# Crop Profile for Strawberries in Pennsylvania

**Prepared May, 2000**
**Revised Jan, 2002**

## General Production Information

- In 1998, Pennsylvania ranked 8th nationally in strawberry acreage with 1200 acres harvested, 11th nationally in total production, and 8th nationally in fresh-market production (1).
- Total production in 1998 was 5.0 million pounds with a value of $5.45 million (1).
- Acreage in the last 5 years had been on a downward trend, decreasing from 1500 acres in 1994 to 1200 acres in 1998 (1, 2). However, preliminary data for 1999 indicates an upturn in acreage (3).
- The top 5 counties in acreage as of 1997 were Lancaster (131 acres), York (124 acres), Erie (103 acres), Indiana (76 acres) and Bucks (66 acres) (4). These counties are near or include the Philadelphia, Pittsburgh, and Erie population centers.
- Harvest from traditional matted-row and ribbon-row producers typically begins during the last week of May and extends through the first week of July. However, some growers use plastic mulch and/or row covers to advance harvest by 1 to 2 weeks.

### Production Methods

Details of production methods for the systems described below are outlined in the "Commercial Berry Production and Pest Management Guide" (5). In this guide, growers are advised to utilize a number of cultural practices which decrease the magnitude of pressure from insects, diseases, and weeds, both before and after plant establishment. Fumigation is recommended if strawberries have been grown on the site within the previous 5 years.

Most strawberries in Pennsylvania are grown in matted-row culture. This sytem is so- named because plants are allowed to runner freely within a certain row width to produce solid beds (or mats) of plants. Dormant plants are planted in mid-Spring, and are not harvested until the following year. Bearing plantings are renovated each year in July, after harvest. This consists of an herbicide application, narrowing the rows, removing foliage, and then allowing runner plants to fill in the rows again. The most commonly grown cultivar in Pennsylvania is ‘Earliglow’. ‘Allstar’, ‘Northeaster’, ‘Jewel’ and ‘Honeoye’ are also commonly grown. Plantings are normally maintained for 3-5 years.

Some growers, mainly in the southern sections of the state, are experimenting strawberry plasticulture. This sytem uses fumigation, plastic-mulched raised beds, trickle irrigation and high plant densities. Plug plants are planted in mid to late August or early September and harvested the following year. Production is dependent on branch crown formation on the mother plant. Runners are removed. Most growers hold their plantings over for a 2nd and sometimes 3rd year of production. Though there is no data on this system in PA, it is likely that growers may not realize a profit unless the planting is held over for a second harvest season, based on research from VA (6). Decreased competition with weeds, less time to production, and an earlier harvest season are the reasons most commonly given for using this system. 'Chandler' is the cultivar most commonly grown.

## Insect Pests

Common insect problems in Pennsylvania are potato leafhoppers, 2-spotted spider mites, root weevils, slugs, spittlebugs, tarnished plant bugs, and aphids. Strawberry clipper and sap beetles are less frequently problems. Eastern flower thrips were a major problem in 1994.

**Potato leafhoppers** have been a very common pest in recent years. Because potato leafhoppers migrate in from southern states, there is no cultural control. Broad-spectrum insecticides are typically used for their control.

**Two-spotted spider mites** have been a problem in many fields in recent years. Their populations typically 'explode' during warm dry spells. Predatory mites can be used for control, but an effectively-timed release requires that growers be aware of the mite population level early on, in order to be able to order and release predatory mites before the two-spotted mites' populations reach levels the predatory mites will be unable to contain. Because winters in PA are too harsh for commercially-reared predatory mites to survive in the field, their release must take place in the spring or summer. Dicofol (Kelthane), fenbutatin-oxide (Vendex), bifenthrin (Brigade), fenpropathrin (Danitol), and abamectin (Agrimek) are labelled as miticides. Chemical control requires thorough coverage of plant foliage and undersides of leaves, as the highest mite populations are on the undersides of the lowest leaves. Complete control is unlikely. Mite populations can develop resistance to miticides quickly, so alternating miticides that have different modes of action is very important. Two applications are recommended; the first to control the adults, and the second 10-14 days later to control nymphs that were eggs at the time of the first spray.

There are 3 species of root weevils that attack commonly attack strawberries in PA. Adults of all 3 species, which are active only at night, hatch in late spring and feed on the leaves, causing damage that

is of little importance. However, the adults then lay eggs at the base of plants, and the larvae which hatch from these eggs feed on the strawberry plants' roots during the summer and fall. A fourth species, the green leaf weevil, the larvae of which also feed on strawberry roots, has been present in large numbers in some fields in northwestern PA. Above-ground symptoms of root damage regardless of species can easily be confused with those resulting from root rots. Cultural control consists of avoiding sites which have been in sod, under which root weevil populations build. Parasitic nematodes can be used for larval control, but degree of control obtained has varied widely under field conditions (7, 8). Pennsylvania had a Section 24C for the use of Furadan for control of the larvae, but this use was lost following the use deletion for strawberries in 1997, leaving no chemical control methods for control of the larvae. Adults can be targeted with sprays of bifenthrin or malathion, but because those of the 3 widespread species are active only at night and leaf damage is frequently missed, their presence may easily go unnoticed until after egg-laying has taken place.

