

# Crop Profile for Peppers (Bell) in New Jersey

**Prepared: May 2005**

## General Production Information

- Bell peppers are grown in New Jersey for the fresh market and processing market.
- New Jersey ranks third (2003) in United States pepper production (16).
- New Jersey supplies 5.5% of the total US pepper production.
- Production has changed from 5,300 acres in 1993 to 3,600 acres in 2003, while crop value has decreased from \$21.79 million (1993) to \$12.00 million (2003) (16, 17).
- Yields averaged 16,000 pounds per acre in 1993 and 24,500 pounds per acre in 2003, with a total production of 84,800,000 pounds (1993) and 88,200,000 pounds (2003). Prices received by growers rank seventh (2003) in the United States with growers receiving between \$0.257 (1993) and \$0.136 (2003) per pound (16, 17).
- Total cost per acre in 1996 was \$4,436 with a net return of \$1,928 (3).
- New Jersey's production season runs from June to late October with the largest supply available in July, August, and September.

## Production Regions

Bell peppers are grown in almost all counties in New Jersey. The majority of the wholesale production and acreage is located in southern New Jersey in the counties of Gloucester, Cumberland, Salem, and Atlantic. There are smaller production areas in the remaining counties mainly for the retail trade. Wholesale fresh market peppers are shipped to the eastern United States and Canada depending on the time of year. Processing peppers are generally the number 2 fruit from the wholesale production.

## Cultural Practices

### Types Grown

Bell peppers are a member of the nightshade family and related to tomato, eggplant and white potato. Most of the peppers produced in the state are for green fruit. There is a small acreage of mature red pepper production. The preferred fruit type is a square thick wall with no recessed shoulder and a shallow blossom end. Recommended varieties include Aristotle, Paladin, Camelot, X3R Camelot, Red Knight, and Revolution. Variety selection depends on market demand, yield, disease tolerance (especially for phytophthora), and plant type.

Peppers are a warm season crop that do not tolerate frost. They grow best within the temperature range of 70 to 80 °F. This crop is sensitive to temperature extremes. Poor fruit set and blossom drop can be expected when night temperatures drop below 60 °F or day temperatures rise above 85 °F.

### **Transplant Production**

Most peppers are transplanted from locally grown plants. Peppers are seeded in greenhouses from February through April for transplanting in May through early July. Growers start seeds in 72 to 200 cell trays. Plants are grown using a standard soilless mix (i.e. Promix) and the fertility level is supplemented with two to three applications of a complete liquid fertilizer. Plants are hardened off by withholding water before setting in the field.

### **Land Preparation**

Peppers grow best on well-drained sandy-loam and loamy sand soils with a pH of 6.0-6.5. A wheat or rye fall cover crop is planted the year before. Growers prefer wheat since it does not seem to hold as much moisture, plus grain rye may grow too tall to incorporate. In the spring, the cover crop is plowed down using either a moldboard or chisel plow. Some fields are fumigated in the fall before the cover crop is planted. For growers who fumigate, the main fumigant used in New Jersey is metam-sodium at the rate of 45 to 70 gal/A. The fumigant is applied using a shank applicator and the soil is sealed behind. If the fumigant is not applied in the fall, it is injected just before plastic is laid in the spring or through the drip system after plastic is applied.

Nutrients are broadcast based on the soil test. Boron may be applied with the other nutrients at the rate of 1.0 lbs/A. The fertilizer is incorporated and the soil prepared before bed making. High raised, dome shaped beds are recommended for disease control and water management. Drip tape and plastic mulch are applied as the raised beds are being made. Some growers apply herbicides as the plastic is being laid.

Others lay the plastic without any herbicide, then band apply between the rows before transplanting. In bare ground culture, herbicides are applied pre-transplant and additional weed control is maintained through cultivation and post emergent herbicides.

## **Field Planting**

Most peppers are set into black plastic with drip irrigation for early production. Late plantings are transplanted into white plastic to moderate soil temperature. Most peppers are planted in double rows on a 5 ft interrow spacing. Spacing between plants in each of the double rows varies from 12 to 18 inches. Some plantings are made on a 4 foot row spacing with single rows of plants 12 inches apart in the row.

Transplants are set with a water wheel, mechanical transplanter, or by hand depending on the size of the farming operation. When transplanting, growers take care to set the plants straight in the transplant plant hole to avoid stem burn when the black plastic becomes too hot. In addition, some growers fill the hole around the plant with soil to reduce the chance of water collecting around the base of the plant, which can lead to disease.

Some peppers grown on plastic are staked using a modified Florida weave system to increase yields and fruit quality. Short stakes (2½ to 3 ft) are placed at every third or fourth plant and strings are woven around them or just placed on one side. Two to three strings are used to support the fruit load.

In plastic mulch culture, additional soluble fertilizer (complete fertilizer including boron) is applied through the drip system at intervals throughout the growing season. The first application is generally applied one week after transplanting, followed with either weekly applications (12 total) or every three weeks for a total of six applications. Some growers use plant tissue testing to adjust their fertility program. Most fungicides and insecticides are applied with boom or air blast type sprayers, and some materials are applied through the trickle irrigation system.

## **Harvesting**

Varieties are ready to harvest in 70 to 80 days, and harvest continues until frost (mid October). Peppers are hand harvested every ten to fourteen days. Fruit are snapped from the plant above the calyx as they

approach a marketable size and the fruit is firm. Fruit that are allowed to stay on the plant too long will reduce total yield. Fruit are picked in plastic  $\frac{5}{8}$  or 1 bushel containers, transported to packing sheds where they are washed, sorted into U.S. Fancy, No. 1, No. 2, and field run grades, and packed in  $1\frac{1}{9}$  (28 lbs.) waxed cardboard cartons and forced-air cooled or placed in refrigerated rooms with pre cooling.

## Worker Activities

Worker activities in the greenhouse include seeding, spotting transplants, and watering. Fungicide-treated seed is handled by workers who use the required personal protection equipment. Most growers make several greenhouse pesticide applications during transplant production, but the existing reentry intervals (REI's) for greenhouse materials do not currently interfere with worker activity.

Field activities include transplanting, staking and tying plants, occasional hoeing for bare ground culture, scouting, and harvesting. At the end of the season workers remove plastic mulch and stakes. Workers risk potential exposure to pesticides during these activities and should follow all safety procedures determined by the label. These procedures include wearing proper personal protective equipment (PPE) and strictly following restricted-entry intervals (REIs). These activities are conducted within the REI restrictions that currently exist for the materials growers are using for pest control.

