Crop Profile for Tomatoes in Pennsylvania

Prepared: April, 1999

General Production Information

- Pennsylvania ranks 6th among U.S. states in tomato acreage.
- 4,900 acres of tomatoes were harvested in 1997. This figure has fluctuated but has remained relatively steady throughout the 1990's.
- 986 Pennsylvania vegetable operations harvest tomatoes. This is more than any other single state, with the exception of California.
- Tomatoes are economically the 2nd most important vegetable crop grown in behind Sweet Corn (not including Mushrooms as a vegetable crop).
- Cash receipts totaled $12.35 million for fresh tomatoes and $2.1 million for processing tomatoes in 1997.
- 26-28,000 tons of processing tomatoes are produced by growers each year.
- 48% of 1997 Pennsylvania tomato production was for fresh market outlets while the remaining 52% was for processing.
- 38% of Pennsylvania tomato producers irrigate approximately 31% of the acres produced.
- Fresh market production averages 11-15,000 lbs./acre, though the most productive growers may yield up to 36,000 lbs./acre.
- To ensure competitive yields and high quality produce, fresh market tomatoes are grown in intensive cultivation systems, which require annual expenditures of $1,500 to $5,000/acre.

Cultural Practices

Fresh Market

About 20% of fresh market tomatoes in are grown on six-inch raised beds. The balance of tomatoes are grown on flat beds. Less than 2% of tomatoes produced for the fresh market are grown using no-till. Most growers use stakes woven with mesh to support the plants. Individual staking is rare. Some growers that produce tomatoes for the fresh market use black polyethylene mulch for weed control, without additional fumigants applied to beds, although herbicide is applied between rows. Less than 25% of growers use red plastic mulch instead of black. Fumigants are used rarely or not at all in most counties, and are applied at the lowest labeled rates when used. Many fresh market growers employ trickle irrigation/nutrient delivery systems. In addition, the crop is transplanted, pruned, tied several

times if a trellis system is used, and hand-harvested.

Processing

For the most part, cultural practices for processing tomatoes are similar to those used for fresh market tomatoes. Most processing tomatoes are grown on bare ground using overhead or drip irrigation. No plastic or stakes are used. Nearly all processing tomatoes are machine harvested. Less than 1% are hand harvested.

Pesticide Usage

Because of the high overhead investment, growers of both fresh market and processing tomatoes tend to make conservative decisions regarding the use of pesticides. Disease control is achieved with preventative pesticide treatments. For fresh market tomatoes, fungicides are typically applied every 7 to 14 days, depending upon weather conditions. Insecticides are used less frequently. The fresh market grower usually applied not more than 7 total fungicide and insecticide applications in 1998, and this was likely a typical year. Due to quality issues, processing tomatoes may use 1-2 more fungicide applications. Plant growth regulators are used on processing tomatoes to synchronize the maturation of the fruit for mechanical harvesting. All tomato growers are faced with resistant pest populations, particularly of the Colorado potato beetle. The rising costs of agrochemical inputs are a major constraint to growers, which may limit tomato production.

Insect Pests

Insects and mites are controlled with a combination of non-chemical and chemical controls. Crop rotation is an important cultural practice for control of Colorado potato beetle and other insect pests. Preplant drenches of transplants with preventative insecticides have been found to be an effective and inexpensive means of insect control in tomatoes. Increasingly, transplants are arriving pre-treated with imidacloprid. Total insecticide applications may be as low 0 to 1 application during the growing season. About 1/3 to 1/2 of the Pennsylvania processing tomato acreage is treated with insecticide in an average year.

Major Insect Pests

Colorado Potato Beetle (*Leptinotarsa decemlineata*)

The Colorado potato beetle is the most severe pest on both processing and fresh market tomatoes in Pennsylvania. This species has developed resistance to every known class of insecticides. CPB adults appear shortly after seedling emergence or transplanting. Early season populations tend to be concentrated in areas where tomatoes or potatoes were previously grown.

