromone (sex attractant) lures and traps. Carefully timed use of Bt is suggested, along with mass releases of parasites such as *Trichogramma* wasps.

Fruit Flies

Biology
Fruit flies are important pests in tomato production in Michigan. They damage fruit and can cause 50% loss in crop. Even 25% field loss will cause grower's output to fall below their input costs, and damage business prospects.

Fruit flies may be a more severe problem on certain varieties during harvest season. Eggs are laid in cracks of ripening fruit.

Cultural Controls
No information available

Chemical Controls

- **Diazinon 500-AG**, 1 pt or 50 WP, 1 lb (1 day)
- **Azinphos-methyl** – Guthion Solupak 50 WP, 3/4 lb or 2L 2 pt (0 days).
- **Malathion 57 EC**, 2 1/2 pt (1 day).
- **Naled**

Alternative Controls

- Methomyl

Aphids

Biology
Potato aphids are a key pest of tomatoes in Michigan. They are small (1/8 inch), and green or pink colored. Aphids cause damage by sucking plant juices and excreting a sticky honeydew that may reduce product quality. Aphids dwarf and weaken plants. Aphids can also carry viruses. They are not a problem at lower temperatures. They can cause complete crop loss, but as little as 25% field loss will cause growers' output to fall below input. When tomatoes are planted in overlapping early, mid and late season crops, they can be a problem throughout the growing season.

Aphids overwinter as eggs on a variety of crops and weeds. The eggs hatch in the spring. After one or more generations on the overwintering host, winged aphids develop and migrate to a variety of other hosts, including vegetable crops. Winged forms appear throughout the season, especially when the host plant is dying or aphids are becoming crowded. Each aphid can give birth to 50 to 100 young. The mother does not lay eggs, but gives birth to baby aphids. All of these babies are female. There may be 5 – 10 generations per year. In the fall, a generation with winged males and females is produced. These migrate back to overwintering hosts, mate and lay eggs.

Cultural Controls
Aphids are usually held in check by natural enemies such as lady beetles, hover fly larvae, lacewing larvae, tiny wasps and fungal diseases. Unfortunately, insecticide or fungicide sprays can disrupt this natural control and result in aphid outbreaks.

Chemical Controls

- Baythroid 2, 1.6 to 2.8 fl oz (0 days)

- Diazinon 500-AG, 1/2 pt or 50 WP, 1/2 lb (1 day)
- Dimethoate 4 EC, 1 pt (7 days).
- Di-Syston 8 E, 1 to 3 pt (30 days)
- Endosulfan (Phaser, Thiodan) 3 EC, 2/3 qt or 50 WP, 1 lb (2 days)
- Lannate SP, 1/2 to 1 lb or LV, 1 1/2 to 3 pt (1 day)
- Provado 1.6 F, 3 3/4 fl oz (0 days)

Alternative Chemical Controls

- Methamdophos

Hornworms

Biology
Hornworms are a key pest in Michigan, they can rapidly defoliate tomatoes. They feed on tomato fruit, boring holes in the fruit. Hornworms can cause 100% crop loss by making fruit unmarketable. A 25% field loss will cause the growers' output to fall below input costs. Hornworms are reported as problem in the Southwest region.

Hornworms overwinter as pupae in the soil and emerge as adult hawk moths in May or June. Eggs are light green and laid singly on the underside of foliage. Larvae feed for 3 to 4 weeks before entering the soil to pupate. There may be 2-3 generations per year in Michigan. Hornworms are well camouflaged and difficult to see on plants. They are easily controlled by insecticides.

Cultural Controls
No information available

Chemical Controls

- Methomyl
- Esfenvalerate

- Asana XL. 2.9 to 5.8 oz (1 day)
- Azinphos-methyl
- Guthion Solupak 50 WP, 1½ to 3 1b or 2L, 3 to 6 pt (14 days).
- *Bacillus thuringiensis* Agree, Biobit. Condor, Cutlass, Dipel, Javelin, MVP II, or Mattch (0 days).
- Baythroid 2, 1.6 to 2.8 fl oz (0 days)
- Carbaryl (Sevin) 80 S, 1 1/4 to 2 1/2 lb or XLR Plus, 1 to 2 qt (3 days).
- Endosulfan (Phaser, Thiodan) 3 EC. 2/3 qt or | 50 WP, 1 lb (2 days).
- Penacap-M2 F, 4 pt (15 days)
- Warrior 1 E, 1.9 to 3.2 fl oz (5 days)
- Imidacloprid
- Oxamyl
- Sulfur and Chlorothalonil

Alternative Controls

Hornworms are commonly attacked by wasp parasitoids and the white wasp cocoons are often seen on the larvae. Parasitized hornworms do not survive to become adults but continue to feed during the larval stage. Parasitoid releases have been used to control hornworms.

Cutworms

Black cutworm (1) left, above: larva; (2) left, below: pupae; (3) right: adult

Biology

Cutworms may overwinter as ½ - 1-inch long larvae or as eggs in the soil. They often cut plants off at the soil surface. Cutworms may be most abundant in weedy areas of a field or adjacent to cover crop strips after the cover crops are killed or tilled down. They pupate in the soil and adult moths emerge in June or July. They may have from 1 – 3 generations per year, but typical cutworm injury occurs only early in the season when plants are small.

Cultural Controls

New transplants should be checked regularly during the first few days after transplanting.

Chemical Controls

- Baythroid 2, 1.6 to 2.8 fl oz (0 days)

Alternative Controls
Entomophagous nematodes have been suggested for control of cutworms.

Flea Beetles

Biology
Flea beetles are very small, 1/16-1/8 inch, and chew small hoes in foliage. They can severely injure transplants and blemish fruit. Flea beetles have large hind legs and jump when disturbed. Adults overwinter in the soil and emerge early in the spring to feed and lay eggs. Larvae feed on plant roots but do not cause significant damage on tomatoes. Flea beetles can cause crop loss of 20% and are generally more of a problem on fresh market tomatoes.

Cultural Controls
No information available

Chemical Controls

- Naled
- Methomyl

Alternative Controls

- Pathogen – *Heterorhabditis bacteriophora*

Tomato Fruitworms (*Heliocoverpa zea*)

Tomato fruitworm adult

Biology

Tomato fruitworms are also called corn earworms. They do not overwinter in Michigan. The moths migrate from the south as early as June or as late as September. Larva may feed on fruits.

Cultural Controls
No information available

Chemical Controls

- Asana XL, 5.8 to 9.6 oz (1 day)
- Warrior 1 E, 2.6 to 3.8 fl oz (5 days)
- Baythroid 2, 1.6 to 2.8 fl oz (0 days)
- Carbaryl (Sevin) 80 S, 1 1/4 to 2 1/2 lb or XLR Plus, 1 to 2 qt (3 days)
- Endosulfan (Phaser, Thiodan) 3 EC, 2/3 qt or 50 WF', 1 lb. (2 days)
- Guthion Solupak 50 WP, 1 1/2 to 3 lb or 2L, 3 to 6 pt (14 days)
- Lannate SP, 1/2 to 1 lb or LV, 1 1/2 to 3 pt (1 day)
- Penncap-M 2 F, 4 pt (15 days)
- SpinTor 2 SC. 3 to 6 oz, (1 day)

Alternative Controls
Tomato fruitworm moths can be monitored using pheromone lures and traps. Parasitoid releases have been used to control tomato fruitworms.

Insecticide Profiles

Insecticides are used on 80% of the fresh market and 60% of the processing tomatoes grown in Michigan.

Naled (organophosphate)

Formulations: Dibrom
Pests Controlled: fruit flies, flea beetle, mites and Colorado potato beetle
Percent of Crop Treated: used by 1% of the growers in Michigan on 100% of their acreage
Types of Applications: emulsive, boom spray or ground spray
Application Rates: 1 pt for one application
Number of Applications: no information available
Timing: in response to scouting, it applied after transplant in the early spring for flea beetles and at harvest for fruit flies
Pre-Harvest Interval: 1-50 days
REI: 48-72 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: good
Advantages: Fast knockdown, broadspectrum, short residual effects (25)
Disadvantages: cannot use at temperatures over 90°F (25)
Alternatives:

Methomyl (Lannate SP) (carbamate) (REI 48 hours) (PHI 1) has moderate efficacy. (2)(3)(7)(10)(11)(13)

Azinphos-methyl (organophosphate)

Formulations: Guthion Solupak
Pests Controlled: Colorado potato beetle and white fly
Percent of Crop Treated: used by 38% of the growers in Michigan, on 100% of their acreage Guthion is used by 75% of the growers in Southwest and 1% in the Southeast, although some years 100% of the growers in Southeast must apply it.
Types of Applications: ground spray or over the row with a boom spray
Application Rates: (suggested) 1 to 1 1/2 lb or 2 L (3)
Number of Applications: no more than 3 per year(3)
Timing: Timing of application is critical for control since applications are effective on small larvae. It is applied two to three weeks after transplanting as a ground spray or over the row with a boom spray
Pre-Harvest Interval: 70-80 days
REI: 48 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Advantages: wide spectrum insecticide
Disadvantages: Increasing resistance is being reported, it is potentially dangerous to beneficial insects
Efficacy Issues: no information available
Comments: Tomatoes for processing require fewer applications although fresh-market tomatoes

have higher value. In the Southeast Region Guthion is usually applied along with fungicides.
Alternatives to Azinphos-methyl include:

Methomyl (Lannate)(carbamate), some resistance has been reported
Imidacloprid (Provado) (REI 12 hours) is highly effective, but expensive. Fewer treatments are required. If aphids are present, growers usually use another chemical because of concerns over resistance. Colorado potato beetle is less resistant to Provado than to Lannate.
Esfenvalerate (Asana) (pyrethroid) is moderately effective alternative for control of Colorado potato beetle reported by growers in Southwest Region. It is more expensive than other alternatives, although fewer treatments are needed. Esfenvalerate is also useful in controlling white fly. It suppresses the beneficial predators of mites causing increases in the mite populations. The loss of esfenvalerate on tomatoes is estimated to cause an 8% loss of fresh market tomatoes.
(2)(3)(7)(10)(11)(13)

Dimethoate (organophosphate)

Formulations: Cygon, Dimethoate 4EC
Pests Controlled: aphids and leaf hoppers
Percent of Crop Treated: 50% of the growers used Dimethoate on 100% of their acreage
Types of Applications: foliar treatment
Application Rates: 6 oz AI as part of a program, 8 oz AI if scouted.
Number of Applications: no information available
Timing: applied during fruit setting either in response to scouting or as part of a treatment program
Pre-Harvest Interval: 7 days
REI: 48 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: Dimethoate is used with thiodan as part of a treatment program.
Efficacy Issues: good
Advantages:does not accumulate in soil, compatible with non-alkaline reaction pesticides (25)
Disadvantages: some phytotoxicity reported (25)
Comments: Leafhoppers come with weather fronts and treatment can be accordingly.
Alternatives:

Endosulphan (Thiodan) (chlorinated hydrocarbon) (REI 24 hours) is moderately effective against aphids, leafhoppers and cutworms
Methamidophos (Monitor) is moderately effective aphids, leafhoppers and cutworms, it is not made any more.
Imadacloprid (Provado) (REI 12 hours) is highly effective, but expensive.

(2)(3)(7)(10)(11)(13)

Metholmyl (carbamate)

Formulations: Lannate SP, Lannate LV
Pests Controlled: looper, Colorado potato beetle, hornworm and corn borer
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates: Growers in the Southeast Region apply 0.5 to 1.0 qts
Number of Applications: 4 to 6 applications a year when insects are present
Timing: In the southwest application is weather related, applied from fruitset throughout the season in the Southwest region
Pre-Harvest Interval: 1 to 50 days
REI: 48 hours
Use in IPM Programs: use is determined by scouting
Use in Resistance Management Programs: Some resistance has been reported in the Southeast region. In the Southeast region Methomyl is used as part of a treatment program that includes Provado and Guthion.
Efficacy Issues: no information available
Advantages: compatible with other pesticides, rapid knockdown (25)
Disadvantages: Due to product volatility, worker safety is a concern.
Comments: Due to higher market value of fresh-market tomatoes Methomyl is more frequently applied to fresh-market than processing tomatoes. Methomyl can be used with fungicides when there is a potential for disease problems.
Alternatives

Sulfur and Chlorothalonil are less of a resistance problem, reported as an alternative in the Southeast Region
Oxamyl (Vydate) (carbamate) (REI 48 hours) is reported as an alternative in the Southwest Region, used as part of a treatment program with Lannate
Imadacloprid (Provado) is reported as an alternative by growers in the Southeast Region
Esfenvalerate (Asana) (pyrethroid) (REI 12 hours) is highly effective, but expensive, some resistance is developing. It is reported as an alternative in the southwest region. Most growers probably use this instead of Lannate because it is a liquid rather than a powder, it is used as part of a treatment program with Lannate. It suppresses the beneficial predators of mites causing increases in the mite populations.
Guthion is reported in the Southeast Region to be less effective than Lannate, resistance is becoming a problem in the Southwest Region where it is reported as part of a treatment program with Lannate.
(2)(3)(7)(10)(11)(13)

Esfenvalerate (synthetic pyrethoid)

Formulations: Asana XL
Pests Controlled: cutworm, armyworm, Colorado potato beetles, hornworms, cabbage loopers, tomato fruitworms
Percent of Crop Treated: no information available

Types of Applications: foliar treatment
Application Rates: (suggested) 5.8 to 9.6 oz (3)
Number of Applications: no information available
Timing: apply when insects appear
Pre-Harvest Interval: 1 day (3)
REI: 12 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: no information available
Disadvantages: Kills predators of mites, which could lead to a mite outbreak, some phytotoxicity has been reported (25)
(2)(3)(7)(10)(11)(13)

Baythroid (synthetic pyrethoid)

Formulations: Baythroid 2
Pests Controlled: Colorado potato beetle, flea beetles, armyworm, aphids, hornworms, cabbage loopers, tomato fruitworm, whiteflies and cutworm
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates: (suggested)1.6 to 2.8 fl oz (3)
Number of Applications: no information available
Timing: no information available
Pre-Harvest Interval: 0 days (3)
REI: 12 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: good
Advantages: very effective against chewing insects, fast-acting (25)
Disadvantages:toxic to fish, not effective against sub-surface soil insects (25)
(2)(3)(7)(10)(11)(13)

Carbaryl (carbamate)

Formulations: Sevin
Pests Controlled: Colorado potato beetle and cutworm
Percent of Crop Treated: no information available
Types of Applications: ground spray or boom spray over the row
Application Rates: no information available
Number of Applications: no information available
Timing: Determination to apply is based on scouting. It is applied after planting. Carbaryl cannot be used near blossom because it effects bees

Pre-Harvest Interval: 3 days
REI: 12 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: short PHI, inexpensive
Disadvantages: non-specific, can harm benefical insects and can drift
Alternative control for Colorado potato beetles and cutworm include:

Methyl bromide soil fumigation. Methyl bromide is very expensive, highly effective and being phased out. Fumigation must be done 10 days prior to planting
Esfenvalerate(Asana) (pyrethroid) is only moderately effective. There are possible resistance concerns
Permethrin is only moderately effective, is not made any longer.
(2)(3)(7)(10)(11)(13)

Cryolite (inorganic stomach poison)

Formulations: Kryocide 96W
Pests Controlled: Colorado potato beetles
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates: (suggested) 18 to 15 lb (3)
Number of Applications: no information available
Timing: no information available
Pre-Harvest Interval: 14 days (3)
REI: no information available
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: most effective on chewing insects(25)
Advantages: no information available
Disadvantages: toxic to bees, compatability problems (25)
(2)(3)(7)(10)(11)(13)

Endosulfan (organochlorine)

Formulations: Thiodan 3 EC, Phaser 50 WP
Pests Controlled: Flea beetles, Colorado potato beetles, aphids, hornworms, cabbage loopers, tomato fruitworms
Percent of Crop Treated: no information available
Types of Application: foliar spray
Application Rates: (suggested) Thiodan 3 EC 2/3 qt or 50 WP 1 lb (3)
Number of Applications: no information available
Timing: no information available

Pre-Harvest interval: 7 days(2)
REI: 12 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: good (2)
Advantages: compatible with most pesticides, relatively non-toxic to bees (25)
Disadvantages: highly toxic to fish, corrosive to iron (25)
(2)(3)(7)(10)(11)(13)

Methyl Parathion (organophosphate)

Formulations: Pencap-M
Pests Controlled: Flea beetles, Colorado potato beetles, hornworms, tomato fruitworms
Percent of Crop Treated: no information available
Types of Applications: foliar treatment (3)
Application Rates: (suggested) 2 to 4 pts (3)
Number of Applications: no information available
Timing: no information available
Pre-Harvest Interval: 15 days (3)
REI: 48 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: inexpensive
Disadvantages: toxic to applicator. Risk of non-target loss.
(2)(3)(7)(10)(11)(13)

Diseases

Bacterial Canker (*Corynebacterium michiganense*)

Biology
Bacterial canker is also called bacterial wilt, was first reported by Erwin F. Smith and was initially named "Grand Rapids disease" because it was discovered in a Grand Rapids greenhouse. Bacterial canker was once a disease of serious consequence in processing tomato, but its importance declined because of the use of hot water treatment of seed. Recent increased incidence of bacterial canker is related to the use of untreated seed.(12)

The initial symptom of bacterial canker is a wilting of leaflets, which is more pronounced in younger plants. The leaflet margins wilt first, then turn brown and die progressively from the margins inwards toward the midrib. The petiole remains green and firm on older, hardened-off plants, whereas young, soft plants may wilt totally and die early. Leaflet die-back progresses from the bottom on the plant upwards, and often only one side of the plant may be affected. In the summer months, infected plants may partially recover but generally are stunted and unthrifty.

Another important symptom is light-colored streaking beginning at leaflet junctures and extending up and down the outside of stems. These streaks darken and may break down to form cankers (necrotic sunken lesions). When the stem of a diseased plant is cut, a yellow or tan discoloration can be seen in the water-conducting tissue resulting in the formation of a yellow or tan line immediately adjacent to the exterior of the stem. Initially the bacteria are confined to the water- and food-conducting vessels; but as decay progresses, the bacteria move to other areas of the stem. The stem tissue becomes yellow and mealy and often spongy to the touch.(13)

The fruit can become infected in one of two ways. The bacteria in the vascular system can move into the fruit and cause a brown blister on the fruit surface. If infected when small, the fruit become stunted, malformed and discolored internally. Secondary spread of the bacteria from cankers to green fruit also takes place. Small water-soaked spots appear on the fruit and soon become surrounded by a white halo. The mature lesions are tan, slightly round and cracked and remain about 1/8 inch (3 mm) in diameter. The lesions are often confused with bacterial spot.

