Crop Profile for Tomatoes in Indiana

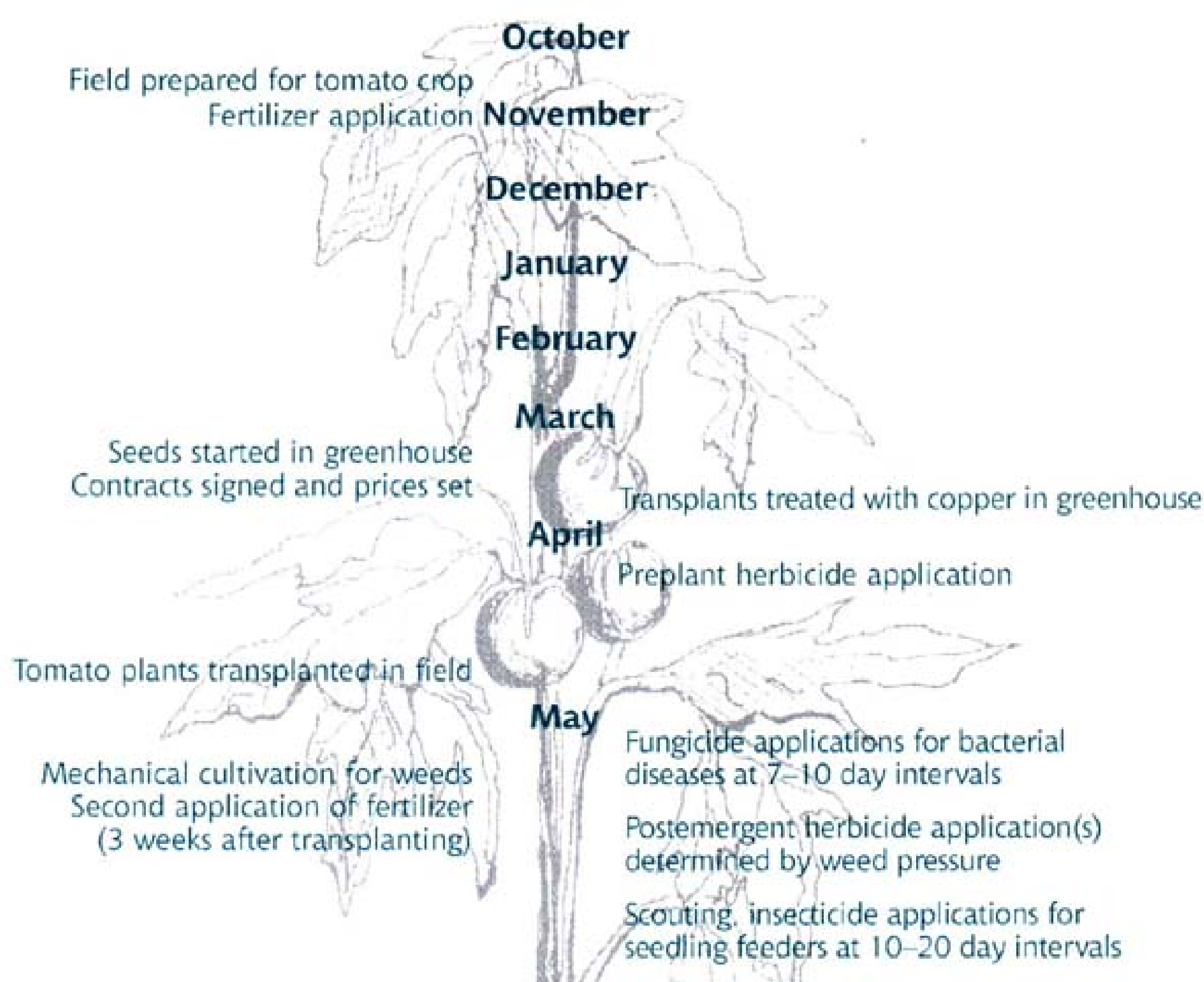
General Production Information

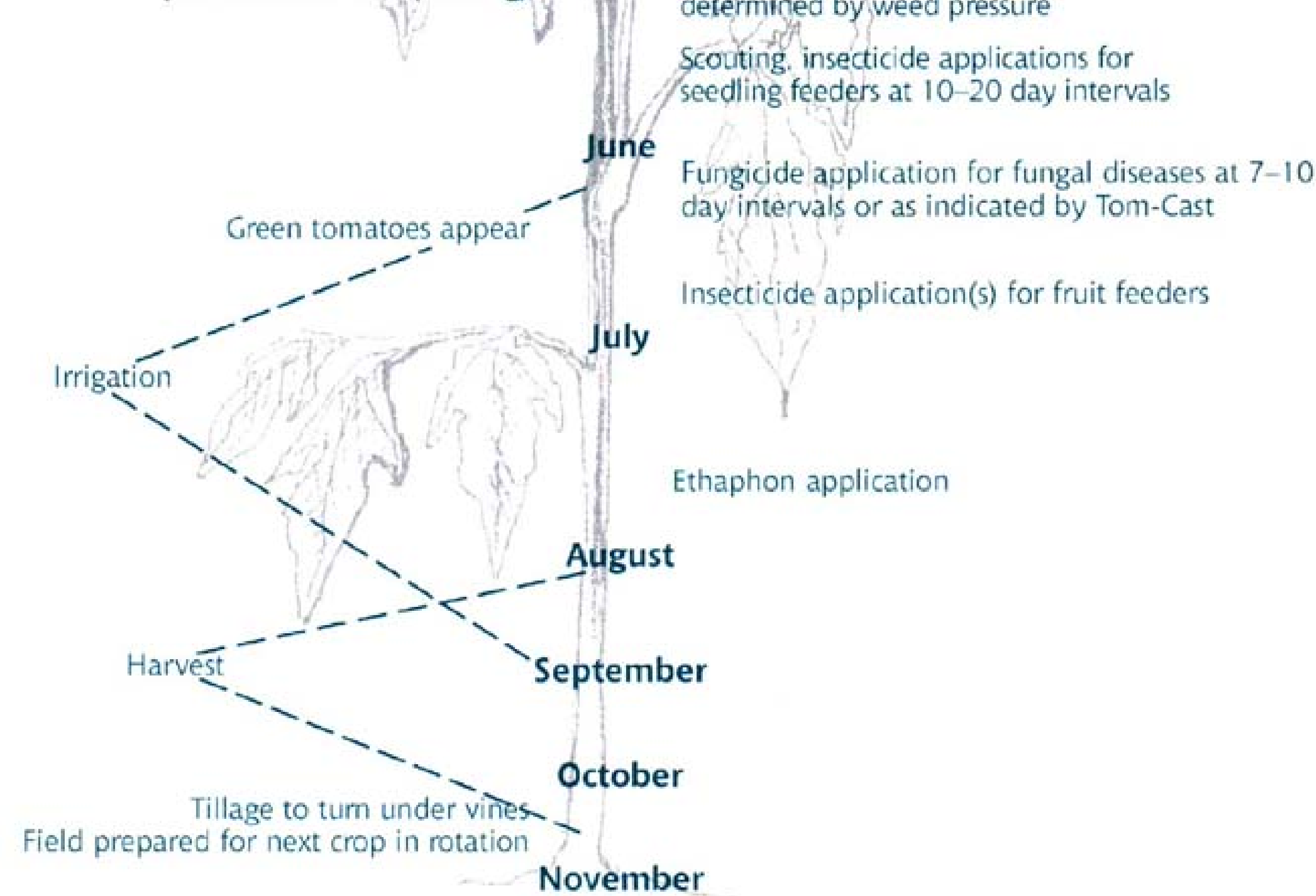
Tomatoes for processing have been grown in Indiana for many years, and for many generations in some families. The expertise of growers, an ideal climate, and good soils contribute to Indiana's ranking third in U.S. production of tomatoes for processing. In addition, easy market access makes Indiana a good base for tomato processors.

Processed tomato products fall into two categories: high value products and soft products. High value includes whole peel products such as whole tomatoes, diced tomatoes, and salsa. Ketchup, sauces, and juice are considered soft products. Tomatoes used for high value products receive higher market prices. Approximately 80% of the tomatoes raised in Indiana go into high value products.

Growers must meet quality standards set for tomatoes by each processor. Extreme damage from diseases and insects can render tomatoes unusable. High value products require tomatoes to be free from blemishes caused by diseases and insects and to be a uniform red color. Uneven color results from defoliation (too much sun) or heavy weed infestations (too little sun). Tomatoes failing to meet quality standards for whole peel products may be used for lower value soft products.