When harvesting begins, growers choose the most effective insecticides and fungicides with the minimum pre-harvest intervals (PHI); preferably a PHI less than 3 days, to accommodate harvest schedules. For the major pepper insect and disease pests, there are currently sufficient choices in effective materials with low (less than 3 days) PHI's and REI's.

Scouting activities typically occur once a week throughout the season. The farms that employ a scouting service are usually visited twice a week for all crops, although individual fields are usually checked on a 7-10 day schedule. Since scouts will be returning to the farm between 48-72 hours, REI's of 48 hours or less are sufficiently short that major pest outbreaks will not occur within a field during the period of no reentry.

## Insect Pests

Insecticide applications primarily target two pests, aphids and European corn borers. Additional applications may be applied later in the season to control corn earworm, beet armyworms, and fall armyworms. These secondary pests reach economically damaging levels on some farms most years in the southern counties but not every year. Occasionally other insect pests occur, including two-spotted spider mites, melon aphids, flea beetles, pepper maggots, pepper weevils, hornworms, cabbage loopers, thrips, stinkbugs, and leafminers. Many of the secondary and occasional pests are controlled as a result of broad-spectrum insecticide applications for European corn borer and aphids. As the control options become more pest-specific, occasional pests become major pests.

### European Corn Borer, *Ostrinia nubilalis*

#### **Description and Damage:**

The European corn borer (ECB) is the primary insect pest of peppers in New Jersey, occurring every year throughout the state. ECB feeds on up to 200 host plants, including some weeds, and is a key pest of sweet corn and peppers and an occasional pest of potatoes and snap beans. ECB overwinter as fully-grown larvae in plant refuse and debris, particularly in corn fields. Larvae pupate in early May, and emerge as adults in late May to early June. In New Jersey, peak adult activity occurs in mid-late May, mid-July, and late August to early September. The second and third peaks coincide with fruit development, and fruit greater than ½ inch in diameter are susceptible to ECB infestation (10). The first generation activity is not a problem for most pepper fields since fruit has not yet developed. However, in some years in areas of early pepper production in the southern region of the state, high levels of first generation damage to crown fruit occurred.

Adult female moths are light yellowish-tan and ¾ inch long whereas the male is a little smaller with more grayish red coloring. Both have a characteristic line with a dot above it about mid-way on the outer wing margin. The adults are active at dusk through early morning, laying eggs on the undersides of pepper leaves and in protected areas on the stems. Larvae hatch in 7-10 days depending on temperature, and feed on the leaves for a short time before boring into the stems and fruit. Larval color ranges from light gray to faint pink with small round dark brown spots on each segment. It has a brown head and indistinct

longitudinal reddish strips. Mature larvae are about  $\frac{7}{8}$  inch long.

Fruit are at risk of infestation by ECB larvae when the fruit diameter is one-half inch or greater. ECB larvae typically bore in under the calyx leaving excrement at the entrance hole. Once larvae enter the fruit, they are protected from insecticide treatments. Good coverage of fruit and leaf surfaces, timing, and choice of materials is critical for obtaining good ECB control. Worm infested fruit may go undetected on the packing line due to the small hidden entrance holes. Infested fruit are more susceptible to bacterial soft rot, so fruit either rot in the field, in the market chain, or the customer finds insect contaminated fruit. At high population levels, ECB is capable of infesting 90 to 100% of bell pepper fruit in untreated fields (1).

### **Monitoring:**

Blacklight traps are used to track the adult ECB population levels on individual farms throughout NJ for growers to determine adult activity. In addition, the Rutgers Cooperative Extension (RCE) Integrated Pest Management (IPM) Program uses a statewide blacklight trap network to produce geo-referenced maps of adult activity. The maps are published weekly throughout the growing season in the RCE Plant & Pest Advisory Newsletter, allowing growers statewide to determine approximate activity in their area. Once fruit diameter is  $\frac{1}{4}$  to  $\frac{1}{2}$  inch or greater, and area or local blacklight traps are recording 1 moth per night or more, a 7-day spray schedule for ECB control is initiated. If ECB counts exceed 100 in 5 nights then a 5-day schedule is recommended.

### **Chemical Controls:**

- acephate (Orthene, Address, Lancer)
  - Percent acres treated: 61.5% (18)
  - Typical rates and frequency of application: 0.75-1.0 lb 97S/A or other labeled formulation, 2 applications. Do not exceed 2 lbs active ingredient per acre per season.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours                      PHI: 7 days

- Efficacy: Good.
  - Use in IPM and resistance management: Acephate is a systemic material that provides residual control for up to 14 days. Although acephate is labeled for some other pepper pests, it is primarily used to protect fruit from ECB infestations.
- *Bacillus thuringiensis* subspecies *kurstaki* (Biobit, Condor, Crymax, Dipel, Deliver, Javelin WG, Lepinox WDG, Mattch, or other labeled formulation)
    - Percent acres treated: 0.9% (18)
    - Typical rates and frequency of application: Consult label for rates and restrictions.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 4 hours                      PHI: 0 days
    - Efficacy: Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest. May result in infested fruit. Must be ingested to be efficacious, and often borers enter fruit directly without feeding first.
    - Use in IPM and resistance management: More effective on small larvae. Use higher rates for heavier infestations and re-apply on a 3-4 day schedule. *B.t.* materials are most effective when temperatures are above 75 °F at application.
  - bifenthrin (Capture)
    - Percent acres treated: Newer material, data not available.
    - Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.

Do not exceed 12.8 fl oz per acre per season.

    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 12 hours                      PHI: 7 days

- Efficacy: Good.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
- cyfluthrin (Baythroid)
    - Percent acres treated: 11.4% (18)
    - Typical rates and frequency of application: 1.6-2.8 fl oz 2E/A, 1-2 applications.

Do not exceed 16.8 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours            PHI: 7 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
- esfenvalerate (Asana)
    - Percent acres treated: 6.9% (18)
    - Typical rates and frequency of application: 5.8-9.6 fl oz 0.66EC/A, 1-2 applications. Do not exceed 68 total fluid ounces per acre per season.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 12 hours            PHI: 7 days

- Efficacy: Fair.
  