**Slugs** cause damage to the fruit and are a problem especially during wet spells. Cultural controls include employing practices which encourage rapid drying of the foliage. Metaldehyde bait is used as the chemical control. It is not allowed to contact the fruit.

**Spittlebugs** cause little damage to the plants, but their spittle masses become annoying to harvesters. Cultural control consists of keeping fields weed-free, as the highest populations occur in weedy fields. Endosulfan (Thiodan, Phaser), azinphos-methyl (Guthion), carbaryl (Sevin), bifenthrin, fenpropathrin and malathion are labelled for spittlebugs; however, the days-to-harvest limitations for all except bifenthrin and possibly fenpropathrin precludes their use during harvest, the time when chemical control is most likely to be needed.

**Tarnished plant bugs** cause a condition known as 'button-berry'. Nymphs feed on developing seeds which normally would have produced a growth hormone that causes the berry to enlarge. Berry growth in the area surrounding the destroyed seeds ceases, causing the deformed 'button-berries'. Growers need to scout for tarnished plant bud nymphs during flowering and control them at that point. Endosulfan, naled (Dibrom), malathion, bifenthrin, fenpropathrin and methomyl (Lannate) are labelled for this use.

**Aphids** are a problem not because of their direct feeding, but because they transmit viruses to the strawberry plants. For that reason, there is a low tolerance of aphid populations. Cultural controls consist of removing nearby wild strawberry populations, the most common source of the viruses, and using plants from a reputable source that will provide virus-free plants. Endosulfan, azinphos-methyl, bifenthrin, malathion, naled and methomyl can be used for aphid control.

**Strawberry bud weevils** (also know as clippers), though not occuring frequently, can be very destructive pests in instances where they do occur. Adults of the clipper lay one egg inside of an unopened blossom, then clip the pedicle below the bud. The larvae develop inside the unopened bud. The adults generally originate in nearby woods, and then clippers become established within the strawberry plantings where the population builds with succeeding years. Chlorpyrifos (Lorsban), prebloom only, carbaryl and bifenthrin are labelled for control.

**Sap beetles** are a larger problem in pick-your-own operations since customers are likely to leave some ripe fruit unharvested. Sap beetles are only a problem where there is an overabundance of ripe fruit. Keeping fruit picked clean is the cultural method of control. Bifenthrin is labelled for use.

**Eastern flower thrips** were a major problem in PA, and other nearby states, in 1994. The nymphs feed on the developing fruits' surface, causing a bronzing of the fruit. Because the thrips migrate in on wind currents, there is no cultural control. Growers which had sprayed chemical controls for tarnished plant bugs or spittlebugs were unlikely to have damage from thrips even in 1994. Naled, Pyrellin E.C. and methomyl can be used for thrips control.

## Diseases

Humid conditions and heavy soils in Pennsylvania are responsible for increasing the magnitude of most of the diseases that occur in PA. Gray mold is the most common problem on strawberries followed by fungal leaf spots. Bacterial (angular) leaf spot, the black root rot complex, red stele (Phytophthora root rot), leather rot and Verticillium wilt occur less frequently. Anthracnose has occurred in a few cases in recent years.

**Grey mold** (*Botrytis*) is the most common disease problem in PA. Growers are encouraged to employ practices which promote foliage drying such as using narrow rows and controlling weeds, and keeping berries picked. One or two fungicide applications may be applied at bloom or preharvest to prevent berry rot (10). Iprodione (Rovral) and vinclozolin (Ronilan) had been very effective; however, their loss will necessitate a change to other materials. Benomyl (Benlate) or thiophanate-methyl (Topsin M) may not be effective in many instances due to the presence *Botrytis* strains resistant to their mode-of-action, so their use is recommended only in combination with captan. Thiram may be used for bloom sprays, though a 3-day PHI precludes its use during harvest. Fenhexamid (Elevate) is a new material that will help to fill the needs for grey mold control. Since captan and thiram are only marginally effective in the control of *Botrytis* and resistance in already widespread to to benomyl and thiophanate-methyl, fenhexamid will be the fungicide of choice to control grey mold on strawberries in PA (10). However, the potential for the development of resistant *Botrytis* populations is very high. Additional materials will be needed for resistance management purposes (10).