PRODUCTION TIME LINE





Growers plant tomatoes on a three-year rotation, typically, with corn and soybeans or wheat. Preparation for the tomato crop begins the preceding fall, following harvest. The field is tilled to form beds 6-7 inches high and 5.5 feet wide. About half of the growers raise tomatoes on beds based on the field's drainage. An application of fertilizer is made in the fall.

The processor contracts with greenhouses to raise tomato transplants. Seeding in the greenhouse is done in March. In most cases the processor supplies growers with transplants. A small number of growers raise tomato transplants in their own greenhouse.

The grower meets with the processor in the spring to sign contracts and set prices for the upcoming crop and determine planting dates. Planting dates are scheduled to maintain a steady flow of tomatoes to the processing plant.

At the five- to seven-leaf stage, seedlings are transplanted into the fields the end of April in southern Indiana and beginning in May for the rest of the state. A hand-loaded mechanical transplanter sets the plants in the field. A preplant application of herbicide is made to the field before transplanting.

The disease management program begins in the greenhouse, where transplants are treated with copper to reduce the threat of bacterial diseases. Copper sprays are applied soon after transplanting to protect against bacterial diseases. Applications will continue at 7-10 day intervals.

After transplanting, growers scout for migratory cutworms, flea beetles, and overwintered Colorado potato beetles. If insect numbers reach the threshold, insecticide applications are made at 14-21day intervals. Growers apply their own pesticides unless conditions are too wet, then they may hire a commercial aerial applicator.

Mechanical weed cultivation continues as needed until just prior to fruit set. Postemergent applications of herbicide depend on the effectiveness of the preplant herbicide and weed pressures. Generally, an application of sidedress fertilizer is made. When used, irrigation begins the first of June, starting in the southern part of the state, and continues until fruit is ripe. Approximately 30% of the growers are on an irrigation schedule.

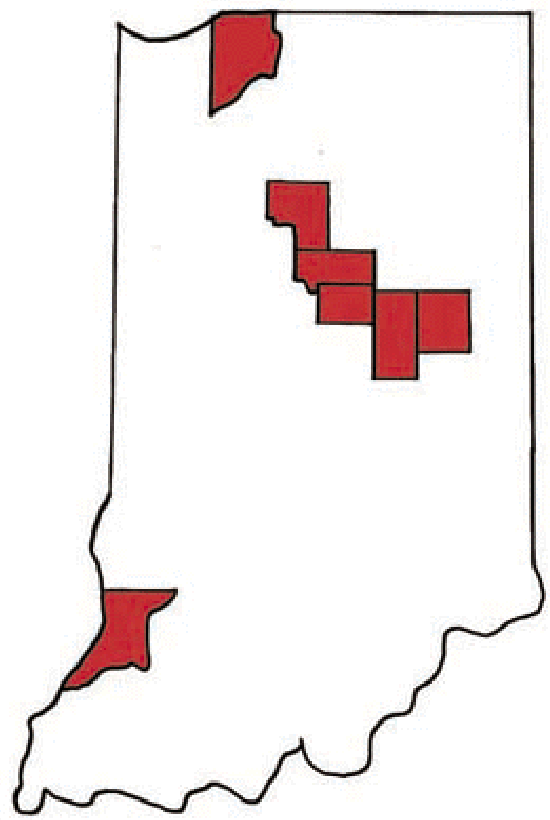
Green tomatoes the size of a walnut appear in southern Indiana around June 10 and in northern parts of the state approximately June 25. Fungicide applications continue at regular intervals or are based on Tom-Cast (see page 8). Scouting and preventative insecticide applications continue for fruit-feeding insects.

Ethaphon (Ethrel, Cepha) applications are made two weeks prior to the anticipated harvest to ripen the entire crop at once. It is applied when 10-30% of the crop is ripe or shows color. Picking can begin 15-21 days after the application. Harvest begins the first of August, starting in southern Indiana, and finishes by mid October. Tomatoes are picked by mechanical harvesters, a change that has occurred in the past five years. Improved harvest equipment, better suited to production in Indiana, has made mechanical harvesting more economical than hand labor.

After harvest, tomato plants are disked under and the field is prepared for the next crop in the rotation. If necessary, the field is deep chiseled to break up surface compaction.