The causal bacterium is considered to be seed-borne. It can also survive in the greenhouse when associated with plant debris.(24) It is known to persist in the soil for 1 to 3 years and possibly in solanaceous weed hosts. Although the disease may develop over a wide range of temperatures, it is most severe in warmer years when temperatures consistently range in the 80s and there is frequent high humidity and rainfall. The bacterium is spread by wind-driven rain and enters the plant through wounds and natural openings.

Cultural Controls

- Prevention
- Sanitation
- Rotation

Control includes using treated seeds, disease-free transplants and transplanting into disease-free soils. It is important to destroy weeds in and around the field, especially those in the tomato family (e.g. nightshade). Also destroy crop debris. Once disease has occurred, sanitize equipment, avoid carrying the disease to uninfected areas. A 2 to 3 year crop rotation away from plants in the tomato family will eliminate the bacterium. Mulching may help control bacterial canker. Resistant cultivars are helpful in controlling bacterial canker.(13)

Chemical Controls

Copper Ammonium Carbonate
Copper Count N 8L, 1 1/2 to 3 qt (0 days) (speck, spot).
Copper Sulfate
Basicop 53 W, 2 to 4 lb (0 days) (canker, spot).
Copper Hydroxide
Champ F or Kocide LF, 2 2/3 to 5 1/3 pt (0 days) (speck, spot).
Champ Formula 2F, 1 1/3 pt (speck) or 1 1/3 to 2 2/3 pt. (spot) (0 days).
Champion WP or Kocide 101 or Kocide DF, 2 to 4 lb (0 days) (speck, spot)
Kocide 2000. 1 1/2 to 3 lb (0 days) (speck, spot).
Kocide 4.5 LF, 1 1/3 to 2 2/3 pt (0 days) (speck, spot).
Nu-Cop 3L, 1 1/3 to 2 2/3 pt (speck) or 1 1/3 to 5 1/3 pt (spot) (0 days)
Nu-Cop 50 DF, 2 to 3 lb. (speck) or 2 to 4 lb. (spot) (0 days).
Copper Hydroxide/Mancozeb
ManKocide, 2.5 to 5 lb. (5 days) (speck, spot).

Fungicides that protect against bacterial speck and/or spot may provide protection against bacterial canker

Alternative Controls
There is no known plant resistance or chemical control for this disease.

Bacterial Spot(*Xanthomonas vesicatoria*)

Biology
Bacterial spot causes fruit blemish, leaf spotting and defoliation on tomato, pepper and other solanaceous hosts (e.g. nightshade). It is generally more of a problem on tomatoes in the southern and temperate zones, although it has caused much damage on tomatoes in Michigan in recent years.(13)

Initial leaf and stem symptoms are small (1/16 to 1/8 inch) circular to irregular black spots with a greasy appearance. As the lesions enlarge, they may become surrounded by a yellow halo. Eventually centers of lesions on leaves dry out and frequently tear. If spots are numerous, leaves die and plants become defoliated. Spots may also occur on flowers and petioles and may cause serious blossom drop, resulting in a split set of fruit.(13)

On infected green fruits, small, slightly raised water-soaked spots appear. These lesions enlarge to 1/8 to 1/4 inch, turn light to dark brown and become rough and scaly. The lesions cause a reduction of fresh-market sales. In processes tomatoes the lesions interfere with the skins slipping off, causing problems.

In the early stages of the fruit infection a white halo surrounds the spot so that it may resemble a canker lesion (see Bacterial Canker). However, this halo disappears as the lesion matures. Spots do not appear on ripe fruit because the high-acid content does not allow the bacterium to develop.

The bacteria can be carried as a contaminant on the surface of seed and overwinter in the soil in association with roots of various non-hosts. The optimum temperature for bacterial growth is between 75°F and 86°F. Abundant rainfall and high humidity are needed for maximum spread and infection. Penetration of plant tissue occurs through wounds caused by broken plant hairs, insect punctures and windblown sand particles.(13)

Cultural Controls
Disease-free seeds should be used. Chemically treated seeds, hot water-treated seed or disease-free transplants should be used. Hot water treatment removes a high percentage of bacteria from the seed. Seeds should be both tested and treated. A three-year crop rotation with nonsusceptible hosts is advisable, in addition to control of weeds from the tomato family. The destruction of crop debris, burying debris and mulching may help control bacterial spot. Resistant cultivars are not available. Windbreaks every 12 rows can be helpful in limiting disease spread.(13)(24)

Chemical Controls

Copper Ammonium Carbonate
Copper Count N 8L, 1 1/2 to 3 qt (0 days) (speck, spot).
Copper Sulfate
Basicop 53 W, 2 to 4 lb (0 days) (canker, spot).
Chlorothalonil/Copper Oxychloride/Maneb
Copper Hydroxide
Champ F or Kocide LF, 2 2/3 to 5 1/3 pt (0 days) (speck, spot).
Champ Formula 2F, 1 1/3 pt (speck) or 1 1/3 to 2 2/3 pt (spot) (0 days).
Champion WP or Kocide 101 or Kocide DF, 2 to 4 lb (0 days) (speck, spot)
Kocide 2000. 1 1/2 to 3 lb (0 days) (speck, spot).
Kocide 4.5 LF, 1 1/3 to 2 2/3 pt (0 days) (speck, spot).
Nu-Cop 3L, 1 1/3 to 2 2/3 pt (speck) or 1 1/3 to 5 1/3 pt (spot) (0 days)
Nu-Cop 50 DF, 2 to 3 lb. (speck) or 2 to 4 lb (spot) (0 days).
Copper Hydroxide/Mancozeb
ManKocide, 2.5 to 5 lb (5 days) (speck, spot).

Alternative Controls
No information available

Bacterial Spec(*Pseudomonas tomato*)

Biology
Bacterial speck has been of minor importance until recent years. Within the last decade, this disease has been encountered with increasing frequency in northern areas. It is now considered a severe disease in tomatoes in Michigan. The use of new, possibly more susceptible varieties, establishment of a permanent population of bacteria in the soil, and changes in cultural or spray practice may all be partially responsible for the increased incidence. *Pseudomonas tomato* does not appear to affect other solanaceous crops such as potatoes, eggplant or pepper, but may survive on nonhost plants.(13)

Bacterial speck may contribute to yield decrease; however, its most devastating effect is on fruit quality. The organism enters green fruit and produces small, slightly raised superficial black specks (1/16-inch diameter) which do not extend much deeper than the skin. The ripe fruit loses susceptibility as it matures because of the low pH of red tomatoes. Small dark spots similar in size to these on fruit appear on leaves and occasionally stems and flowers. Often these spots are surrounded by a chlorotic halo. Yield reductions occur when the speck organism causes abortion of flowers. Occasionally the bacterium will cause necrosis of the leaf margins.(13)

Bacterial population build-up and spread are greater under wet cool conditions, as free moisture on the surface of the leaves is necessary for infection. The organism is inhibited when the average daily temperature exceeds 70°F. The speck organism enters the plant through natural openings and wounds. The pathogen can colonize the surface of tomato leaves and maintain itself there until environmental conditions are favorable for infection. Epidemics of bacterial speck occur most frequently after rainstorms when there has been extensive soil movement and abrasion of leaves. The optimum time for serious epidemics in Michigan occurs during June and the first part of July when temperatures are cool and fruit is still susceptible.(13)

The bacterium can survive on seed, in plant debris in the soil and on many nonhost plants. Although previously it was not known to overwinter in northern regions, it can survive at least one season.

Cultural Controls
Bacterial speck control programs are currently built around prevention. Crop rotation, the use of disease-free seed (hot water treatment advised) and transplants and the destruction of weeds around a tomato field are the most practical and effective measures of control. Crop rotations of 3 years or more out of solanaceous crops is suggested. The destruction of crop debris and mulching may help control bacterial speck. Resistant cultivars are not available.(13)

Chemical Controls

Copper Ammonium Carbonate
Copper Count N 8L, 1 1/2 to 3 qt (0 days) (speck, spot).
Copper Sulfate
Basicop 53 W, 2 to 4 lb (0 days) (canker, spot).
Chlorothalonil/Copper Oxychloride/Maneb

Bravo C/M, 4 to 6 lb (5 days) (speck, spot).

Copper Hydroxide

Champ F or Kocide LF, 2 2/3 to 5 1/3 pt (0 days) (speck, spot).
Champ Formula 2F, 1 1/3 pt (speck) or 1 1/3 to 2 2/3 pt (spot) (0 days).
Champion WP or Kocide 101 or Kocide DF, 2 to 4 lb (0 days) (speck, spot)
Kocide 2000. 1 1/2 to 3 lb (0 days) (speck, spot).
Kocide 4.5 LF, 1 1/3 to 2 2/3 pt (0 days) (speck, spot).
Nu-Cop 3L, 1 1/3 to 2 2/3 pt. (speck) or 1 1/3 to 5 1/3 pt (spot) (0 days)
Nu-Cop 50 DF, 2 to 3 lb (speck) or 2 to 4 lb (spot) (0 days).