- Use in IPM and resistance management: Due to the lower residual, treat every 5-7 days for ECB control. The broad-spectrum contact activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- indoxacarb (Avaunt)
  - Percent acres treated: newer material, data not available.
  
  - Typical rates and frequency of application: 3.5 oz 30WDG/A, 1-2 applications. Do not plant any crop not on the label for food or feed for 30 days after last application. Do not apply more than 14 oz per acre per crop.
  
  - Method of application: Foliar application with ground or aerial equipment.
  
  - REI: 12 hours            PHI: 3 days
  
  - Efficacy: Very good.
  
  - Use in IPM and resistance management: Use at threshold levels and rotate with materials from other insecticide classes for resistance management. Helps conserve certain beneficial insect populations.
  
- lambdacyhalothrin (Warrior)
  - Percent acres treated: Newer material, data not available.
  
  - Typical rates and frequency of application: 2.56-3.84 fl oz/A, 1-2 applications.
  
  - Method of application: Foliar application with ground or aerial equipment.
  
  - REI: 12 hours            PHI: 5 days
  
  - Efficacy: Good.

- Use in IPM and resistance management: Lambda-cyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- methomyl (Lannate)
  - Percent acres treated: 58.4% (18)
  
  - Typical rates and frequency of application: 3.0 pts LV/A or other labeled formulation, 1-2 applications.
  
  - Method of application: Foliar application with ground or aerial equipment.
  
  - REI: 48 hours            PHI: 3 days
  
  - Efficacy: Inconsistent.
  
  - Use in IPM and resistance management: Treat at threshold levels and reapply on a 5-7 day spray schedule to maintain control. Use in rotation with materials from other insecticide classes for resistance management.
  
- methoxyfenozide (Intrepid)
  - Percent acres treated: Newer material, data not available.
  
  - Typical rates and frequency of application: 4.0-8.0 fl oz/A (early season), 8.0-16.0 fl oz/A (late season); 1-2 applications. Do not apply more than 64 fl oz per acre per season.
  
  - Method of application: Foliar application with ground or aerial equipment.
  
  - REI: 12 hours            PHI: 1 day
  
  - Efficacy: Good, especially at high rates.
  
  - Use in IPM and resistance management: Early season rates are for young crops and small

plants. Later season rates are recommended for heavier infestations under conditions of larger plants and dense foliage, since larvae need to ingest the material. A 7-14 day re-treatment interval is recommended to protect new growth until moth flights and/or infestations subside. Methoxyfenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Rotate with materials from other insecticide classes for resistance management.

- permethrin (i.e., Pounce)

- Percent acres treated: 5.6% (18)
- Typical rates and frequency of application: 8.0 fl oz 3.2EC/A.

For sweet, bell-type peppers only.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 24 hours            PHI: 3 days
- Efficacy: Good.
- Use in IPM and resistance management: Due to the lower residual, treat every 5-7 days for ECB control. Use in rotation with other classes of insecticides. Overuse of permethrin will impact predators and parasites and may cause a secondary outbreak of aphids.

- spinosad (Spintor 2SC, Entrust)

- Percent acres treated: 29.4% (18)
- Typical rates and frequency of application:

§ Spintor 2SC: 3.0-6.0 fl oz 2SC/A, 3-4 applications. Do not exceed 29 total fluid ounces per acre per season.

§ Entrust: 1.0-2.0 fl oz/A, 3-4 applications. Do not apply more than 9 oz per acre per crop.

- Method of application: Foliar application with ground or aerial equipment.
  - REI: 4 hours                      PHI: 1 day
  - Efficacy: Good.
  - Use in IPM and resistance management: Spinosad controls multiple lepidopteran species, as well as thrips and leafminers. It does not affect certain parasites and predators so that secondary pest outbreaks are minimized. Treat at threshold levels and/or time applications to peak egg hatch. Rotate with materials from other insecticide classes for resistance management.
- tebufenozide (Confirm)
    - Percent acres treated: 0.7% (18)
    - Typical rates and frequency of application: 8.0-16.0 fl oz 2F/A, 1-2 applications.

Do not exceed 64 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
  - REI: 4 hours                      PHI: 7 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Tebufenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Lower rates are recommended for light infestations and higher rates for moderate to heavy infestations. Application timing is important since the material must be ingested before larvae enter the fruit. Re-application is recommended when insect populations are high and/or the plants are rapidly growing. For resistance management, rotate with materials from other insecticide classes.
- zeta-cypermethrin (Mustang Max)

- Percent acres treated: newer material, data not available.
- Typical rates and frequency of application: 2.24-4.0 fl oz/A, 1-2 applications.
- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours            PHI: 1 day
- Efficacy: Good.
- Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

### **Alternatives:**

There are effective materials that are alternatives for the EPA targeted materials, including cyfluthrin, esfenvalerate, lambdacyhalothrin, methoxyfenozide, permethrin, spinosad, and tebufenozide.

### **Cultural Control Practices:**

Effective weed control may help reduce ECB damage by improving spray coverage within the field. Eliminate weeds around the fields to reduce breeding sites. Incorporate crop residue as soon as possible after harvest or at the end of the season to reduce the survival of overwintered ECB larvae. Locate pepper fields as far away as possible from corn.

### **Biological Controls:**

There are many general predators like lady beetles, syrphid fly larvae, lacewings, spiders, and minute pirate bugs, which feed on the eggs and small larvae of ECB. However, when populations of ECB are high, natural control is less reliable.

## **Other Issues:**

Acephate, esfenvalerate, cyfluthrin, tebufenozide may not be used during some harvest periods due to the 7-day PHI. Overuse of pyrethroids will lead to aphid and/or spider mite outbreaks.

### **Green Peach Aphid, *Myzus persicae***

### **Melon Aphid, *Aphis gossypii***

## **Description and Damage:**

The most common aphid species found on peppers is the green peach aphid (GPA), although occasionally melon aphids (MA) can be found on peppers. GPA are small, soft bodied, pear shaped, about  $\frac{1}{10}$ - $\frac{1}{5}$  inch long, and typically light green to pink or red with or without wings, or dark brown with wings. Melon aphids are smaller and range in color from light to dark green. MA are easily distinguished from GPA by characteristic black leg joints and cornicles, two projections on the rear end which look like 'tail pipes'.