Colorado potato beetles are chewing insects. Their damage consists of holes in the leaves and/or consumption of whole leaves and stems. The CPB overwinters as an adult several inches beneath the soil surface. Eggs are deposited in groups of 10 to 30 on the undersides of leaves. The larvae feed for 2 to 3 weeks before entering the soil to pupate. There are 1-2 generations each year in Pennsylvania. They will feed on tomatoes, potatoes, and eggplant.

Non-chemical controls:
Rotation to nonsolanaceous crops (crops other than potato, tomato, eggplant, and pepper) is extremely important in reducing CPB problems. Scouting is used and spraying is only done when necessary. The application of late-season sprays is avoided to prevent the buildup of insecticide-resistant beetles. *Bacillus thurigiensis tenebrionis* is used on some tomato crop acreage.

Chemical controls:
The main chemical used on the Colorado potato beetle is the newly registered chemical, imidacloprid (Admire 16-24 fl oz 2F/A and Provado 3.75 fl oz 1.6F/A). Imidacloprid is very effective in low dosages against the CPB. Admire has largely replaced oxamyl (Vydate) as the insecticide of choice in soil-applied transplant drenches, whereas Provado has replaced many of the standard foliar insecticides. Imidacloprid is also a valuable chemical for use on aphids, whiteflies and flea beetles. There have been essentially no chemicals that can serve as effective alternatives to imidacloprid; however, the newly labeled Spintor (spinosad 0.023-0.13 lbs. ai/A) is proving to be quite effective. This alternative insecticide is preferred by some growers hoping to slow imidacloprid resistance in the Colorado potato beetle. Other chemicals used on tomatoes for Colorado potato beetle control include abamectin, esfenvalerate, cryolite, azinphos-methyl, azadirachtin, rotenone, endosulfan, and lambda-cyhalothrin.

Aphids (Green Peach and Potato)

Second in terms of insect pest severity are aphids. Aphids are small, soft-bodied, greenish insects, usually found on the undersides of leaves. They suck plant juices, causing leaves to curl and lose color. In addition to the damage caused by their feeding, aphids may transmit a mosaic virus disease. The green peach aphid, which has developed resistance to all the major insecticides used against it, is the biggest insect control issue. All life stages may occur annually and many generations may occur in a year. Aphids are unusual in that the female may produce young without mating. Also, they can produce live young. During adverse weather conditions, winged aphids may be produced. At certain times male and female aphids are produced, and these mate to produce young. Aphids overwinter in the egg stage.

Chemical controls:
Insecticide application is applied at the time aphids first appear on the leaves. Repeated treatments are sometimes necessary. Thorough spray coverage of the undersides of leaves is important. Many growers use Imidacloprid (Admire, Provado). It has low toxicity and is one of the most effective chemicals available. The pyrethroids Lambda-cyhalothrin (Warrior) and cyfluthrin (Baythroid) are used; as well as the older organophosphates such as dimethoate; carbamates such as oxamyl (Vydate) and methomyl; and cyclodienes such as endosulfan (Thiodan). Cost or availability of chemicals due to their use on other crops in a diversified fresh-market farm will influence choice of chemicals.

Worms (Tomato Fruitworms, European Corn Borer, and other lepidopteran larvae)

The third highest rated insect in terms of pest severity are lepidopteran larvae. When feeding on tomatoes, the larvae burrow into the fruit. The European corn borer and the corn earworm are the most important insects in the United States because it causes serious damage in a wide range of plant hosts.

Chemical controls:
Treatment of worms mainly consists of lambda-cyhalothrin (Warrior 2.56-3.84 fl. oz. IE/A), cyfluthrin (Baythroid 1.6-2.8 fl oz 2E/A), azinphos-methyl (Guthion 3-6 pt 2L/A), esfenvalerate (Asana 2.9-9.6 fl oz 0.66 EC/A), methomyl (Lannate 1.5-3 pt LV/A), cryolite (15-30 lb Kryocide 96WP/A or 25-50 lb Prokil cryolite 96WP/A), and fenpropathrin (Danitol 10.67 oz 2.4ED/A). The microbial extract spinosad (Spintor 3-6 fl oz/A) was recently registered and may gain market share for worms.