Copper Hydroxide/Mancozeb

ManKocide, 2.5 to 5 lb (5 days) (speck, spot).

Alternative Controls

No information available

Early Blight (*Alternaria solani*)

Biology

Early blight is a serious defoliator and fruit rotter of tomatoes in the Midwest. It also can cause extensive leaf rotting of potato, another member of the solanaceous family, and is also known to attack eggplant, horsenettle and nightshade.(13)

The fungus can be destructive to both immature seedlings and mature tomato plants. On seedlings, it causes damping off, leaf spotting and collar rot (see Collar Rot).(13)

When clean tomato transplants are set out in the field, they usually remain free of leaf spot until blossom. If present on transplants, the disease will continue to develop under conditions of high moisture.(13)

Leaf symptoms are dark brown to black spots ranging in size from 1/32 to 1/2 inch. First symptoms appear on older leaves. Within the lesion target or bullseye, rings appear which are a result of growth flushes of the fungus. Lesions often coalesce to form large dead areas in the leaf. When the leaf is covered with many lesions, the leaf yellows and drops off, leaving the fruit susceptible to sunscald. Lesions can also occur on the stems and blossoms. Blossom infection will cause blossom drop.(13)

Fruit become infected in the green and ripe stages. Infection generally occurs at the point of attachment to the stem but can occur through growth cracks and wounds on the fruit. On fruits, early blight causes dark brown, leathery sunken spots with concentric rings. When attacked, young fruits often drop off prematurely.

In humid weather, infected areas on the fruit become covered with a black, velvety coat of spores. Crowded, poorly nourished plants with a heavy fruit set, early maturing varieties and varieties that concentrate their fruit set are most susceptible.(13)

The fungus overwinters in plant debris and seed. Although spore production and lesion enlargement are greatest in cool weather (less than 70°F), infection is greatest in warm weather (above 75 to 85°F). Heavy dews, extremely humid weather and abundant rainfall are essential for heavy disease pressure.

Cultural Controls

Crop rotation of 3 to 4 years will eliminate the fungus from the soil. Delay planting, early harvest, weed control and the use of resistant varieties helps to control early blight. Disease forecasting help to predict when treatment is necessary.(13)

Chemical Controls

Chlorothalonil
Bravo 500, 2 to 3 pt (foliage) or 3 to 4 pt (fruit) (0 days)
Bravo Ultrex 82.5 WDG, 1 to 1.8 lb (foliage)
Bravo Weather Stik or Bravo 720 or Supanil 720 or Terranil 6L or Echo 720. 1 3/8 to 2 pt (foliage) or 2 to 3 pt (fruit) (0 days).
Mefenoxam / Chlorothalonil
Ridomil Gold/Bravo, 2 lb. (14 days).
Ziram
Ziram 76 DF. 3 to 4 lb.(7 days).
Chlorothalonil/Copper Oxychloride/Maneb
Bravo C/M, 4 to 6 lb (5 days).
Copper Hydroxide
Champ F or Kocide LF, 2 2/3 to 4 pt (0 days).
Champ Formula 2F, 1 1/3 to 2 pt (0 days).
Champion WP or Kocide 101 or Kocide DF or Nu-Cop 50 DF, 2 to 3 lb (0 days).
Kocide 2000, 1 1/2 to 3 lb (0 days).
Kocide 4.5 LF, 1 1/3 to 2 2/3 pt (0 days).
Nu-Cop 3L, 1 1/3 to 4 pt (0 days).
Copper Ammonium Carbonate
Copper Count N 8L, 1 1/2 to 3 qt (0 days).
Mancozeb
Dithane 75 DF or M-45 or WSP, 1 1/2 to 3 lb (5 days).
Dithane F-45, 1 1/5 to 2 2/5 qt (5 days).
Manzate 200 75 DF. 1 1/2 to 3 lb (5 days).
Penncozeb 75 DF or 80 WP, 1 1/2 to 3 lb (5 days) .
Maneb
Maneb 75 DF or 80 WP, 1 1/2 to 3 lb (5 days).
Manex, 1 1/5 to 2 2/5 qt (5 days).

Copper Hydroxide / Mancozeb
ManKocide. 2.5 to 5 lb (5 days).
Azoxystrobin
Quadris F, 5.0 to 6 1/5 fl oz (7 days).
Fosetyl-Aluminum/Maneb
Aliette/Maneb 2+2, 4 lb. (14 days).
Copper Sulfate
Basicop 53 WP. 2 to 4 lb (0 days).

Alternative Controls
No information available

Late Blight (*Phytophthora infestans*)

Biology
Late blight caused the historic Irish potato famine in the 1840s. Late blight can devastate fields of both potatoes and tomatoes if not properly controlled. In Michigan, the disease occurs only sporadically on tomatoes but losses can be heavy.(13)

Initial leaf symptoms are pale green to brown spots, usually with a purplish cast. Affected areas rapidly enlarge, become water soaked, turn dark brown to purple-black, shrivel and die. Often pale yellow or green halos encircle the enlarging lesion.

All above-ground parts are susceptible. If a lesion appears on the stem, it can rapidly girdle and kill it. Early in the morning, white to purplish mold can be observed on the advancing edge of the lesion. The mold is only present under conditions of high relative humidity and abundant free moisture.(13)

Fruit rot usually begins near the stem end and is more frequent on the upper half of the fruit surface. Greyish-green to brown irregularly shaped blotches appear on the fruit surface and rapidly enlarge. The rotted portion, which may eventually cover the whole fruit surface, is wrinkled but remains intact and is often covered by a white mold.

Late blight is caused by a fungus that grows most actively in cool (55 to 65°F), moist weather. The fungus produces spores between 50 and 80°F, but more spores are produced in the lower end of the temperature range. These spores are disseminated from affected tissue by water movement. Under favorable weather conditions, the pathogen can blight the foliage so rapidly that it appears the plants were hit by frost. Decaying vines may be recognized by a foul odor. The fungus overwinters in undecomposed debris from previously diseased tomato or potato plants or in potato tubers in the soil or in cull piles of rotted tomatoes or potatoes. These overwintering sites serve as an inoculum source in the spring. Infected transplants may also serve as the original source of the disease.(13)

Cultural Controls

The use of disease-free transplants and the destruction of overwintering sites and volunteer plants reduce the occurrence of the disease. The use of resistant cultivars may help control Late blight. Disease forecasting helps to identify times when treatment may be necessary.(13)

Chemical Controls

Azoxystrobin
Quadris F, 6 1/5 fl oz (7 days).
Fosetyl-Aluminum/Maneb
Aliette/Maneb 2+2, 4 lb. (14 days).
Chlorothalonil
Bravo Ultrex WDG, 1.3 to 1.8 lb (foliage) or 1.8 to 2.75 lb (fruit) (0 days).
Bravo Weather Stik or Bravo 720 or Supanil 720 or Terranil 1 3/8 to 2 pt (foliage) or 2 to 3 pt (fruit) (0 days).
Bravo 500, 2 to 3 pt (foliage) or 3 to 4 pt (fruit) (0 days)
Maneb
Maneb 75 DF or 80 WP, 1 1/2 to 3 lb.(5 days).
Manex, 1 1/5 to 2 2/5 qt (0 days).
Mancozeb
Dithane F-45, 1 1/5 to 2 2/5 qt (5 days).
Dithane 75 DF or M-45 80 W or WSP, 1 1/2 to 3 lb (5 days).
Manzate 200 75 DF. 1 1/2 to 3 lb (5 days).
Penncozeb 75 DF or 80 WP, ¾ to 3 lb,.(5 days) .
Copper Ammonium Carbonate
Copper Count N 8L, 1 1/2 to 3 qt (0 days).
Chlorothalonil/Copper Oxychloride/Maneb
Bravo C/M, 4 to 6 lb. (5 days).
Copper Sulfate
Basicop 53 WP. 2 to 4 lb (0 days).
Copper Hydroxide
Kocide 101 or Kocide DF, 2 to 3 lb (0 days).
Kocide LF, 2 2/3 to 4 pt (0 days).
Kocide 4.5 LF, 1 1/3 to 2 2/3 pt (0 days).
Kocide 2000, 1 1/2 to 3 lb (0 days).
Nu-Cop 3L, 1 1/3 to 5 1/3 pt. (0 days).
Copper Hydroxide / Mancozeb
ManKocide. 2.5 to 5 lb (5 days).
Mefenoxam / Chlorothalonil
Ridomil Gold/Bravo, 2 lb. (14 days).
Mefenoxam / Mancozeb
Ridomil Gold MZ, 2 1/2 lb. (5 days).

Mefenoxam / Copper Hydroxide
Ridomil Gold / Copper, 2 lb. (14 days).
Metalaxyl / Mancozeb
Ridomil MZ, 72. 2 ½ lb. (14 days).