Aphids mate and lay eggs in the fall in protected areas on alternate host plants including weeds and fruit trees like peach and cherry. Eggs hatch in the spring, and the first two to three generations consist of females that give birth to live young without being fertilized by males. Aphids have a great capacity for reproduction at this stage and a population explosion may occur if left uncontrolled. As crowding and overpopulation occurs, winged forms migrate to new host plants, where they feed and produce more generations of wingless females.

Aphids feed on the undersides of the leaves, injecting piercing sucking mouthparts into the plant tissue and removing plant juices. While feeding they excrete excess plant sap that accumulates on the plant surfaces below infested leaves. A black to grayish sooty mold fungus grows on the sap, discoloring the leaves and fruit. The sooty mold is difficult to wash off and may result in unmarketable fruit. Heavy aphid infestations also result in leaf curling and yellowing, reducing plant vigor and causing stunting. Aphid damage may be greater during dry, warm periods.

Aphids also transmit plant viruses, even at very low population levels (25). Virus transmission occurs

when the aphid probes the plant, and the winged aphids spread the virus through the field. Most early-season insecticide applications for peppers target aphids in order to minimize virus. However, aphid control has not been shown to be an effective, economical, or recommended means of preventing viruses (1). While insecticides do not control aphid-vectored viruses, symptom expression may be delayed with their use (8).

Aphids are controlled most years by naturally occurring predators and parasites. Pyrethroids and other broad-spectrum insecticide treatments, especially early in the season, kill natural enemies and can result in aphid outbreaks that can be difficult to control. Statewide, 100% of the acreage is at risk for aphid infestation each year, however less than 25% of the fields reach threshold levels primarily due to treatments for other pests like ECB.

### **Monitoring:**

Check transplants before planting for infestations that may have started in the greenhouse. Monitor for aphids when scouting other insect pests. Check on the undersides of the leaves for aphids, and look on leaf surfaces for the presence of sooty mold. Treat when infestations are increasing to levels greater than 2 per leaf (12).

### **Chemical Controls:**

- acephate (Orthene, Address, Lancer)
  - Percent acres treated: 61.5% (18)
  - Typical rates and frequency of application: 0.5-1.0 lb 97S/A, or other labeled formulation, 1-2 applications. Do not to exceed 2 lbs active ingredient per acre per season.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours            PHI: 7 days
  - Efficacy: Good for GPA only; not recommended for MA.
  - Use in IPM and resistance management: Since only two applications are permitted, acephate is

primarily used for ECB control. This material would be used for above threshold levels of aphids if ECB is above threshold at the same time.

- acetmiprid (Assail)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 0.8-1.2 oz 70WP/A, 1-2 applications. Do not make more than 4 applications per season or apply more than 7 oz per acre per season.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 12 hours            PHI: 7 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Use in rotation with classes of insecticides other than the neonicotinoids. Lower rates preserve beneficial insect and spider populations and allow for faster rebound of the beneficial populations.

- azadirachtin (Aza-Direct, Azatin, Ecozin, Neemix, etc.) (GPA only)

- Percent acres treated: 0.0% (18)

Typical rates and frequency of application: 10-21 oz XL/A (Azatin) or other labeled formulation.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours            PHI: 0 day
- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: Azadirachtin is an insect growth regulator that has broad-spectrum activity against numerous pepper pest species. Do not apply when plants are newly transplanted, wilted, or stressed. For resistance management, rotate with materials from other insecticide classes.

- dimethoate (Dimethoate)

- Percent acres treated: 28.7% (18)

Typical rates and frequency of application: 0.50-0.67 pt 4EC/A or other labeled formulation, 1-2 applications.

- Method of application: Foliar application with ground or aerial equipment
- REI: 48 hours            PHI: 0 days
- Efficacy: Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: This material is recommended for pepper maggot, and may control above threshold levels of aphids at the same time pepper maggots are active.

- disulfoton (Di-Syston)

- Percent acres treated: 0% (18)
- Typical rates and frequency of application: 6.7-13.3 oz/1,000 ft row, 1 application, in furrow.
- Method of application: In furrow application with ground equipment
- REI: 48 hours            PHI: 30 days
- Efficacy: GPA only; not recommended for MA. Recent data is not available, so effectiveness is unknown.
- Use in IPM and resistance management: This material would be used as a preventative for aphids, and would not be recommended in an IPM program.

- endosulfan (Thionex, Thiodan, Phaser, etc.)
  - Percent acres treated: 4.3% (18)
  - Typical rates and frequency of application: 0.5-0.66 pts 4EC/A or other labeled formulation, 1-2 applications. Do not exceed 2.0 lbs ai per acre per year.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 48 hours            PHI: 4 days
  - Efficacy: GPA only; not recommended for MA.
  - Use in IPM and resistance management: This material is recommended for pepper maggot, and may control above threshold levels of aphids at the same time pepper maggots are active.
  
- imidacloprid (Admire, Provado)
  - Percent acres treated: 11.3% (Admire=7.3%; Provado=3.8%) (18)
  - Typical rates and frequency of application:
    - § Admire: 10-24 fl oz 2F/A, 1 application (lower rates provide a shorter residual control).
    - § Provado: 3.75 fl oz 1.6F/A, 1-2 applications.

Do not exceed 0.5 pounds active ingredient per acre per season regardless of application method or formulation. A 12-month plant back interval must be observed for crops not on the label.

- Method of application:
  - § Admire: soil application can be applied in-furrow, as a transplant drench, side-dressed, or drip-irrigated.
  - § Provado: Foliar application by ground or aerial equipment.
- REI: 12 hours            PHI: 21 days (Admire)

- REI: 12 hours            PHI: 0 days (Provado)
  - Efficacy: Good.
  - Use in IPM and resistance management: The Admire application is used as a preventative treatment for aphids, and will control other minor pepper pests such thrips, flea beetles, and whiteflies. For resistance management, do not apply Provado on a crop already treated with a soil application of Admire. This material is highly toxic to bees.
- methomyl (Lannate)
    - Percent acres treated: 58.4% (18)
    - Typical rates and frequency of application: 1.5-3.0 pts LV/A, 1-2 applications.
    - Method of application: Foliar application with ground or aerial equipment
    - REI: 48 hours            PHI: 3 days
    - Efficacy: Fair for GPA; not labeled for MA.
    - Use in IPM and resistance management: Treat at threshold levels and reapply on a 5-7 day spray schedule if populations remain above threshold. Use in rotation with materials from other insecticide classes for resistance management.
  - oxamyl (Vydate L)
    - Percent acres treated: 2.6% (18)
    - Typical rates and frequency of application: 1.0-2.0 qt 2L/A, 1 application.