Other Insect/Mite problems
(many of these treatments rarely occur but are occasionally vital to producing quality fruit)

Leafminers and pinworms

Leafminers and pinworms are a rare problem in Pennsylvania under field conditions, but cam be a serious problem in greenhouse production. The pinworm is an introduced pest on southern transplants.

Chemical controls:
Abamectin (Agri-Mek 8-16 fl oz 1.5 EC/A) is the main chemical used for control. Other chemicals used include dimethoate, esfenvalerate, diazinon, cyromazine, cyfluthrin, azinphos-methyl, methyl parathion, and oxamyl.

True Armyworm (TAW), Fall Armyworm (FAW), Beet Armyworm (BAW)

Chemical controls:
Cyfluthrin (Baythroid), methyl parathion (Lannate), lambda-cyhalothrin (Warrior).

Mites

Chemical controls:
Abamectin or dicofol (Kelthane MF). Use of dimethoate for aphids and leafminers may help reduce mite population.

Thrips

A major concern is thrips spread of tomato spotted wilt virus. Growers are advised to avoid transplants grown in greenhouses that harbor ornamentals, flowers or hanging baskets. Some growers scout for thrips and begin treatments when thrips are observed.

Chemical controls: Use of lambda-cyhalothrin (Warrior) for other pests reduces thrips populations. *In the greenhouse*: malathion is used. The use of endosulfan (Thiodan) for control of aphids or whiteflies in the greenhouse will suppress thrips. *In the field*: imidacloprid (Admire, Provado) and azinphos-methyl (Guthion) are used. Spinosad may be tried for this insect in the near future.

Stinkbug

Chemical controls:
Cyfluthrin (Baythroid), endosulfan (Thiodan), and lambda-cyhalothrin (Warrior).

Whiteflies

Chemical controls:
imidacloprid (Admire), esfenvalerate (Asana XL), azinphos-methyl (Guthion), imidacloprid (Provado), and endosulfan (Thiodan).

Fruit Fly (Vinegar Fly)

Chemical controls:
In the field:diazinon; *basket or bin treatment*:apply a dust containing 0.1% pyrethrum + 1% piperonyl butoxide at the rate of 0.5 to 1 pound of dust per ton of fruit. Processing:indoors, apply pyrethrum fog when plant is shut down temporarily and before cleanup.

Cutworms

Chemical controls:
Preplanting: diazinon; *postplanting*: esfenvalerate (Asana XL), methyl parathion (Lannate), carbaryl (Sevin bait), lambda-cyhalothrin (Warrior).

Spider Mites

Chemical controls:
Abamectin (Agri-Mek) is the main chemical used. Some endosulfan (Thiodan) is also used.

Diseases

Diseases are the most important category of pest in Pennsylvania tomatoes, particularly fresh market tomatoes, where growers need to keep plants healthy over a longer harvest period. Early blight, bacterial spot, and late blight are the most severe diseases in Pennsylvania, both for fresh market and processing tomatoes. In addition, anthracnose can be severe on fresh market tomatoes, which are harvested ripe, and on processing tomatoes. Early blight, Septoria leaf spot, and Botrytis fruit rot are a consistent problem, requiring chemical treatment every year. Late blight and Septoria leaf spot have occurred with growing frequency in the past few years, and often require control measures. Sclerotinia becomes a major control issue once it has infested a field. The bacterial diseases, including bacterial speck, bacterial spot, and bacterial canker, are more problematic than fungal diseases for fresh market tomatoes. They are difficult to control, since few effective products are available. The only effective controls are the copper products. Bacterial diseases are less of an issue for processing tomatoes, except when they occur early in

the growing season. Processing varieties are generally more resistant to bacterial diseases, and these bacterial diseases are primarily a cosmetic problem. Some growers in Pennsylvania maintain a simplified approach to disease control, using a single effective fungicide as their primary control throughout the season. Chlorothalonil (Bravo) is the most popular choice. Most growers, however, rotate fungicides with dissimilar modes of action. This is important for fungicides where the risk of resistance development is high. Azoxystrobin (Quadris) is an important newly labeled broad-spectrum fungicide for tomatoes in Pennsylvania. It is very effective against some fungal diseases that are not controlled by chlorothalonil. Many growers alternate azoxystrobin with chlorothalonil for very effective control of fungal diseases.