- Rank in United States 3rd
- Indiana portion of U.S. production (tons) 2%
- Value of Indiana production $14 million
- Acres planted 7,000 acres
- Acres harvested 6,800 acres
- Yield per acre 25 tons
- Average price per ton $84
- Price range $50-$90
- Production cost per acre $1,7911
- Net return per acre $450
- Source:
  - 1993-1997 5-year average, Indiana Ag Statistic Service
  - 11997 Production cost study by Department of Horticulture, Purdue University

Production Regions



The counties highlighted on the map have the highest production of tomatoes for processing in the state. Many Indiana tomato growers have raised tomatoes for several generations. Families often pass processing contracts on to the next generation.

Insect Pests

Insect pests generally cause tomato damage that lowers the quality of the crop, but few threaten a crop every year. In general, without treatment growers can lose up to 10% of their crop from insect damage. Scouting is essential to protect the crop from damage and determine the need for insecticide.

Major insect pests can be divided into insects that feed on seedlings and those that feed on fruit as in the following chart.

Seedling feeders	**Fruit feeders**
May - June	**July - August**
Black cutworm	Tomato fruitworm
Colorado potato beetle	Yellow striped armyworm
Flea beetle	Stink bug
Variegated cutworm (south)	Variegated cutworm

Seedling Feeders

Flea beetle

Flea beetles are one of the first insect pests to attack tomato transplants, but really no serious damage occurs to the plant. They are present everywhere but usually not at numbers that cause severe problems. Adults can overwinter and become active by mid spring.

Percent of acres affected: 20%

Occurrence: Flea beetles appear May through July; two to three generations each year.

Damage: Adults chew holes in leaves. Transplants are most sus-ceptible due to their small leaf area. Injury is worse near overwintering sites.

Threshold: 30% defoliation of transplants

Crop loss: Yield loss is minor; less than 2%

Cutworms

Variegated: Adult moths are most active in early to mid May in southern areas; early to mid July in northern areas. Black: Adult moths are active early in the season (late March to early April). Black cutworms are a worse problem in the southern part of the state because larvae are active when tomato fields are being planted.

Percent of acres affected: 2%

Occurrence: Occurrence is sporadic. Larvae are present, May to August.

Damage: Variegated cutworm larvae feed on foliage and fruit. Black cutworm larvae cut off transplants, killing the plants and reducing stands.

Threshold: Variegated: 7-10 moths in pheromone trap per week, or 2-3% fruit feeding. Black: 1 larva/100 plants.

Crop loss: Moderate damage to crop yield, potentially 5%. Although sporadic, variegated cutworms can cause 5-10% fruit damage.

Nonchemical control:

- Destroy winter annual weeds 10-14 days before tomatoes are transplanted to discourage black cutworms.
- Scout in early morning to observe larvae.

Variegated cutworms can be a problem as a "regular" cutworm that cuts plants off at ground level early in the season and as a "climbing" cutworm that climbs plants and eats green fruit later in the season.

Colorado potato beetle

The Colorado potato beetle doesn't appear often, but when present causes severe damage. Adults overwinter in soil, in or near fields that grew potatoes, tomatoes, or eggplant.

Percent of acres affected: 2%

Occurrence: The Colorado potato beetle emerges and begins to feed in late April to early May in southern Indiana. It appears two to three weeks later in northern Indiana. Up to three generations per year.

Damage: Adults and larvae eat leaves of transplants. Damage can be severe. Colorado potato beetles will completely defoliate a plant in three to four days. Threshold: One adult, larva, or egg mass per plant

Crop loss: When present severe loss of 5% can be experienced

Nonchemical control

- Rotate out of tomatoes, potatoes, or eggplant every three years. Do not plant tomatoes within (r) mile of one of these crops.
- Scout in the early morning to observe adults feeding at top of plant.

Fruit Feeders

Tomato fruitworm

The tomato fruitworm cannot overwinter in the northern half of the state, so it migrates from the South. Peak moth activity is from mid July in southern Indiana to late August in the North. Moths are attracted to flowers and fruit. Tomato fruitworm is a worse pest in southern Indiana counties.

Percent of acres affected: 80%

Occurrence: Occurrence is sporadic. Fruitworms appear when fruit forms, in mid July.

Damage: Larvae bore into green fruit contaminating the area with feces and forming watery cavities. The fruit rots from secondary fungal infections.