Do not apply more than 24 pt per acre per season.

- Method of application: Foliar application with ground or aerial equipment
- REI: 48 hrs            PHI: 7 day

- Efficacy: Good for GPA only; not recommended for MA.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity of this material results in its use when multiple pests are present.
- oxydementon-methyl (Metasystox R):
  - Percent acres treated: 0.9% (18)
  - Typical rates and frequency of application: 2.0 pt 2SC/A, 1- 2 applications.

Do not exceed 2 applications per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 24 hours            PHI: 0 days
- Efficacy: Good for GPA only; not recommended for MA in NJ.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides.
- pymetrozine (Fulfill)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 2.75 oz 50WDG/A, 1-2 applications.

Do not exceed 5.5 oz/A per acre per season and allow at least 7 days between applications.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours            PHI: 0 days
- Efficacy: Good.

– Use in IPM and resistance management: This material selectively control aphids and has a low toxicity to beneficial insects. Apply when aphids first appear, before populations build to damaging levels.

- thiomethoxam (Platinum, Actara)

– Percent acres treated: Newer material, data not available.

– Typical rates and frequency of application:

§ Platinum: 5-8 oz 2SC/A (lower rates provide a shorter residual control), 1 application.

§ Actara: 2-3 oz 25WDG/A. 1-2 applications. Do not exceed a total of 8.0 oz per acre per season.

– Method of application:

§ Platinum: soil application can be applied in-furrow, as a transplant drench, side-dressed, or drip-irrigated.

§ Actara: Foliar application by ground or aerial equipment.

– REI: 12 hours            PHI: 30 days (Platinum)

REI: 12 hours            PHI: 0 days (Actara)

– Efficacy: Good.

– Use in IPM and resistance management: Thiomethoxam is in the same insecticide class as imidacloprid. The Platinum application is used as a preventative treatment for aphids, and will control other minor pepper pests such thrips, flea beetles, and whiteflies. Actara is highly toxic to bees.

### Alternatives:

The materials available for aphid control that are alternatives to EPA targeted materials include

acetmiprid, imidacloprid, pymetrozine, and thiomethoxam. Most of these materials are low on toxicity to the predators and parasites that control aphids naturally.

### **Cultural Control Practices:**

Destroy weed populations around the field. Incorporate crop residue as soon as possible after the last harvest.

### **Biological Controls:**

Numerous natural enemies help keep aphid populations under control, including lacewing larvae, syrphid fly larvae, lady beetle adults and larvae, true bugs and other predators. Parasites and a fungal disease are also important biological control agents. Overuse of pyrethroids has been shown to cause aphid outbreaks due to their detrimental impact on predators and parasites. Conservation of natural enemies in pepper fields usually results in good aphid control.

### **Other Issues:**

Acephate, acetmiprid, and oxamyl may not be used during some harvest periods due to the 7-day PHI.

### **Two Spotted Spider Mite, *Tetranychus urticae***

#### **Description and Damage:**

Adult two spotted spider mites (TSSM) overwinter in the soil, on tree bark, in debris, and in sheltered areas. They become active in early spring, but usually reach peak abundance in mid to late July, and are active through frost depending on the environmental conditions. Mites are very small ( $1/60$  inch in length – a little smaller than a pinhead) and difficult to see with the naked eye; a 10x hand lens facilitates identification. Adults have eight legs, are oval shaped, and are various shades of green, yellow, or pink, with a characteristic dark spot on each side of the body.

Females deposit individual spherical eggs on the undersides of the leaves or in sheltered areas on the plant. Immature mites molt three times and reach adulthood in less than a week depending on environmental conditions. Adults and nymphs feed on the undersides of the leaves, extracting plant sap and causing whitish spots or stippling damage that appears as leaf yellowing on the upper leaf surface. As populations increase, the leaves turn brown, the fruit may become injured from mite feeding, and leaves and fruit become covered in fine webbing. Heavy infestations may result in leaf drop and unmarketable fruit.

Hot dry weather promotes mite development. Infestations generally begin next to field margins from adjacent weedy or grassy areas or from other hosts like soybean, tomato, or eggplant fields. Mites disperse through wind, worker, and equipment movement. Rain and overhead irrigation help to hinder outbreaks. Mites are found most years in pepper fields in the southern region of the state (Atlantic, Camden, Salem, Gloucester, and Cumberland counties), but they do not typically reach economically damaging levels except during long periods of hot dry weather. The use of certain pesticides that impact the natural enemy complex (pyrethroid sprays in particular) are known to cause spider mite outbreaks (11). Infestations may go undetected until population levels are high and difficult to control since mites are small and the damage may be mistaken for nutrient deficiency. If left untreated, mites will cause yield losses of 50% or more depending on the time of infestation.

### **Monitoring:**

Observe plants near field edges, especially next to dusty roads. A 10X hand lens or shaking leaves over white paper helps in identification. Fields should be monitored weekly especially during dry periods. Early season thresholds are 10-15% crown leaves infested; the late season threshold is 50% terminal leaves infested (12).

### **Chemical Controls:**

- avermectin (Agri-Mek)
  - Percent acres treated: 0.9% (18)
  - Typical rates and frequency of application: 8.0-16.0 fl oz 0.15EC/A, 1-2 applications. Do not apply more than 48 fl oz per acre per season, and do not make more than 2 consecutive applications.

- Method of application: Foliar application with ground or aerial equipment
  - REI: 12 hrs                      PHI: 7 day
  - Efficacy: Good.
  - Use in IPM and resistance management: Apply when mites first appear and use in rotation with other classes of miticides for resistance management.
- bifenazate (Acramite)
    - Percent acres treated: New registration, data not available.
    - Typical rates and frequency of application: 0.75-1.0 lb 50WS/A, 1 application.
    - Method of application: Foliar application with ground equipment.
    - REI: 12 hours                      PHI: 3 days
    - Efficacy: Good.
    - Use in IPM and resistance management: Treat at threshold levels of mites and use in rotation with other miticides.
- bifenthrin (Capture)
    - Percent acres treated: Newer material, data not available
    - Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.
- Do not exceed 12.8 fl oz per acre per season.
- Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours                      PHI: 7 days

- Efficacy: Will reduce early mite infestations, but will not control high mite populations.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
- dicofol (Kelthane)
    - Percent acres treated: 13.4% (18)
    - Typical rates and frequency of application: 0.75-1.5 pt EC/A, 1-2 applications.