Major Disease Pests

Early and Late Blight

Early blight causes necrosis of leaves, stems, and flowers, and occurs during warm rainy or humid weather. The disease overwinters on the residue of previous crops, particularly tomatoes and potatoes. Infection occurs first, and is most severe, on older plant tissue. Early blight is controlled in Pennsylvania primarily by chemical controls. However, there are some cultural practices that reduce initial disease inoculum or subsequent spread.

Late blight is an increasingly important disease in Pennsylvania, though it doesn't occur every year. It is favored by cool, wet conditions, and is controlled primarily by chemical controls. The most commonly used chemicals are azoxystrobin (Quadris), mancozeb, or Tattoo C (chlorothalonil and propamocarb hydrochloride). Tattoo C was available in 1998 under section 18 registration in Pennsylvania. It does not yet have a section 3 registration. Metalaxyl (Ridomil) has also been used. Several races of *Phytophthora infestans* (the fungus which causes late blight) are now resistant to metalaxyl. Therefore, metalaxyl is effective only on some pathogen populations. Ridomil Gold contains copper, which was added to slow resistance development.

Leaf Spots and Fruit Rots

The leaf spot diseases are recognized by lesions or blotches produced on plant foliage or stems. In addition to early blight (see above), leaf spot diseases include gray leaf spot and Septoria leaf spot.

Crop rotation, proper fertility, and the use of disease-free transplants are important in disease management. Preliminary studies indicate that this disease is reduced in no till tomatoes compared to

tomatoes grown on black plastic. Leaf blights are also controlled in Pennsylvania with chemical controls. Fruit rot results from infection by *Alternaria, Colletotrichum*, and other pathogens.

Anthracnose, the most important fruit rot on processing tomatoes, overwinters on decayed plant material in the soil. Sunken circular lesions on the fruit, often with dark centers with a concentric ring pattern characterize this disease. To control anthracnose, growers use disease-free seed, practice crop rotation, and plow under crop refuse. Protectant fungicide sprays are necessary on processing tomatoes.

Buckeye rot infects tomato fruit when severe rain or high humidity occurs. It is not an issue in fresh market tomatoes, but is of economic importance to growers of processing tomatoes. Buckeye rot is controlled in Pennsylvania through a three-year crop rotation schedule.

Wilts

Fusarium and Verticillium wilts occur in Pennsylvania. Wilt symptoms begin on older leaves. The leaves of Fusarium infected plants turn yellow, while leaves of Verticillium infected plants will often have brown V-shaped lesions. Vascular system discoloration occurs for both Fusarium wilt (brown or red-brown) and Verticillium wilt (tan). Crop rotation is relatively ineffective for Fusarium wilt, but resistant cultivars are available for both wilt diseases. Rotation in combination with resistant varieties is widely practiced and often successful in controlling disease. Chemical controls are ineffective.

Disease Management

Non-chemical controls:
Crop rotation is currently the leading non-chemical control practice used (90% of tomato crop). Fresh tomatoes are rotated to minimize the economically damaging effects of early blight, bacterial speck and spot, canker, and Septoria leaf spot. Processing tomatoes are rotated to reduce damage resulting from bacterial speck and spot, canker, early blight, buckeye rot, and anthracnose. On fresh market tomatoes, resistant varieties are used to control Fusarium wilt and Verticillium wilt. For processing tomatoes, resistant varieties are selected to control Fusarium wilt and Verticillium wilt.