Threshold: Seven moths in pheromone trap/week

Crop loss: Crop loss can be severe: up to 3-4%

Chemical control:
Insecticide must be present on plants when eggs hatch. Treatments after larvae are in fruit are of no value: damage is done and control is poor. Scheduled applications of insecticides begin with fruit to protect quality. Insecticides and fungicides are applied together.

Yellow striped armyworm:

The damage the yellow striped armyworm does is usually more severe than that of the tomato fruitworm, but it is often mistaken for fruitworm damage. The yellow striped armyworm does not overwinter in the North and must migrate from the South. It's a worse pest in the southern part of state.

Percent of acres affected: 70-80%

Occurrence: Moth activity seen mid June to September.

Damage: Larvae bore into green fruit. One worm feeds on several fruits and will destroy several clusters.

Threshold: One egg mass per plant

Crop loss: Yellow striped armyworms can cause 1-8% fruit loss. Loss is severe in some locations, a nuisance in others.

Chemical control: Treatment must continue even after completion of flowering.

<u>**Stink bug**</u>

Stink bugs become a concern at the initiation of fruit set. They move into the field from surrounding weeds.

Percent of acres affected: 80%

Occurrence: The stink bug appears annually, in mid July to September.

Damage: Stink bugs cause damage by removing fluids and injecting enzymes into the fruit.

Threshold: No threshold, difficult to sample. Requires preventative applications of insecticide.

Crop loss: Stink bug damage lowers quality. Without treatment, 8-10% fruit damage can be expected.

Stink bug

Stink bug damage to tomatoes. Adults and nymphs insert their sucking mouth parts into fruit to feed. As tomatoes ripen, yellow spots and hard, corky fruit form at the feeding sites.

Chemical control for all insect pests:

- **Cyhalothrin** (Warrior)
  Target insects: cutworms, Colorado potato beetle (CPB), tomato fruitworm, yellow striped armyworm, stink bug
  Percent of acres treated: 85-90% Average rate and frequency:

cutworms 1.9-3.2 fl.oz./acre 1-2 applications
stink bug 1.9-3.2 fl.oz./acre 2-5 applications
CPB 2.6-3.8 fl.oz./acre 1 application
tomato fruitworm, armyworm 2.6-3.8 fl.oz./acre 2-5 applications
PHI: 5 days
Comments: Not to exceed 2.88 pt./acre of active ingredient

- **Endosulfan** (Thiodan)
Target insect: stink bug
Percent of acres treated: 25%
Average rate and frequency:
Thiodan 50 WP 1-2 lb./acre 2-5 applications
Thiodan 3 EC .6 -1.33 qt./acre 2-5 applications
PHI: 2 days

- **Cyfluthrin** (Baythroid)
Target insects: Colorado potato beetle (CPB), tomato fruitworm, yellow striped armyworm, stink bug
Percent of acres treated: 10-15%
Average rate and frequency:
CPB 1.6-2.8 fl.oz./acre 1 application
armyworm, stink bug, tomato fruitworm 1.6-2.8 fl.oz./acre 2-5 applications

- **Methyl parathion** (Penncap-M)
Target insects: flea beetle, Colorado potato beetle (CPB), stink bug
Percent of acres treated: 10%
Average rate and frequency:
flea beetle 2-4 pt./acre 1 application
CPB 4 pt./acre 1 application
stink bug 4 pt./acre 2-5 applications
PHI: 15 days

- **Esfenvalerate** (Asana XL)
Target insects: flea beetle, cutworms, Colorado potato beetle
Percent of acres treated: 5%
Average rate and frequency:
5.8-9.6 fl.oz./acre 1-2 applications
PHI: 1 day
Comments: Not to exceed .35 lb./acre of active ingredient

- **Carbaryl** (Sevin; Adios)
Target insects: flea beetle, cutworms
Percent of acres treated: 5%
Average rate and frequency:
FLea beetle 2 lb./acre 50 WP 1 application, 1.25 lb./acre 80 S, 1 qt./acre XLR Plus
cutworms 4 lb./acre 50 WP 1-2 applications, 2.5 lb./acre 80 S, 2 qt./acre XLR Plus
PHI: 3 days

- **Imidacloprid** (Provado, Admire)
Target insect: Colorado potato beetle
Percent of acres treated: less than 1%
Average rate and frequency:
Provado 3.75 fl.oz./acre 1 application
Admire 16-24 fl.oz./acre 1 application
PHI: none, Provado; 21 days, Admire.
Comments: Not to exceed 18.75 fl.oz./acre of active ingredient

Diseases

Production of tomatoes for processing in the eastern United States would be impossible without fungicides and copper bactericides to control diseases. Preventative applications of pesticides must be made to avoid or reduce losses from diseases.