Do not exceed 1.6 pts per season.

- Method of application: Foliar application with ground or aerial equipment
- REI: 12,24 hours      PHI: 2 days
- Efficacy: Good.
- Use in IPM and resistance management: Treat at threshold levels of mites and use in rotation with other miticides.

### **Alternatives:**

Although not labeled for spider mites, the use of spinosad (with a silicon adjuvant) for other pests may suppress mite populations (1).

### **Cultural Control Practices:**

Destroy weeds around the field in the fall or early spring to reduce overwintering populations. Populations generally decline after periods of heavy rainfall, and overhead irrigation may have the same effect. Avoid planting near alfalfa, small grains, and hay. Maintain mowed areas next to fields, or avoid mowing overgrown weedy areas especially during dry periods.

## **Biological Controls:**

Mite natural enemies like minute pirate bugs, predatory thrips, and predatory mites usually keep populations under control. Outbreaks have been associated with the use of insecticides like the pyrethroids that destroy natural enemy populations (11).

## **Other Issues:**

Avermectin and bifenthrin may not be used during some harvest periods due to the 7-day PHI.

## **Corn Earworm, *Heliocoverpa zea***

### **Description and Damage:**

The corn earworm (CEW) adult moth is yellowish-tan with a characteristic dark spot near the middle of the wing. Females deposit individual spherical eggs on the leaves and blossoms of pepper plants. Eggs hatch in 3-5 days depending on environmental conditions, and larvae move to the fruit to feed. Larval color varies from light green to pink, yellow, and brown. Adult moths are active at dusk through early morning, laying eggs on susceptible host plants like sweet corn, peppers, tomatoes, lettuce, and weeds. As the larvae mature they bore into the fruit to feed, usually leaving obvious entry and exit holes. Occasionally they will enter under the calyx similar to ECB. Fruit may rot in the field prior to harvest or may go undetected through the packing line only to be rejected at the market.

CEW pupae overwinter in the soil throughout New Jersey in mild winters, although survival is usually not successful north of 39° latitude. Adults typically appear in July in New Jersey. Adults are highly migratory, and move from other areas into New Jersey especially associated with weather systems of southern origin. During the fall hurricane season (late August through September), large influxes of moths may occur. Peppers are not a favored host, but in the absence of other host plants (especially sweet corn), and in combination with high populations, peppers may sustain fruit loss. Growers are usually applying insecticides for ECB control at the time of CEW activity, so pesticide choice becomes a factor

since some ECB materials (particularly acephate) are not effective for CEW. In southern New Jersey, CEW are present most years but do not usually reach economically damaging levels due to preventative treatments. Northern counties rarely have problems with CEW on peppers.

### **Monitoring:**

Rutgers Cooperative Extension publishes a statewide Plant & Pest Advisory newsletter that contains maps of adult black light trap population levels. The maps are useful for growers to determine area population levels and possible risk of fruit infestations. A threshold of 20 moths per night is the general guideline used for assessing risk of infestation. As populations reach threshold levels growers are advised to switch to materials that control both CEW and ECB.

### **Chemical Controls:**

- *Bacillus thuringiensis* (Agree, Biobit, Condor, Crymax, Dipel, Deliver, Javelin WG, Lepinox WDG, Mattch, or other labeled formulation)
  - Percent acres treated: 0.9% (18)
  - Typical rates and frequency of application: Consult label for rates and restrictions.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 4 hours                      PHI: 0 days
  - Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
  - Use in IPM and resistance management: More effective on small larvae. Use higher rates for heavier infestations and re-apply on a 3-4 day schedule. *B.t.* materials are most effective when temperatures are above 75 °F at application.
  
- bifenthrin (Capture)
  - Percent acres treated: Newer material, data not available.

- Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.

Do not exceed 12.8 fl oz per acre per season.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours            PHI: 7 days

- Efficacy: Good.

- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.

- carbaryl (Sevin)

- Percent acres treated: 2.4% (18)

- Typical rates and frequency of application: 1.5-2.5 lb 80S/A or other labeled formulation, 1 application.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours            PHI: 0 days

- Efficacy: Fair

- Use in IPM and resistance management: This material is not typically recommended for use in IPM programs due to the high mortality of bees and beneficial predators.

- cyfluthrin (Baythroid)

- Percent acres treated: 11.4% (18)

- Typical rates and frequency of application: 1.6-2.8 fl oz 2E/A, 1-2 applications. Do not exceed 16.8 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours            PHI: 7 days
  - Efficacy: Good.
  
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
- emamectin (Proclaim)
    - Percent acres treated: New registration, data not available.
    - Typical rates and frequency of application: 2.4-4.8 fl oz 5 SG/A, 1-2 applications. Do not exceed 16.8 total fluid ounces per acre per season.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 48 hours            PHI: 7 days
    - Efficacy: Poor.
    - Use in IPM and resistance management: Emamectin selectively controls several lepidopteran pepper pests, but is recommended for use on small larvae when larvae first appear and before populations reach damaging levels. Rotate with materials from other insecticide classes for resistance management.
- esfenvalerate (Asana)
    - Percent acres treated: 6.9% (18)
    - Typical rates and frequency of application: 5.8-9.6 fl oz 0.66EC/A, 1-2 applications. Do not exceed 68 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 7 days
  - Efficacy: Variable.
  - Use in IPM and resistance management: Due to the lower residual, this material is used every 5-7 days during the period of threshold levels of CEW. The broad-spectrum contact activity results in its use when multiple pests are present. Rotate with materials from other insecticide classes for resistance management. Repeated use of pyrethroids may flare aphid and mite populations.
- indoxacarb (Avaunt)
    - Percent acres treated: newer material, data not available.
    - Typical rates and frequency of application: 3.5 oz 30WDG/A, 1-2 applications. Do not plant any crop not on the label for food or feed for 30 days after last application. Do not apply more than 14 oz per acre per crop.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 12 hours            PHI: 3 days
    - Efficacy: Good.
    - Use in IPM and resistance management: Use at threshold levels and rotate with materials from other insecticide classes for resistance management. Helps conserve certain beneficial insect populations.
- lambdacyhalothrin (Warrior)
    - Percent acres treated: New registration, data not available.
    - Typical rates and frequency of application: 2.56-3.84 fl oz/A, 1-2 applications.

- Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 5 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Lambdacyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
- methoxyfenozide (Intrepid)
    - Percent acres treated: Newer material, data not available
    - Typical rates and frequency of application: 4.0-8.0 fl oz/A (early season), 8.0-16.0 fl oz/A (late season); 1-2 applications. Do not apply more than 64 fl oz per acre per season.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 12 hours            PHI: 1 day
    - Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
    - Use in IPM and resistance management: Early season rates are for young crops and small plants. Later season rates are recommended for heavier infestations under conditions of larger plants and dense foliage, since larvae need to ingest the material. A 7-14 day re-treatment interval is recommended to protect new growth until moth flights and/or infestations subside. Methoxyfenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Rotate with materials from other insecticide classes for resistance management.
- permethrin (i.e., Pounce)

- Percent acres treated: 5.6% (18)
  - Typical rates and frequency of application: 4.0-8.0 fl oz 3.2EC/A or other labeled formulation.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours            PHI: 3 days
  - Efficacy: Fair. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
  - Use in IPM and resistance management: Use in rotation with other classes of insecticides. Overuse of permethrin will impact predators and parasites and may cause a secondary outbreak of aphids. The new generation pyrethroids may show more activity.
- spinosad (Spintor 2SC, Entrust)
    - Percent acres treated: 29.4% (18)
    - Typical rates and frequency of application:
      - § Spintor 2SC: 3.0-6.0 fl oz 2SC/A, 2-4 applications. Do not exceed 29 total fluid ounces per acre per season.
      - § Entrust: 1.0-2.0 fl oz/A, 2-4 applications. Do not apply more than 9 oz per acre per crop.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 4 hours            PHI: 1 day
    - Efficacy: Fair.
    - Use in IPM and resistance management: Spinosad controls multiple lepidopteran species, including European corn borer, as well as thrips and leafminers. It does not affect certain parasites and predators so that secondary pest outbreaks are minimized. Treat at threshold levels and/or time applications to peak egg hatch. Rotate with materials from other insecticide classes for resistance management.

- zeta-cypermethrin (Mustang Max)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 2.24-4.0 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 1 day
  - Efficacy: Good.
  - Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

### **Alternatives:**

There are alternatives to carbaryl, although most of the recommended materials except for emamectin are in the same chemical class (pyrethroids, permethrin) so that resistance management is a concern. Although not recommended for New Jersey commercial growers, neem and *Bt kurstaki* are other alternatives.

### **Cultural Control Practices:**

Effective weed control may help reduce CEW damage by improving spray coverage within the field.

### **Biological Controls:**

There are many general predators like lady beetles, syrphid fly larvae, lacewings, spiders, and minute pirate bug, which feed on CEW eggs and small larvae. However, when populations of CEW are high, natural control is less reliable.

## **Other Issues:**

Esfenvalerate, emamectin, and cyfluthrin may not be used during some harvest periods due to the 7-day PHI. Pyrethroid resistance may be developing in the mid-western and southwestern states.

## **Fall Armyworm, *Spodoptera frugiperda***

### **Description and Damage:**

Fall armyworms (FAW) migrate from the southern states and appear in New Jersey in July, and are attracted to pepper fields as sweet corn fields mature in late August through September. FAW females deposit fuzzy light brown egg masses on the undersides of leaves. Larvae are light to dark brown with a dark stripe along each side, a pattern of four black dots on each segment down the back, and a characteristic inverted 'Y' shape on the head capsule. Larvae emerge and spread out to feed on both the leaves and the fruit. As they mature they bore anywhere on the fruit and usually leave obvious large entry holes. They cause direct damage to the fruit, and can be a contaminant as well as cause significant fruit rot. Fruit infestations do not usually go undetected. Under high populations many fruit may turn prematurely red and rot in the field. Populations in New Jersey depend on southern survivorship and migration, and vary year to year.

### **Monitoring:**

Pheromone traps can be used to track the adult male populations to determine influxes of moths. Trap captures of 10-20 per night in the green unitraps, in combination with presence of egg masses and/or evidence of larvae in the field, signal that FAW is a target pest for fall fruit cover sprays. The presence of threshold levels will influence the choice of materials used, since materials effective for ECB may not be effective for other fruit-invading pests.

### **Chemical Controls:**

- *Bacillus thuringiensis* (Agree, Biobit, Condor, Crymax, Dipel, Deliver, Javelin WG, Lepinox WDG, Match, or other labeled formulation)

- Percent acres treated: 0.9% (18)
- Typical rates and frequency of application: Consult label for rates and restrictions.
- Method of application: Foliar application with ground or aerial equipment.
- REI: 4 hours                      PHI: 0 days
- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: More effective on small larvae. Use higher rates for heavier infestations and re-apply on a 3-4 day schedule. *B.t.* materials are most effective when temperatures are above 75 °F at application.

- bifenthrin (Capture)

- Percent acres treated: Newer material, data not available.
- Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.

Do not exceed 12.8 fl oz per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours                      PHI: 7 days
- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.

- cyfluthrin (Baythroid)

- Percent acres treated: 11.4% (18)
- Typical rates and frequency of application: 2.8 fl oz 2E/A, 1-2 applications.

Do not exceed 16.8 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 24 hours            PHI: 7 days
- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.

- emamectin (Proclaim)

- Percent acres treated: New registration, data not available
- Typical rates and frequency of application: 2.4-4.8 fl oz 5 SG/A, 1-2 applications. Do not exceed 16.8 total fluid ounces per acre per season.
- Method of application: Foliar application with ground or aerial equipment.
- REI: 48 hours            PHI: 7 days
- Efficacy: Very good.
- Use in IPM and resistance management: Emamectin selectively controls several lepidopteran pepper pests, but is recommended for use on small larvae when larvae first appear and before populations reach damaging levels. Rotate with materials from other insecticide classes for resistance management.