Alternative Controls
No information available

Septoria Blight (*Septoria lycopersici*)

Biology
Septoria is a fungal pathogen that causes leaf spot on tomatoes. The pathogen is spread by splashing water, tools and animal movement. It overwinters as mycelium and spores in infected seeds and plant debris. The disease can develop rapidly at high temperatures and moisture, although it can still be active at lower temperatures.(13)

The first symptoms of septoria blight are small yellow specks on leaves. These spots enlarge and may become tan or brown in color. The lower leaves generally show the first signs of infection. As the disease progresses black pycnidia begin to form.(13)

Cultural Controls
The use of disease free seeds, 2- to 3-year rotations, sanitation and resistant varieties is important deep plowing of refuse.(13)

Chemical Controls

Chlorothalonil
Bravo 500, 2 to 3 pt (0 days)
Bravo Ultrex 82.5 WDG, 1 to 1.8 lb
Bravo Weather Stik or Bravo 720 or Supanil 720 or Terranil 6L or Echo 720. 1 3/8 to 2 pt (0 days).
Chlorothalonil/Copper Oxychloride/Maneb
Bravo C/M, 4 to 6 lb. (5 days).
Copper Hydroxide
Champ F or Kocide LF, 2 2/3 to 5 1/3 lb (0 days).
Champ Formula 2F or Kocide 4.5 LF, 1 1/3 to 2 2/3 pt. (0 days).
Champion WP or Kocide 101 or Kocide DF or, 2 to 4 lb. (0 days).
Kocide 2000, 1 1/2 to 3 lb (0 days).
Nu-Cop 3L, 1 1/3 to 5 1/3 pt.(0 days).
Mefenoxam / Chlorothalonil

Ridomil Gold/Bravo, 2 lb. (14 days).

Ziram

Ziram 76 DF. 3 to 4 lb. (7 days).

Mancozeb

Dithane 75 DF or M-45 or WSP, 1 1/2 to 3 lb (5 days).
Dithane F-45, 1 1/5 to 2 2/5 qt (5 days).
Manzate 200 75 DF. 1 1/2 to 3 lb (5 days).
Penncozeb 75 DF or 80 WP, 1 1/2 to 3 lb (5 days) .

Maneb

Maneb 75 DF or 80 WP, 1 1/2 to 3 lb (5 days).
Manex, 1 1/5 to 2 2/5 qt (5 days).

Copper Hydroxide / Mancozeb

ManKocide. 2.5 to 5 lb (5 days).

Azoxystrobin

Quadris F, 5.0 to 6 1/5 fl oz (7 days).

Fosetyl-Aluminum/Maneb

Aliette/Maneb 2+2, 4 lb. (14 days).

Copper Sulfate

Basicop 53 WP. 2 to 4 lb (0 days).

Alternative Controls

No information available

Damping off (*Rhizoctonia solani and Pythium spp.*)

Biology

Damping off is a seed disease, caused by several fungi, most commonly Pythium. Pythium is an important cause of pre-emergence and post-emergence damping off. Infection rates can be high, particularly during the periods of cool, wet weather. It can lead to a failure to germinate. Infected seedlings wilt, turn brown and die, resulting in poor stands. Yield loss due to pythium damping off can be up to 100%.(13)

Pythium grows as white mycelium which branch and form reproduction structures. The spores move in water to a host. They survive best on dead plant and animal matter, but can do well on living plants particularly in wet soils. The fungus enters plant cells, consumes cellular material and kills the cells. If the initial infection of a plant is at a more mature stage of growth, it is able to resistant the fungal growth. At immature stages such as seeds and young seedlings, the fungus is able to grow readily into the plant tissues and kill the plant. Young roots can be attacked by fungus at any stage of plant growth. (13)

Seedlings that are attacked at the ground level develop a water-soaked, discolored stem and topple over. Infected plants seldom recover.

Cultural Controls
Soil moisture is important in controlling damping off disease. Seedlings should not be overwatered. Good drainage is important in limiting disease development, avoid low, wet areas. Good sanitation procedures, such as disinfestation of flats and other greenhouse items, reduces damping off. Planting at times conducive to rapid plant growth minimizes the opportunity for infection. Compost and other soil amendments are able to improve drainage and air circulation and thereby decrease infection. Also crop rotation helps to decrease the incidence of damping. Mulching may help control Pythium.(13)

Chemical Controls
Seed treatments, incorporating fungicide into the soil before planting and foliar treatments can help control damping off. It is important to use both a Pythium and a Rhizoctonia-inhibiting fungicide in your spray program, as most of the fungicides used for this purpose are specific for one or the other fungus.

Seed Treatment:

- Bacillus subtilis
- Oxadixyl
- Captan
- Thiram

Preplanting incorporation:

- Mefenoxam applied as a broadcast preplant incorporation or a surface application.
- Ridomil Gold EC, 1 to 2 pt.
- Ridomil Gold WSP, 1 to 2 lb.
- Ridomil Gold GR, 20 lb.

Foliar Treatment:

- Fosetyl-Aluminum
- Aliette WDG, 2.5 to 5 lb. (14 days).
- Fosetyl-Aluminum/Maneb
- Aliette/Maneb 2+2, 4 lb. (14 days).

Alternative Controls
No information available

Tomato Wilts (*Verticillium alboatrum, V. dahliae, Fusarium oxysporum f. lycopersicae*)

Biology

Several fungi, *including Verticillium alboatrum, V. dahliae and Fusarium oxysporum f. lycopersicae*, cause wilting due to blockage of the water-conducting vessels. The Fusarium fungus attacks only tomato, while the Verticillium fungus infects many species of plant, including potatoes, peppers, cucumbers and rhubarb as well as a number of weeds. Both fungi can infect many plants without causing symptoms(4)

Fusarium and Verticillium wilts cause a yellowing of older leaves. In Fusarium-infected plants, leaf yellowing often occurs only on one side of the plant and is followed by the leaves turning brown, dying and dropping off. Fusarium-infected plants often die before reaching maturity whereas Verticillium-infected plants generally survive the growing season but are stunted and low yielding. If the stem of a diseased plant is cut longitudinally, dark brown streaking of the vascular system is evident especially at the nodes. The discoloration generally extends farther up the plant in Fusarium-infected plants. Both organisms are commonly found in many soils and are capable of persisting in the soil for several years. (4)(22)

The Fusarium wilt pathogen is most active between 80 and 90°F, so the disease is usually prevalent late in the season and tends to cause serious losses in years of high soil and air temperatures.

Conditions that predispose plants to Fusarium infection are: succulence and rapid growth, unthriftiness, low levels of nitrogen and phosphorus, and high levels of potassium. The Verticillium wilt pathogen grows best when soil temperatures are in the 60 to 70°F range. High temperatures slow the growth of wilt. Infected plants, however, may be more evident in hot weather because of water stress.(4)

Cultural Controls

Disease-free transplants and hot water-treated seed will reduce the spread of these wilt organisms into clean fields. The use of resistant cultivars is the best way to control Fusarium and Verticillium wilt. A long (4 to 6 year) rotation will reduce, but not totally eliminate the fungus from the soil. When Verticillium wilt is present in a field, do not plant other susceptible hosts in the rotation. Nematodes may increase the spread of the pathogen, so controlling nematodes may be helpful in disease control. Also solarization of the soil and soil pH of 7 may also help.(13)

Chemical Controls

Preplant soil fumigation

- **methyl bromide**, 175 to 240 lb
- **Metam-Sodium**
- Vapam, 50 to 100 gal or Vapam HL, 30 to 75 gal. injection
- Vapam, 75 to 100 gal or Vapam HL 56 ¼ to 75 gal as chemigation.

Alternative Controls
No information available

Mold: White Mold (*Sclerotina*), **Gray Mold** (*Botrytis*), **Leaf Mold** (*Cladosporium*)

Biology
Molds are a moderate concern in tomatoes.(1)

White mold is caused by a fungi that overwinters as sclerotia on infected tissues and in the soil. In spring they germinate and produce ascospores that are released into the air. White mold can persist in the soil as black sclerotial bodies for many years. Spores are carried by the wind to new host plants. Under favorable conditions, such as ample moisture and cool temperatures the spore germinates and infects the host. The initial symptoms of the disease are white mycelium. These form dark sclerotia that send out spores for further inoculation. Leaves develop white cottony growth on their surface when infected, this occurs both in the ground and in storage. Infected tissues become dark, soft and watery. When infected are in storage the disease can spread to non-infected.(1)

Gray mold is caused by a fungal pathogen, *botrytis. Botrytis* produces long gray mycelium, In cool damp weather it is a greater concern.(1)

Cultural Controls
Plant in well drained soil using proper spacing to prevent crowding. Avoid areas with poor air circulation. Water early in the day and deeply; avoid frequent light watering. Weed control is important in controlling white mold because many weeds are hosts to the white mold fungus. Infected plant material should be carefully removed and destroyed. 3-4 year rotations with non-host are suggested to minimize occurrence, avoid beans, cucurbits, celery, and cabbage. Resistant cultivars may help control gray mold. Raising the pH above 6.3 may also help.

Chemical Controls

Fosetyl-Aluminum/Maneb
Aliette/Maneb 2+2, 4 lb. (14 days).
Chlorothalonil
Bravo 500, 2 to 3 pt. (0 days)
Bravo Ultrex 82.5 WDG, 1.3 to 1.8 lb (0 days)
Bravo Weather Stik or Bravo 720 or Supanil 720 or Terranil 6L, 1 3/8 to 2 pt (0 days) .
Mancozeb
Dithane F-45, 1 1/5 to 2 2/5 qt (5 days).
Dithane 75 DF or M-45 or WSP, 1 1/2 to 3 lb (5 days).