Bacterial Diseases

Canker

Bacterial canker infects seeds in the greenhouse. The diseased seedlings introduce the pathogen into production fields. Rain or irrigation water carries the bacteria and spreads the pathogen to nearby plants. Bacterial canker is favored by high temperatures and humid weather.

Percent of acres infected: 5-10%

Occurrence: Canker appears throughout the season. It occurs every year but not in every field.

Damage: Bacterial canker can spread throughout the plant, interfering with water-conducting tissue, which causes part or all of the plant to wilt. Symptoms include scorching of leaf margins, fruit lesions, stunted growth, and stem cankers.

Critical timing: Protective copper sprays are applied from the time seedlings are transplanted through the period of peak flower production.

Crop loss: The loss is 0-25% depending on the stage of plant development when infections occur. Early season infections reduce yields, due to decreased flower production and leaf loss. Fruit lesions prevent the crop from meeting quality standards imposed by processing plants, resulting in near total loss of the crop. Late season infections have little effect on crop yields.

Spot and Speck

Both diseases are spread by splash dispersal of bacteria from infected plants to plants in neighboring rows and adjacent fields. Bacterial spot favors high temperatures and humid weather. Bacterial speck is a threat when conditions are relatively cool and wet during early crop growth.

Percent of acres infected: Spot, 10-15%; speck, 25-50%

Occurrence: Symptoms of both diseases may be seen throughout the season. Contaminated seeds infect seedlings in production facilities.

Damage: Bacterial spot and speck cause moderate to severe defoliation, blossom blight, and lesions on green and ripe fruit.

Critical timing: Preventative copper sprays to seedlings begin in the greenhouse. Sprays continue in the field through the period of peak flower production.

Crop loss: Losses range up to 50%. Defoliation and blossom loss reduce yield. Spots on fruit reduce quality. Late season disease outbreaks have negligible effects on crop yields.

Nonchemical control of bacterial diseases:

- Rotate out of host crop (i.e. tomato, eggplant, pepper) for two to three years.
- Use disease-free seeds and transplants.
- Sanitize plant production equipment.
- Control weeds related to tomatoes (nightshade) which may harbor bacteria.
- Schedule irrigation to allow plants to dry before nightfall.
- Cultivate fields after harvest to hasten the decomposition of infested crop residue.

Chemical control of bacterial diseases:

- Percent of acres treated: Nearly 100%
- Comments: Concern of bactericide resistance
    - **Copper hydroxide** (Kocide 2000, Champ II)
      Average rate and frequency: Full label rates (rates vary with product and must be reviewed each year. Applications begin 10-14 days after transplanting and continue at 7-10 day intervals until fruit is almost mature.
    - **Copper resinate** (Citcop 5E)
      Average rate and frequency: Full label rates (rates vary with product and must be reviewed each year. Applications begin at first bloom, before disease appears; two to four sprays are applied at 7-10 day intervals.

Fungal Diseases

Early blight

Early blight is caused by a fungus that survives in plant residue in the soil. Rain or irrigation water carries and spreads the disease within the field and to adjacent fields.

Percent of acres infected: 80-100%

Occurrence: A common disease, early blight occurs mid to late season (July through August, sometimes September). Outbreaks are more severe when plants are stressed by drought, other pests, or poor nutrition. Early blight occurs occasionally on greenhouse seedlings.

Damage: Initial infections usually occur on older, dying leaves. Unprotected plants can be completely defoliated. If ripe fruit is not protected it may become infected.

Critical timing: July through August

Crop loss: Yield is reduced by 30-50% from defoliation and fruit rot. Early season outbreaks may result in reduced fruit production.

Nonchemical control:

- Rotate out of tomatoes and potatoes for three years.
- Use certified disease-free transplants.
- Control weeds and volunteer tomatoes.
- Maintain optimum fertility levels.
- Schedule irrigation to allow plants to dry before nightfall.
- Cultivate fields after harvest to promote decomposition of infested crop residue.