Chemical controls:
Prior to the recent registration of azoxystrobin (Quadris) on tomatoes, mancozeb was the primary fungicide used on *fresh market tomatoes*. At that time, mancozeb was used on approximately 75% of the fresh market tomato crop, and it continues to be used extensively. The fungicide is applied at a rate of 2.4 Lb. a.i./acre. Prior to the registration of azoxystrobin, mancozeb was applied approximately 4-6 times per year to control early blight, anthracnose, and Septoria leaf spot. Chlorothalonil is used on about 1/4 of Pennsylvania's fresh market tomato crop. This fungicide is applied at a rate of 2.25. Lb. a.i./

acre 3-6 times per year to control early blight and anthracnose. The recent registration of azoxystrobin has increased grower options. However, azoxystrobin has some systemic activity, and therefore resistance management is a concern. Alternation of chemicals with varying modes of action will reduce the potential for resistance build-up. If chlorothalonil were to be lost from use, the best substitutes would be mancozeb or azoxystrobin. If mancozeb were lost, chlorothalonil or azoxystrobin would be the best substitutes, with no predicted loss or gain of tomato yield; however, this would likely result in increased cost to the grower. Another chemical used on fresh market tomatoes is copper (on bacterial speck and spot). However, copper is used on less than 5% of the tomato acres in the state.

Chlorothalonil, azoxystrobin, and mancozeb are the key fungicides used on *processing tomatoes*. Chlorothalonil has historically been used on Pennsylvania's entire crop with few exceptions. The fungicide is applied at an approximate rate of 2.25 lb. a.i./acre 4 times per year to control early blight, anthracnose, Septoria leaf spot, gray leaf spot, anthracnose and buckeye rot. If chlorothalonil were lost from use, a combination of mancozeb, azoxystrobin, and copper could be used. Mancozeb has historically been used on around half of Pennsylvania's processing tomatoes. The fungicide is applied at an approximate rate of 2.4 lb. a.i./acre twice a year to control early blight, anthracnose, Septoria leaf spot, gray leaf spot, and buckeye rot. If mancozeb were lost, a combination of chlorothalonil, azoxystrobin, and copper could be used.

Weeds

Nearly all fresh market growers use black polyethylene mulch for weed control, without additional fumigants applied to beds, although herbicide is applied between rows. Annual broadleaves, annual grasses, and nutsedge are the most severe weed problems on Pennsylvania's tomato crop.

Major Weed Pests

Eastern black nightshade

This weed is problematic since it is also solanaceous and the herbicides usually used in tomatoes (napropamide, trifluralin, pebulate, metribuzin, and metolachlor) fail to control it. Chloramben was effective on black nightshade, but the manufacturer discontinued it because the costs of reregistration exceeded the economic potential of the product.

Non-chemical controls:
Currently, non-chemical components of IPM are being used to control weeds on 95% of Pennsylvania tomatoes. For processing tomatoes, non-chemical weed control methods include cultivation for annual weeds, transplanting in a way to create crop competition for all annual weeds and perennials, crop rotation for annual weeds, hand weeding for annual weeds and yellow nutsedge, and cereal cover crop mulch for annual weeds. For fresh tomatoes, methods used are black plastic for all annual weeds, cultivation for all annual weeds, crop rotation for yellow nutsedge and morning glory, transplanting in a way to create crop competition for all annual weeds, and hand weeding for all annual and perennial weeds.

Chemical controls:
Metolachlor (Dual) was granted an emergency exemption under section 18 for use against eastern black nightshade and yellow nutsedge in tomatoes in 1998. Pennsylvania has requested a metolachlor section 18 for 1999. National registration for this use is currently pending. The rate is 0.80-1.0 pt/A on coarse soils if organic matter is less than 3% or 1.33-1.67 pt/A on fine soils (16).