Manzate 200 75 DF, 1 1/2 to 3 lb (5 days).
Penncozeb 75 DF or 80 WP, 3/4 to 3 lb (5 days) (*Cladosporium*).

Mefenoxam/Chlorothalonil
Ridomil Gold/Bravo, 2 to 3 lb (14 days).

Chlorothalonil/Copper Oxychloride/Maneb
Bravo C/M, 4 to 6 lb (5 days)

Benomyl
Benlate 50 W or SP, 5 lb (1 day)

Maneb
Maneb 75 DF or 80 WP, 1 ½ to 3 lb (5 days)
Manex, 1 1/5 or 2 2/5 qt (5 days)

Alternative Controls
No information available

Anthracnose (*Colletotrichum coccodes*)

Biology
Anthracnose causes rotting of ripe fruit, which reduces yield and fruit quality. Anthracnose also causes a high mold count in canned tomatoes. Early symptoms appear on the fruit, as small, slightly depressed, water-soaked circular spots. The lesions increase in size (up to ½ inch), become further sunken and often contain a pattern of concentric rings. The lesions generally darken, and small, black, fruiting bodies called acervuli appear in the center. In smaller lesions, the central portion may turn dark because of numerous fruiting structures just below the surface. In moist, warm weather these fruiting bodies exude masses of slimy tan or salmon-colored spores. As the fungus spreads within the fruit, a semi-soft decay is evident. Lesions often coalesce, resulting in large rotted areason the fruit. Fruit is more susceptible as it ripens, and although green fruit may be infected, disease symptoms will not occur until the fruit begins to ripen. The organism can penetrate the fruit cuticle directly, but may enter through wound sites also. On a ripe fruit, a lesion can develop within 5 to 6 days of spore contact. Lesion development is most rapid at 80°F, although the pathogen can cause infection over a range of temperatures (55 to 95°F). Spores are disseminated by during wet rainy weather.(13)

The organism overwinters in infected plant debris but is also capable of surviving in the soil. A 2- or 3-year crop rotation and avoidance of sandy soil sites to minimize injury from blowing sand particles will reduce anthracnose. A chemical spray program beginning no later than blossom set and consisting of recommended fungicides applied weekly up to harvest reduces disease incidence.(13)

Cultural Controls
Anthracnose can be minimized by the use of resistant varieties, disease-free seeds, crop rotation and early harvesting of the crop. Plowing under crop debris may help reduce inoculum. Rotation of three

years or more out of solanaceous crops is suggested. Disease forecasting can help to determine when treatment is necessary.(13)

Chemical Controls

Chlorothalonil
Bravo 500, 3 to 4 pt (0 days)
Bravo Ultrex 82.5 WDG, 1.8 to 2.7 lb (0 days)
Bravo Weather Stik or Bravo 720 or Supanil 720 or Terranil 6L or Echo 720. 2 to 3 pt (0 days).
Chlorothalonil/Copper Oxychloride/Maneb
Bravo C/M, 4 to 6 lb (5 days).
Mancozeb
Dithane 75 DF or M-45 or WSP, 1 1/2 to 3 lb (5 days).
Dithane F-45, 1 1/5 to 2 2/5 qt (5 days).
Manzate 200 75 DF. 1 1/2 to 3 lb (5 days).
Penncozeb 75 DF or 80 WP, 1 1/2 to 3 lb (5 days) .
Maneb
Maneb 75 DF or 80 WP, 1 1/2 to 3 lb (5 days).
Manex, 1 1/5 to 2 2/5 qt (5 days).
Copper Hydroxide / Mancozeb
ManKocide. 2.5 to 5 lb (5 days).
Azoxystrobin
Quadris F, 5.0 to 6 1/5 fl oz (7 days).
Fosetyl-Aluminum/Maneb
Aliette/Maneb 2+2, 4 lb. (14 days).
Copper Hydroxide
Champ F or Kocide LF, 2 2/3 to 5 1/3 pt, (0 days).
Champ Formula 2F or Kocide 4.5 LF, 1 1/3 to 2 2/3 pt (0 days).
Champion WP or Kocide 101 or Kocide DF or, 2 to 4 lb (0 days).
Kocide 2000, 1 1/2 to 3 lb (0 days).
Nu-Cop 3L, 1 1/3 to 5 1/3 pt (0 days).
Nu-Cop 50 DF 2 to 3 lb (0 days).
Mefenoxam/Chlorothalonil
Ridomil Gold/Bravo, 2 to 3 lb (14 days)
Ziram
Ziram 76 DF, 3 to 4 lb (7 days)
Copper Sulfate
Basicop 53 WP. 2 to 4 lb (0 days).

Alternative Controls
Disease forecasting

Buckeye Rot (*Phytophthora parasitica*)

Biology

Buckeye Rot is caused by a fungus that appears infrequently in northern tomato-growing areas, although it occurs commonly in the south. Fruit rot is the most common symptom, although the pathogen can produce irregular, brown necrotic lesions on stem and leaves and cause seedling damping off. The pathogen can attack fruits of eggplants and peppers as well as tomatoes. Both green and red fruit, especially those in contact with the soil surface, may become infected. It is more of a concern with processing tomatoes than fresh market tomatoes.(13)

The initial symptom is a small grayish-brown spot that appears at the point of fruit/soil contact. The spot gradually enlarges, forming a pattern of concentric rings of wide, light-brown and narrow, dark-brown bands. The lesion becomes leathery in texture and is slightly sunken. Under very moist conditions, a cottony, white fungal growth appears on the lesion.(13)

Buckeye rot is most common during long periods of excess soil moisture and soil temperatures between 64 and 80°F. Under extremely favorable environmental conditions, losses can be heavy if spread is left unchecked.

Cultural Controls

Tomatoes should not be planted on heavy, poorly drained soils. Low areas of the field are most likely to suffer losses first from Buckeye rot. Rotation with hosts outside the solaneaceous family as well as staking and mulching will reduce losses.(13)

Chemical Controls

Mefenoxam/Copper Hydroxide (Ridomil Gold) 2 lb
Metalaxyl / Chlorothalonil
Metalaxyl

Alternative Controls

No information available

Fungicide Profiles

Azoxystrobin

Formulations: Quadris F

Diseases Controlled: late blight, early blight, anthracnose and septoria blight.
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates: 5.0 to 6 1/5 fl oz (3)
Number of Applications: no information available
Timing: no information available
Pre-Harvest Interval: 7 days (3)
REI: 12 hours (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: no information available
Disadvantages: resistance is a concern.
(3)(4)(10)(16)

Mancozeb (dithiocarbamate)

Formulations: Penncozeb, Dithane 75 DF or M-45 or WSP, Dithane F-45, Manzate 200 DF
Diseases Controlled: late blight, early blight, anthracnose, septoria blight, damping off, bacterial spot, bacterial speck, leaf mold, white mold and gray mold
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates: Dithane 75 DF or M-45 or WSP, 1 1/2 to 3 lb, Dithane F-45, 1 1/5 to 2 2/5 qt, Manzate 200 75 DF 1 1/2 to 3 lb, Penncozeb 75 DF or 80 WP, 1 1/2 to 3 lb(3)
Number of Applications: no information available
Timing: 7-10 days (27)
Pre-Harvest Interval: 5 days (3)
REI: 24 hours (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: no information available
Disadvantages: a B2 carcinogen, there are some processor restrictions
(3)(4)(10)(16)

Benomyl (carbamate)

Formulations: Benlate 50 W or SP
Diseases Controlled: leaf mold, white mold and gray mold
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates: 5 lb (3)

Number of Applications: no information available
Timing: 7-14 day interval (3)
Pre-Harvest Interval: 1 day(3)
REI: 24 hours (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: preventative and eradicating fungicide, excellent residual activity (27)
Disadvantages: resistance is a concern
(3)(4)(10)(16)

Copper Compounds (inorganic compounds)

Formulations: Copper Hydroxide (Champ F or Kocide LF, Champ Formula 2F or Kocide 4.5 LF, Champion WP or Kocide 101 or Kocide DF, Kocide 2000, Nu-Cop 3L, Nu-Cop 50 DF), Copper Sulfate (Basicop 53 WP), Copper Hydroxide (ManKocide), Copper Ammonium Carbonate (Copper Count N 8L)
Diseases Controlled: used to control late blight, early blight, septoria blight, bacterial spot and bacterial speck.
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates:

- Champ F or Kocide LF, 2 2/3 to 5 1/3 pt
- Champ Formula 2F or Kocide 4.5 LF, 1 1/3 to 2 2/3 pt
- Champion WP or Kocide 101 or Kocide DF, 2 to 4 lb
- Kocide 2000, 1 1/2 to 3 lb
- Nu-Cop 3L, 1 1/3 to 5 1/3 pt

Nu-Cop 50 DF 2 to 3 lb
Basicop 53 WP. 2 to 4 lb
ManKocide. 2.5 to 5 l
Copper Count N 8L, 1 1/2 to 3 qt
Number of Applications: no information available
Timing: begin when disease threatens, 5 to 7 day intervals (3)
Pre-Harvest Interval: 0 days (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: compatible with most other pesticides (27)
Disadvantages: toxic to fish (27)
(3)(4)(10)(16)

Metalaxyl (phenylamide)