**Fungal leaf spots**, caused by numerous different pathogens, are also common, but cases are rarely severe enough to cause yield decreases. Using practices that encourage foliage drying is again the main cultural control, though the usage of resistant cultivars also decreases incidence. Fungicide sprays are used only upon occasion. Captan is effective in the control of leafspots (10).

**Angular (bacterial) leaf spot** is less common that fungal leaf spots. The bacteria originates with nursery stock and is spread by splashing water. Incidences increase in instances in which overhead

irrigation is used in large quantities, such as when late spring frosts plague growers, necessitating the use of overhead irrigation for frost protection. ‘Earliglow’ and ‘Allstar’, the most widely grown cultivars in PA, are very susceptible (11). Cultural controls consist of minimizing overhead irrigation usage. There is no adequate chemical control.

**Black root rot**, a disease complex involving pathogens (*Rhizoctonia* or *Pythium*), cultural problems, and often lesion nematodes, had been diagnosed on 21% of the samples sent in to the plant disease clinic during 1995-99 (12). Black root rot in PA has occurred mainly in strawberry fields that have been replanted to strawberries without preplant fumigation. Fumigation can be used for chemical control. However, increased disease severity may result following fumigation if Rhizoctonia root rot is involved (13). Cultural controls consist of moving to a new site, if possible, and identifying and correcting site problems and production practices that may have contributed to the disease, such as overuse of herbicides or fertilizers, or poor soil drainage.

**Phytophthora root rot** (red stele) occurs when susceptible cultivars are planted (10). Site selection (avoidance of areas with poor drainage), and use of resistant cultivars are the main cultural controls. Metalaxyl (Ridomil) and fosetyl-Al (Aliette) are useful for control, but their use is recommended only as necessary for resistance management purposes. Another species of *Phytophthora* causes a condition known as leather rot, which creates an off-taste and smell in the fruit. Using straw mulch to keep the fruit from contacting the soil and protecting the fruit from splashing soil is the main cultural control. Metalaxyl and fosetyl-Al are useful for the control of leather rot also.

**Verticillium wilt** occurs upon occasion. Avoidance of sites which have recently grown Verticillium-susceptible crops and cultivar selection are the main cultural controls. There is no chemical control.

**Anthracnose**, which is typically a problem in warm, humid climates, is a disease which can affect all parts of the plant. It was identified in 11% of commercial samples submitted to the Plant Disease Clinic during 1995-99 (12). It is unlikely that this reflects the typical incidence of this disease in the state. It is more likely that a lack of familiarity with this disease has caused growers or agents to send in a disproportionately larger percentage of samples with this disease, as compared to other diseases. However, the range of the pathogens causing anthracnose apparently is extending (13). There is no satisfactory cultural or chemical control.

## Nematodes

The 2 types of nematodes that cause damage to PA strawberries are the lesion nematode and the dagger nematode (9). Lesion nematodes are associated with the disease complex known as Black Root Rot (see below). Plants attacked by lesion nematodes become stunted, weak and predisposed to secondary root-

rotting pathogens (9). Dagger nematodes vector tomato ringspot and tobacco ringspot viruses. Control generally consists of fumigation.

## Weeds

Weeds were cited as the largest problem growers face with strawberry production in Pennsylvania (14). There are very few herbicides remaining for use on strawberries, and only one preemergent herbicide (napropamide) that is labelled for use on new strawberry plantings. Certain fumigants can control weeds during the establishment year, but a low percentage of PA growers utilize fumigation. Weed control is the reason most commonly given by growers for experimenting with strawberry plasticulture. Even in this system, however, weeds still cause problems by growing through the planting holes.

Weed control problems change during the life of a strawberry planting. The establishment year, because there are few options for control, often presents the greatest challenges. Annual broadleaves and grasses are problematic, along with perennial weeds if they had not been controlled prior to the establishment of strawberries. In the ensuing years, perennial weeds and those against which herbicides are weak often present the greatest problems.

**Yellow nutsedge** is a perennial which must be controlled prior to planting. There are no labelled chemical options effective for control once the crop is established. Cultural controls (cultivation, handpulling) are ineffective or even deleterious because the nutlets produced by the plants may be spread.

**Canada thistle** and dandelions are also perennials which also should be controlled prior to planting. Cultivation must be repeated numerous times in order to exhaust taproot reserves and can only be used between rows after the planting is established. Handpulling is ineffective. 2,4-D (Formula 40) at renovation or in early spring can be used for chemical control.

**Pigweeds** (redroot, smooth and tumble), purslane, and lambsquarters are summer annuals that are problematic throughout the state. During the establishment year, control consists largely of handweeding and cultivation. In the following years, napropamide (Devrinol) and terbacil (Sinbar) are effective in their control. Straw mulch applied as winter protection, which is pulled into the row middles in the spring, also plays a large role in decreasing germination of these annuals in years following the establishment year.