Nutsedge*Cyperus sp.*

Yellow nutsedge is the next most severe weed problem, and is prevalent on both fresh market and processing tomatoes. This perennial weed forms rhizomes and nutlets in August. It may be a pest in cucurbits, beans, and sweet corn, as well as tomatoes. Nutsedge usually is controlled in vegetable crops with herbicides. For a high level of infestation, the nutsedge population should be reduced by growing corn in crop rotation, since corn herbicides are available for effective control of nutsedge. In the spring, nutsedge-infested areas are disked frequently to prevent the development of large plants, because nutsedge plants over 5 inches tall are difficult to kill by tillage, and herbicides also are less effective on large plants.

Chemical controls:
For processing tomatoes, the main herbicides used to control yellow nutsedge are metribuzin (Sencor/ Lexone) and pebulate (Tillam). Metribuzin is applied to 45% of planted acres once per year at a rate of 0.35 lb. a.i./acre. Pebulate is applied to 13% of planted acres once per year at a rate of 2.5 lb. a.i./ acre. If metribuzin were restricted, substitutes would include cultivation, hand weeding, and the herbicide paraquat. With these substitutes, a 20% loss is the predicted impact on yield. If the use of pebulate were to be restricted, one substitute that could be used would be cultivation. All of the acres currently treated with pebulate could be cultivated with no predicted impact on yield.

For fresh market tomatoes, the main herbicides used to control yellow nutsedge are metribuzin (Sencor/ Lexone) and pebulate (Tillam). Metribuzin is applied to roughly 90% of planted acres once per year at a normal rate of 0.5 lb. a.i./acre. Pebulate is applied to approximately 30% of the Pennsylvania fresh market tomato acres at a rate of 3-4 lb. a.i./ acre. If metribuzin were restricted, two possible substitutes

are cultivation and the herbicide paraquat. With these substitutes, the predicted impact on yield would be a 25% loss. If pebulate were restricted, substitutes would include methyl bromide and paraquat. No impact on yield is predicted.

Additional Weed Controls Being Used

Preplant Incorporated - Seeded

- "Napropamide (Devrinol 50DF) prior to seeding. Primarily controls annual grasses and certain broadleaf weeds. May reduce stand and yield of fall grains, especially on coarse-textured soils, if fields are only disked. Moldboard plowing will reduce the risk of injury.

Preplant Incorporated -- Transplants

- "Napropamide (Devrinol 50DF) prior to transplanting. Primarily controls annual grasses and certain broadleaf weeds. Used in combination with metribuzin to improve the spectrum of broadleaf weeds controlled. May reduce stand and yield of fall grains if fields are only disked. Moldboard plowing will reduce the risk of injury.

- "Pebulate (Tillam 6E or other formulations). Primarily controls annual grasses and yellow nutsedge. Used in combination with metribuzin to improve the spectrum of broadleaf weeds controlled.

- "Trifluralin (Treflan 4EC or other formulations). Primarily controls annual grasses and certain broadleaf weeds. Used in combination with metribuzin to improve the spectrum of broadleaf weeds controlled. Will not control ragweed, or jimsonweed.

- "Metribuzin (Lexone/Sencor 75DF or other formulations) before transplanting. Primarily controls broadleaf weeds. Tank-mix with napropamide, pebulate, or trifluralin to control annual grasses at planting, or use sethoxydim 1.5 EC to control grasses postemergence. An additional postemergence application of metribuzin may be necessary to control broadleaf weeds.

Postemergence -- Transplanted

- "Metribuzin (Sencor/Lexone 75DF or Sencor/Lexone 4F). Primarily controls broadleaf weeds, but does NOT control nightshades. Use napropamide, pebulate, or trifluralin incorporated or apply sethoxydim 1.5EC postemergence to control annual grasses. Repeat application to suppress or control yellow nutsedge.

- "Paraquat (Gramoxone Extra 2.5SC) as a directed spray between the rows.

- "Pebulate (Tillam 6E or other formulations) over transplants up to fruit formation. Incorporated into soil immediately after application where nutsedge is a problem.

- "Sethoxydim (Poast 1.5EC) postemergence to control annual grasses and certain perennial grasses. Repeated applications may be necessary to control certain perennial grasses. Yellow nutsedge, wild onion, or broadleaf weeds will not be controlled.

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