<u>Septoria leaf blight</u>

The pathogen survives in infested crop residue. Spores produced by the pathogen are carried in rain and irrigation water to plants in nearby rows and adjacent fields.

Percent of acres infected: 10-50%

Occurrence: Septoria leaf blight occurs every year between June and September, but not in every field.

Damage: Septoria leaf blight damages foliage and stems. Premature leaf drop results in susceptibility of the fruit to sunscald.

Critical timing: July through August

Crop loss: Yield loss can range from 5-50% depending on the severity of the outbreak and the stage at which the disease becomes established in the field.

Nonchemical control:

- Rotate out of tomatoes every three years.
- Control weeds that may harbor the disease, such as black nightshade, horse nettle, and Jimson weed.
- Cultivate fields after harvest to hasten the decomposition of infested crop residue.

<u>Anthracnose fruit rot</u>

The fungal pathogen overwinters in infested plant residue and soil. Spores from the residue in the soil may be splashed onto leaves and fruit by rain and irrigation water. Lesions are most often observed on ripe fruit.

Percent of acres infected: 100%

Occurrence: Anthracnose fruit rot occurs in late July through September. Initial infections may occur on green fruit.

Damage: Symptoms become most evident when tomatoes begin to ripen. Fungus growing in lesions, along with soft rot bacteria, form a semisoft decay.

Critical timing: Preventative sprays begin the first of July when first tomatoes are larger than a walnut.

Crop loss: Fruit infected with 3% anthracnose fruit rot can result in total rejection at the processing plant.

Nonchemical control:

- Rotate out of tomatoes every three years.
- Avoid fields with a history of severe anthracnose problems.
- Use later maturing varieties which show some resistance.
- Schedule irrigation to allow plants to dry before nightfall.
- Cultivate fields after harvest to hasten the decomposition of infested crop residue.

anthracnose

Anthracnose fruit rot is the major fungal disease affecting processing tomatoes in the Midwest. Characteristic circular lesions are apparent on ripe fruit.

Chemical control of fungal diseases:

Some tomato processors do not accept tomatoes treated with mancozeb (EBDC). Growers rely on chlorothalonil and azoxy-strobin to control all three fungal diseases. Growers alternate applications of the three fungicides listed below throughout the season.

- **Chlorothalonil** (Bravo, Terranil, Echo)
  Target diseases: early blight, Septoria leaf blight, anthracnose fruit rot
  Percent of acres treated: 100%
  Average rate and frequency: 2-3 pt./acre flowable; 1.5-2.5 lb./acre dry. Applied at 7-10 day intervals or as indicated by Tom-

Cast.

- **Mancozeb** (Dithane M-45 DF, Manzate 200 DF, Penncozeb, Manex II)
  Target diseases: early blight, Septoria leaf blight, anthracnose fruit rot
  Percent of acres treated: 50-100%
  Average rate and frequency: 2-3 pt./acre flowable; 2-3 lb./acre dry. Applied at 7-10 day intervals or as indicated by Tom-Cast.
  PHI: 5 days Comments: There are reports of synergistic control of bacterial diseases when mancozeb is tank mixed with copper hydroxide.

- **Azoxystrobin** (Quadris)
  Target diseases: early blight, Septoria leaf blight, anthracnose fruit rot
  Percent of acres treated: 100%
  Average rate and frequency: 5-6.2 fl.oz./acre at 7-14 day intervals or as indicated by Tom-Cast. PHI: 7 days

Tom-Cast (TOMato disease foreCASTer) is a weather-based computer model that indexes the risk of development of early blight, anthracnose fruit rot, and Septoria leaf blight. Tom-Cast helps growers predict diease outbreaks. Im-proved timing of fungicide applications helps to better manage fungal diseases.

Weeds

Eastern black nightshade

Production practices have selected Eastern black nightshade to be the major weed problem of Indiana tomato producers.

Acres affected: 100%

Occurrence: Appears annually in early spring (late April to late May).

Damage: Reduced yield and quality due to competition for light, nutrients and water.

Critical timing: Eastern black nightshade germinates at the same time tomatoes are transplanted in the field. The early season competition greatly reduces growth in the tomato plant if it is not controlled.

Crop loss: Average 5-10% yield loss. Up to 50% yield loss with heavy infestations even with hand cultivation. Eastern black nightshade berries are poisonous and cause rejection at processing plant.