**Common groundsel**, field pansy and woodsorrel are winter annuals which have become a larger problem in the years since the loss of DCPA (Dacthal). Common groundsel can cause large crops losses, as can field pansy. Though each can be a problem in any area of the state, common groundsel has been

the larger problem in the northwestern part of the state, while field pansy has more frequently been a problem in the southeastern and east -central areas. Pennsylvania was granted an emergency exemption (Section 18) for the use of oxyfluorfen (Goal) to control these weeds in 1998 and 1999.

Other weeds which are less competitive, but still are occasionally cited as production problems include chickweed, annual grasses, and quackgrass. Sethoxydim (Poast) is useful for postemergent grass control.

**Grower use of pesticides:**
The National Agricultural Statistics Service surveyed Pennsylvania strawberry growers during the fall of 2000. Growers were asked to describe each pesticide application used on that year's strawberry crop. The pesticide use information is summarized below.

| Agricultural Chemical | Percentage of Acres Applied | Average number of Applications | Average Rate per Application (in Pounds AI Per acre) | Total Average Pounds AI used per crop year | Total Pounds AI Applied |
|---|---|---|---|---|---|
| **Herbicides:** | | | | | |
| 2,4-D | 51.0 | 1.0 | 1.09 | 1.19 | 800 |
| Napropamide | 60.0 | 1.2 | 2.86 | 3.54 | 2700 |
| Oxyfluorfen | 16.0 | 1.0 | 0.29 | 0.29 | 100 |
| Sethoxydim | 29.0 | 1.1 | 0.30 | 0.34 | 100 |
| Terbacil | 45.0 | 1.3 | 0.23 | 0.31 | 200 |
| **Insecticides:** | | | | | |
| Azinphos-methyl | 23.0 | 1.3 | 0.44 | 0.61 | 200 |
| Bifenthrin | 29.0 | 1.5 | 0.08 | 0.12 | * |
| Carbaryl | 8.0 | 1.2 | 1.29 | 1.65 | 200 |
| Chlorpyrifos | 35.0 | 1.3 | 1.01 | 1.33 | 600 |
| Endosulfan | 33.0 | 1.3 | 0.91 | 1.27 | 600 |
| **Fungicides:** | | | | | |

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|---|---|---|---|---|---|
| Benomyl | 43.0 | 2.7 | 0.37 | 1.01 | 600 |
| Captan | 71.0 | 2.6 | 1.85 | 4.84 | 4400 |
| Fenhexamid | 22.0 | 1.7 | 0.73 | 1.26 | 400 |
| Iprodione | 19.0 | 2.8 | 0.79 | 2.28 | 500 |
| Metalaxyl | 5.0 | 1.0 | 0.14 | 0.15 | * |
| Thiophanate-methyl | 12.0 | 2.0 | 0.55 | 1.12 | 200 |
| | * Total applied less than 50 lbs. | | | | |

A spot-survey of Pennsylvania growers, covering 10% of PA strawberry acreage was conducted in 1999. In this survey, it was found that relatively few growers use fumigation. Roughly 10% of the acreage treated with methyl bromide/chloropicrin. A lower percentage of acreage (2-5%) is treated with metam-sodium. The non-chemical pest controls outlined in the next section are also findings from the 1999 spot-survey.

### Grower usage of non-chemical pest controls

**Insect control**. Several non-chemical controls were used by growers to minimize insect pressure. Seventy percent of growers surveyed reported using crop rotation to avoid population buildups of insects within strawberry plantings, and 40% keep berries cleaned off. Seventy percent reported using scouting and monitoring.

**Disease control**. Cultural controls are utilized by many growers to decrease disease incidence. Ninety percent of the growers surveyed use straw mulch to keep berries off of the ground, 95% avoid wet sites to decrease root rot incidence, 80% use cultivars with disease resistance, and 70% keep rows narrow and 60% control weeds to increase air circulation. Forty percent of growers keep their berries picked. Twenty percent of growers surveyed also used raised beds to decrease disease incidence.

**Weed control**. To control weeds, 30% of PA growers use preplant cover crops, 75% use crop rotations, 90% use hand weeding or cultivation, and 90% use straw mulch. Straw mulch, widely used for winter protection and left in the aisles once removed from the rows, aids in control of all weeds, but especially annuals, after the establishment year.

## Contacts

**Author:**
Kathy Demchak
Horticulture Department
Penn State University

**Grower Reviewer:**
Robert Trax Sr.
Trax Farms
Finleyville, PA

**Contact Person:**
Bill Hoffman
Pennsylvania PIAP Program
116 Buckhout Lab
University Park, PA
16802
814-865-1074

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