Formulations: Ridomil Gold EC, Ridomil Gold WSP, Ridomil Gold GR, Ridomil Gold MZ
Diseases Controlled: late blight, buckeye rot, damping off, fruit and root rot
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates:Ridomil Gold/Bravo, 2 lb. Ridomil Gold MZ, 2 1/2 lb. (3)
Number of Applications: no information available
Timing: no information available
Pre-Harvest Interval: 14 days(3)
REI: 7 days (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: long lasting activity (27)
Disadvantages: B2 carcinogen, resistance concerns, corrosive (21)
(3)(4)(10)(16)

Oxadixyl (phenylamide)

Formulations: Anchor
Disease Controlled: damping off
Percent of Crop Treated: no information available
Types of Applications: Seed treatment
Application Rates: 1 1/2 oz / 100 lb seed (3)
Number of Applications: 1
Timing: not applicable
Pre-Harvest Interval: not applicable
REI: not applicable
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: curative and eradicant, available in combination with fungicides to broaden spectrum of effect
Disadvantages: no information available
(3)(4)(10)(16)

Thiram (Dithiocarbamate, organic fungicide)

Formulations: Thiram 50 WP Dyed, 42-S Thiram
Diseases Controlled: control early blight, anthracnose and septoria blight.
Percent of Crop Treated: no information available
Types of Applications: seed treatment

Application Rates: 6 oz / 100 lb seed (3)
Number of Applications: 1
Timing: not applicable
Pre-Harvest Interval: not applicable
REI: not applicable
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: It is a broad-spectrum pesticide and less expensive than alternatives
Disadvantages: no information available
(3)(4)(10)(16)

Methyl bromide (fumigant)

Formulations: Methyl bromide
Diseases Controlled: Fusarium wilt and verticillium wilt
Percent of Crop Treated: no information available
Types of Applications: Preplant soil fumigation
Application Rates:175 to 240 lb
Number of Applications:1
Timing: pre-plant
Pre-Harvest Interval: not applicable
REI: no information available
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: more effective in dry soils (27)
Advantages: helps in soil insect control (27)
Disadvantages: being phased out, phytotoxic (27)
(3)(4)(10)(16)

Metham (fumigant)

Formulations: Vapam, Vapam HL
Diseases Controlled: Fusarium wilt and verticillium wilt
Percent of Crop Treated: no information available
Types of Applications: Preplant soil fumigation
Application Rates:Vapam, 50 to 100 gal or Vapam HL, 30 to 75 gal.
injection Vapam, 75 to 100 gal or Vapam HL 56 ¼ to 75 gal as chemigation
Number of Applications: no information available
Timing: no information available
Pre-Harvest Interval: no information available
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available

Efficacy Issues: highly efficient
Advantages: controls bacteria, fungi, weeds and soil insects.(278)
Disadvantages: very expensive
(3)(4)(10)(16)

Chlorothalonil (nitrile compound)

Formulations: Bravo 500, Bravo 720, Bravo Ultrex, Bravo Weather Stik, Echo, Daconil
Diseases Controlled: late blight, early blight, anthracnose, septoria blight, bacterial spot, bacterial speck, leaf mold, white mold, gray mold and buckeye rot
Percent of Crop Treated: no information available
Types of Applications: Foliar Treatment
Application Rates: Bravo 500, 3 to 4 pt, Bravo Ultrex 82.5 WDG, 1.8 to 2.7 lb, Bravo Weather Stik or Bravo 720 or Supanil 720 or Terranil 6L or Echo 72 2 to 3 pt (3)
Number of Applications: no information available
Timing: suggested 7-14 day intervals (27)
Pre-Harvest Interval: 0 days (3)
REI: 48 hours (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: broad-spectrum foliage protectant fungicide
Disadvantages: B2 carcinogen
(3)(4)(10)(16)

Fosetyl-aluminum/Maneb

Formulations: Aliette/Maneb 2+2
Diseases Controlled: late blight, early blight, anthracnose, septoria blight, leaf mold, white mold and gray mold
Percent of Crop Treated: no information available
Types of Applications: Foliar Treatment
Application Rates: 4 lb. (3)
Number of Applications: no information available
Timing: 7-10 day intervals (3)
Pre-Harvest Interval:14 days(3)
REI: 12 hours (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available

Advantages: gives long persistant control (27)
Disadvantages: no preventative action (27)
(3)(4)(10)(16)

Maneb (carbamate)

Formulations: Maneb 75 DF or 80 WP, Manex
Diseases Controlled: late blight, early blight, anthracnose, septoria blight, leaf mold, white mold and gray mold
Percent of Crop Treated: no information available
Types of Applications: Foliar Treatment
Application Rates: Maneb 75 DF or 80 WP, 1 1/2 to 3 lb, Manex, 1 1/5 or 2 2/5 qt (3)
Manex, 1 1/5 to 2 2/5 qt (5 days).
Number of Applications:no information available
Timing:no information available
Pre-Harvest Interval: 5 days(3)
REI: 24 hours (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues:no information available
Advantages:compatible with common pesticides, controls a wider range of diseases than any other single fungicide (27)
Disadvantages: a B2 carcinogen, there are some processor restrictions.
(3)(4)(10)(16)

Ziram (Carbamate)

Formulations: Ziram 76 DF
Diseases Controlled: Early blight, septorial blight, anthracnose
Percent of Crop Treated: no information available
Types of Applications: foliar treatment
Application Rates: Ziram 76 DF, 3 to 4 lb (3)
Number of Applications: no information available
Timing: 7 to 14 day intervals
Pre-Harvest Interval: 7 days (3)
REI: 48 hours (3)
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: no information available
Advantages: repess cucumber beetles and Japanese beetles (27)
Disadvantages: incompatible with copper or lime (27)

(3)(4)(10)(16)

Nematodes

Biology
Root-knot and root-lesion nematodes can reduce tomato yields. Fields with soil or root problems of undetermined cause should be tested for nematodes.

Root knot nematodes can cause galls, forked roots and bunching of the roots. They are endoparasites. Adult female root knot nematodes feed on roots and become swollen. They produce an egg mass at the root surface. The first stage larva develops in the egg and the second stage larva exits the egg. The second stage larva is worm-like in shape and motile. It moves through the soil until it finds a suitable root. The larva enters the root and becomes sedentary. Nematode juveniles enter plant root tips, migrate through the tissue to feeding sites near the center of the root, and stop movement to feed. Crop rotation is usually not effective for control of root knot nematodes because of their wide host range.

Root lesion nematodes are migratory endoparasites. They overwinter in soil or roots as eggs, larva and adults. Larva and adults are migratory. Adult females lay eggs inside roots. Eggs hatch in the roots or when root tissue decomposes they are released into the soil. First larva stage occurs in the egg, the second larval stage is motile and moves through the soil, into roots. Lesion nematodes burrow into the cortex and feed, causing necrosis and discoloration. Lesion nematodes repeatedly enter and exit roots, causing tissue damage and making the roots susceptible to secondary pathogens.

Cultural Controls
If plant-parasitic nematodes are present in population densities above the economic threshold tomatoes, crop rotation with non-host crops is suggested.

Chemical Controls

- 1 ,3-D --Telone II, 15 gal (mineral soil)
- Metham (Busan 1020 or Vapam) 40 to 100 gal

Alternative Controls
No information available

Nematicide Profiles

Dichloropropene (fumigant)

Formulations: 1,3-D, Telone II
Pests Controlled: nematodes
Percent of Crop Treated: no information available
Types of Applications: fumigant
Application Rates: 15 gal on mineral soil is suggested
Number of Applications: 1
Timing: fall fumigant; injected into the soil
Pre-Harvest Interval: no information available
REI: 5 days
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: particular effective against cyst forming nematodes and meadow nematodes.(26)
Advantages: also helps control weeds and diseases(26)
Disadvantages: cannot use on heavy soils(26)

Metham (fumigant)

Formulations: Busan 1020 or Vapam
Pests Controlled: general-purpose fumigant for nematodes, fungicide and herbicide
Percent of Crop Treated: no information available
Types of Applications: fumigant
Application Rates: 75 to 100 gal
Number of Applications: 1
Timing: fall fumigant or pre-planting fumigant in the spring
Pre-Harvest Interval: no information available
REI: 48 hours
Use in IPM Programs: no information available
Use in Resistance Management Programs: no information available
Efficacy Issues: highly efficient
Advantages: controls bacteria, fungi, weeds and soil insects.(20)
Disadvantages: very expensive

Weeds

Weed control is important in minimizing competition between the crop and weeds, effecting crop growth, as well as in disease and insect control. Black nightshade is in the same family as tomato making it hard to control. Black nightshade is a host to Colorado potato beetle and controlling these weeds helps to control. Weed control is also an essential part of controlling tomato diseases such as bacterial spot, bacterial speck, bacterial canker, early blight and white mold.(17)

Cultural Controls

Crop Rotation
Cultivation
Hand weeding

Chemical Controls

Herbicides are used to control weeds and minimize competition. Any production area would not be able to overcome the losses caused by weeds if all herbicides were removed. Herbicides are used on 99% of the fresh market and 95% of the processing tomatoes grown in Michigan. Some of the herbicides can be alternated with others, but the loss of an individual would be critical.(17)

Herbicide Profiles

Trifluralin (dinitroanaline)