Nonchemical control:

- Rotate crops. However due, to the large soil seed bank of nightshade in Indiana fields, when tomatoes are planted Eastern black nightshade problem is still a problem.

- Hand cultivation, but it is cost-prohibitive. Hand cultivation can cost $100-$230 per acre, and yields may still be reduced.

Chemical Control:

Eastern black nightshade is of the same family as tomatoes (Solanaceae) making it difficult to control with herbicides. No herbicides currently labeled for tomatoes control Eastern black nightshade.

In 1991 the manufacturer of Amiben (chloramben) stopped making the herbicide. Most growers stockpiled supplies and used chloramben through the 1995 growing season.

Section 18
A Section 18 was granted for Dual (metolachlor) in 1997 and 1998. Without any chemical control Eastern black nightshade threatens the financial stability of Indiana tomato growers.

Growers are unable to raise tomatoes on severely infested fields even when they practice crop rotation. In heavily infested fields Eastern black nightshade not only lowers the yield and quality of the tomato crop, but also the crop following tomatoes.

Under the Section 18 exemption, the use of Dual offers no greater risk to applicators or any threatened, endangered and non-target species. Dual is applied to soybeans, field corn and snap beans in Indiana. The number of treated acres of tomatoes are less than one percent of the total crop acres in Indiana.

Eastern Black Nightshade

Eastern black nightshade is of the same family as tomatoes (Solanaceae) making selective control difficult.

Other Weed Pests

- Annual grasses: giant, green and yellow foxtail, barnyard grass and crabgrass
- Vines: annual morningglories
- Broadleaves: Eastern black nightshade, lambsquarters, pigweed, yellow nutsedge; sometimes cocklebur and velvetleaf

Acres affected: 100%

Occurrence: Weeds appear early in May in southern Indiana and mid May for the remainder of the state.

Damage: Competition for light, water, and nutrients. Heavy growth of weeds, especially vines, can prevent fungicide and insecticide applications from reaching the targeted pest. Weedy fields also hinder harvesting equipment.

Crop loss: Reduced yield from competition. Reduced yield and reduced quality when fungicide and insecticide applications failed to control targeted pest. Tomatoes are smaller, less uniform and possibly damaged from disease and insects.

Nonchemical control:
Cultivation done by 80% of growers. Some limited handweeding done.

Chemical control:

Preemergence and postemergence control:

- **Metribuzine** (Sencor/Lexone)
  Target weeds: Broadleaves, annual morning glory
  Acres treated: 100%
  Average rate: .5-1 pt./a of 4F,4L .33-.66 lb/a of 75DF PHI:7 day
  Comments: Do not exceed 1.33 lb. 75DF Apply only to transplants

- **Metolachlor** (Dual, Dual II 8E, 7.8 E)
  Target weeds: Eastern black nightshade, annual grasses, pigweed, ragweed
  Acres treated: 75%
  Average rate: 1-1.5 pt./a PHI: 90 days
  Comments: Maximum 2 pt/a on course soils; maximum 2.5 pt/a on fine-medium soils with < 3% OM; maximum 3 pt./a on fine-medium soils with > 3% OM Apply only to transplants Section 18 for 1997 and 1998

- **Trifluralin** (Treflan 4E, 10G)
  Target weeds: Annual grasses, pigweed
  Acres treated: 50-70%
  Average rate: .6 pt/a on light soils with <2% OM 1.5 pt on dark soils in 25 gal of water/a
  Comments: Apply only to transplants

Postemergence control:

- **Sethoxydim** (Poast, Ultima 160 1.5 E)
  Target weeds: Annual grasses
  Acres treated: 60%
  Average rate: 1-1.5 pt/a plus 1 pt. nonionic surfactant PHI: 20 day
  Comments: Maximum 4.5 pt/a

- **Clethodim** (Select 2EC)
  Target weeds: Annual grasses
  Acres treated: 20%
  Average rate: 8 fl.oz/a and 1%v/v crop oil concentrate, Can be tank mixed with Lexone/Sencor. PHI: 20 days
  Comments: Do not apply tank mix within 24 hours of another pesticide. Apply to actively growing grass (2?-6?) New in 1998

Other herbicides applied to tomatoes for processing, but by less than 10 % of the growers, include dacthal, devrinol, tillam and paraquat.

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