Formulations: Treflan 4E, Trilin 4E
Weeds Controlled: annual grasses and some broadleaves
Percent of Crop Treated: used on 23% of fresh market and 29% processing tomatoes grown in Michigan
Types of Applications: pre-plant incorporated on mineral soils
Application Rates: 0.5-1 ai/acre
Number of Applications: 1
Timing: Preplant incorporation
Pre-Harvest Interval: Not applicable
REI: 12 hours
Use in IPM Programs: No information available
Use in Resistance Management Programs: No information available
Efficacy Issues: short residual period
Advantages: cheap, relatively good herbicide
Disadvantages: potential for root pruning and stunting
(3)(14)(16)(17)

Paraquat (bipyridylium)

Formulations: Gramoxone Extra 2.52
Weeds Controlled: emerged annual weeds
Percent of Crop Treated: used on 2% of processing tomatoes grown in Michigan
Types of Applications: spray
Application Rates: 0.5 ai/acre
Number of Applications: 1-3, usually 1
Timing: before transplanting or after seeding but before emergence, or using shields to protect crops
Pre-Harvest Interval: 30
REI: 12 hours
Use in IPM Programs: No information available
Use in Resistance Management Programs: kills escapers
Efficacy Issues: no control of perennials
Advantages: kills all emerged green foliage
Disadvantages: no residual control, potential for tomato injury
(3)(14)(16)(17)

Napropamide (amide)

Formulations: Devrinol 50 DF
Weeds Controlled: germinating grasses and broadleaves
Percent of Crop Treated: used on 10% of fresh market and 10% processing tomatoes grown in Michigan
Types of Applications: Preplant incorporation
Application Rates: 1-2 lb ai
Number of Applications: 1
Timing: before planting
Pre-Harvest Interval: Not applicable
REI: 12 hours
Use in IPM Programs: No information available
Use in Resistance Management Programs: No information available
Efficacy Issues: No information available
Advantages: no root suppression
Disadvantages: expensive, fair effectiveness
(3)(14)(16)(17)

Metribuzin (triazine)

Formulations: Sencor 75DF
Weeds Controlled: broadleaves and some grasses
Percent of Crop Treated: used on 50% of fresh market and 80% processing tomatoes grown in Michigan

Types of Applications: Preplant incorporation, preemergence
Application Rates: 0.25-0.5 lb/ai
Number of Applications: 1-2
Timing: Preemergence, post emergence
Pre-Harvest Interval: 7 days
REI: 12 hours
Use in IPM Programs: No information available
Use in Resistance Management Programs: No information available
Efficacy Issues: very effective on most weeds, does not control eastern black nightshade
Advantages: effective, relatively inexpensive
Disadvantages: can cause phytotoxicity
(3)(14)(16)(17)

Ethephon

Formulations: Ethrel 2 lb/gal
Weeds Controlled: none, promotes ripening
Percent of Crop Treated: used on 90% of processing tomatoes grown in Michigan
Types of Applications: Post emergence
Application Rates: 0.25-1 lb/acre
Number of Applications: 1
Timing: 5-15% fruit have color
Pre-Harvest Interval: Not applicable
REI: no information available
Use in IPM Programs: No information available
Use in Resistance Management Programs: No information available
Efficacy Issues: No information available
Advantages: a plant growth regulator that produces ethylene
Disadvantages: may cause yield loss if applied at wrong time
Alternatives: There is not an effective alternative to ethephon
(3)(14)(16)(17)

Pebulate (thiocarbamate)

Formulations: Tillam 6E
Weeds Controlled: used for preplant control of grass and nutsedge in tomatoes
Percent of Crop Treated: used on 5% of fresh market and 10% processing tomatoes grown in Michigan
Types of Applications: Preplant incorporation
Application Rates: 4-6 lbs ai/acre
Number of Applications: 1
Timing: Preplant incorporation
Pre-Harvest Interval: Not applicable

REI: 12 hours
Use in IPM Programs: No information available
Use in Resistance Management Programs: No information available
Efficacy Issues: Poor herbicide
Advantages: controls nutsedge
Disadvantages: expensive, not very effective
(3)(14)(16)(17)

Sethoxydim (cyclohexenone)

Formulations: Poast 1.5L
Weeds Controlled: annual and perennial grasses
Percent of Crop Treated: used on 30% of fresh market and 16% processing tomatoes grown in Michigan
Types of Applications: Post emergence
Application Rates: 0.19-0.28 lbs ai
Number of Applications: 1
Timing: Post emergence
Pre-Harvest Interval: 20 days
REI: 12 hours
Use in IPM Programs: No information available
Use in Resistance Management Programs: No information available
Efficacy Issues: kills only grasses
Advantages: kills grasses
Disadvantages: weak on quackgrass
(3)(14)(16)(17)

Glyphosate (phosphono amino acid)

Formulations: Roundup 4L
Weeds Controlled: wide spectrum weed control, perennial weeds after they have emerged
Percent of Crop Treated: used on 2% of fresh market tomatoes grown in Michigan
Types of Applications: Pre-plant
Application Rates: 2-3 lbs ai
Number of Applications: 1
Timing: It is applied either before planting in the spring or after harvest in the fall
Pre-Harvest Interval: Not applicable
REI: 12 hours
Use in IPM Programs: No information available
Use in Resistance Management Programs: kills most weeds
Efficacy Issues: No information available
Advantages: kills most weeds
Disadvantages: can’t be weeds in the crops

Alternative Controls cultivation, handweeding of small fields
(3)(14)(16)(17)

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References

1. Agrios, G. N. (1988). Plant Pathology. San Diego, California, Academic Press, Inc.
2. Davis, M., George Hamilton, W. Thomas Lanini, Thomas Spreen, Craig Osteen (1998). The Importance of Pesticides and Other Pest Management Practices
in U.S. Tomato Production. U.S. Department of Agriculture. NAPIAP Report Number 1-CA-98.

3. George Bird, B. B., Ed Grafius, Mary Hausbeck, Lynnae J. Jess, William Kirk and Walter Pett (1999). 1999 Insect, Disease and NematodeControl
Recommendations. East Lansing, Michigan, Michigan State University.
4. MacNab, A. A., A. F. Sherf, et al. (1994). Identifying Diseases of Vegetables. University Park, Pennsylvania, Penn State College of Agricultural Sciences.
5. Michigan Agricultural Statistics Service (1988). Michigan Commercial Vegetable Survey. Lansing, Michigan, Michigan Department of Agriculture cooperating
w/ United States Department of Agriculture: National Agricultural Statistics Service.
6. Michigan Agricultural Statistics Service (1996). Michigan Rotational Survey: Vegetables - 1995-96. Lansing, Michigan, Michigan Department of Agriculture.
7. Michigan Agricultural Statistics Service (1998). Mass Chemical Use Surveys. Lansing, Michigan, Michigan Department of Agriculture: 5.
8. Michigan Department of Agriculture (1995). Michigan Agricultural Statistics. Lansing, MI, Michigan Department of Agriculture.
9. Michigan Department of Agriculture (1998). Michigan Agricultural Statistics 1997-1998. Lansing, Michigan, Michigan Department of Agriculture: 147.
10.Michigan Pesticide Use and Usage Project (1997). Crop/Pesticide Use Profile in Michigan Commodity: Cabbage. East Lansing, Michigan, Michigan State
University: 19.
11.MSU Extension (1997). Insect, Disease and Nematode Control for Commercial Vegetables. East Lansing, Michigan, Michigan State University.
12.Stephens Christine, D. F. (1986). Bacterial Canker of Tomato. East Lansing, MI, Michigan State University.
13.Stephens, D. H., Hugh Price (1983). Tomato Disorders. East Lansing, MI, Michigan State University.
14.United States Department of Agriculture, N. A. S. S. (1994). Vegetable Chemical Use Survey. Washington, DC, US Department of Agriculture: 30.
15.United States Department of Agriculture, N. A. S. S. (1998). Agricultural Statistics 1998. Washington, DC, US Department of Agriculture: 47.
16.Ware, G. (1994). *The Pesticide Book*. Fresno, California, Thomson Publications.
17.Zandstra, B. (1999). 1999 Weed Control Guide for Vegetable Crops. East Lansing, Michigan, Michigan State University.
18.Zandstra, B. H. and H. C. Price (1988). Yields of Michigan Vegetable Crops. East Lansing, Michigan, Michigan State University: 8.
19. http://www.nass.usda.gov/mi/press/pr9868.htm
20.Goldy, Ron. Comments
21.Grafius, Ed. Department of Entomolgy, MSU. Tomato, Pepper and Insect Pests. MSU extension E-971.
22.MSU Extension, Home Horticulture-01701457. Tomato Diseases
23.Foster, Rick & Flood, Brian. Vegetable Insect Management with emphasis on the Midwest.Ohio: Meister Publishing Co., 1996
24.Hausbeck, M. 1999 Comments.
25. Thomson 1994-5 *Agricultural Chemicals Book I - Insecticides.* Thompson Publications, Fresno, CA.
26. Thomson 1995 *Agricultural Chemicals Book III - Miscellaneous Agricultural Chemicals.* Thompson

Publications, Fresno, CA.
27. Thomson 1995 *Agricultural Chemicals Book IV - Fungicides.* Thompson Publications, Fresno, CA
28. Thomson 1993 *Agricultural Chemicals Book II - Herbicides.* Thompson Publications, Fresno, CA.

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