- lambdacyhalothrin (Warrior)
  - Percent acres treated: New registration, data not available.
  - Typical rates and frequency of application: 2.56-3.84 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 5 days
  - Efficacy: Poor.
  - Use in IPM and resistance management: For control of first and second instar FAW larvae only. Lambdacyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- methomyl (Lannate)
  - Percent acres treated: 58.4% (18)
  - Typical rates and frequency of application: 1.5 pt LV/A, or other labeled formulation, 2-3 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 48 hours            PHI: 3 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Treat at threshold levels and reapply on a 5-7 day spray schedule to maintain control. Use in rotation with materials from other insecticide classes for resistance management.

- methoxyfenozide (Intrepid)
  - Percent acres treated: Newer material, data not available
  - Typical rates and frequency of application: 4.0-8.0 fl oz/A (early season), 8.0-16.0 fl oz/A (late season); 1-2 applications. Do not apply more than 64 fl oz per acre per season.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 1 day
  - Efficacy: Good.
  - Use in IPM and resistance management: Early season rates are for young crops and small plants. Later season rates are recommended for heavier infestations under conditions of larger plants and dense foliage, since larvae need to ingest the material. A 7-14 day re-treatment interval is recommended to protect new growth until moth flights and/or infestations subside. Methoxyfenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Rotate with materials from other insecticide classes for resistance management.
  
- spinosad (Spintor 2SC, Entrust)
  - Percent acres treated: 29.4% (18)
  - Typical rates and frequency of application:
    - § Spintor 2SC: 4.0-8.0 fl oz 2SC/A, 2-4 applications. Do not exceed 29 total fluid ounces per acre per season.
    - § Entrust: 1.25-2.5 fl oz/A, 2-4 applications. Do not apply more than 9 oz per acre per crop.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 4 hours            PHI: 1 day
  - Efficacy: Good.
  - Use in IPM and resistance management: Spinosad controls multiple lepidopteran species,

including European corn borer, as well as thrips and leafminers. It does not affect certain parasites and predators so that secondary pest outbreaks are minimized. Treat at threshold levels and/or time applications to peak egg hatch. Rotate with materials from other insecticide classes for resistance management.

- tebufenozide (Confirm)
  - Percent acres treated: 0.7% (18)
  - Typical rates and frequency of application: 8.0-16.0 fl oz 2F/A, 1-2 applications.

Do not exceed 64 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 4 hours                      PHI: 7 days
- Efficacy: Good.
- Use in IPM and resistance management: Tebufenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Lower rates are recommended for light infestations and higher rates for moderate to heavy infestations. Application timing is important since the material must be ingested before larvae enter the fruit. Re-application is recommended when insect populations are high and/or the plants are rapidly growing. For resistance management, rotate with materials from other insecticide classes.

- zeta-cypermethrin (Mustang Max)
  - Percent acres treated: newer material, data not available
  - Typical rates and frequency of application: 3.2-4.0 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours                      PHI: 1 day
  - Efficacy: Poor.

– Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

### **Alternatives:**

The effective alternatives to methomyl for FAW control include emamectin, methoxyfenozide, spinosad, tebufenozide. Although not recommended for New Jersey commercial growers, neem is another alternative.

### **Cultural Control Practices:**

Plow down crop residue to destroy pupae.

### **Biological Controls:**

No reliable biological control measures are available for FAW.

### **Other Issues:**

Tebufenozide, emamectin, and cyfluthrin may not be used during some harvest periods due to the 7-day PHI.

## **Beet Armyworm, *Spodoptera exigua***

### **Description and Damage:**

Beet armyworms (BAW) are another southern pest that migrate into southern New Jersey in mid- to late August. The larvae have a wide host range, including alfalfa, asparagus, beans, beets, cole crops, lettuce, spinach, onions, peppers, and tomatoes, as well as some weeds. Population levels depend on favorable survival in the southern states in combination with favorable conditions for migration. In New Jersey, outbreaks occur sporadically in the southern counties. Early detection and management of high population levels is important for effective control, since larvae are difficult to control and can quickly defoliate fields if left uncontrolled.

Like fall armyworms, BAW females deposit oval-shaped light brown fuzzy eggs in clusters on the undersides of the leaves. Eggs hatch in 3 to 4 days, and larvae mature in 2 to 3 weeks depending on environmental conditions. Larvae are green or greenish-black, and have a characteristic dark spot above the second pair of legs. Small larvae feed in groups on the plant within fine webbing on the undersides of the leaves. As the larvae mature they spread out on the plant, consuming leaves and fruit. The larvae skeletonize leaves and damage fruit by both boring into the fruit at the calyx end and leaving surface marks. Most years some BAW occur in the southern counties at low levels, but occasionally large influxes of moths occur. High populations can quickly defoliate fields, resulting in 100% loss if not controlled with effective materials (1). Resistance management is a concern since BAW migrates from areas where resistance to several materials is present.

### **Monitoring:**

Pheromone traps (green unitrap) can be used to determine when influxes of moths occur. As trap captures increase to 20 per night, scout fields for presence of larvae, infested plants, and/or egg masses. Infestations should be monitored closely, and control measures should be evaluated within a week after application.

### **Chemical Controls:**

- *Bacillus thuringiensis* (Agree, Biobit, Condor, Crymax, Dipel, Deliver, Javelin WG, Lepinox WDG, Mattch, or other labeled formulation)
  - Percent acres treated: 0.9% (18)
  - Typical rates and frequency of application: Consult label for rates and restrictions.
  - Method of application: Foliar application with ground or aerial equipment.

- REI: 4 hours                      PHI: 0 days
- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: More effective on small larvae. Use higher rates for heavier infestations and re-apply on a 3-4 day schedule. *B.t.* materials are most effective when temperatures are above 75 °F at application.

- bifenthrin (Capture)

- Percent acres treated: Newer material, data not available
- Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.

Do not exceed 12.8 fl oz per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours                      PHI: 7 days
- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.

- emamectin (Proclaim)

- Percent acres treated: New registration, data not available.
- Typical rates and frequency of application: 2.4-4.8 fl oz 5 SG/A, 1-2 applications. Do not exceed 16.8 total fluid ounces per acre per season.
- Method of application: Foliar application with ground or aerial equipment.

- REI: 48 hours            PHI: 7 days
  
- Efficacy: Good.
  
- Use in IPM and resistance management: Emamectin selectively controls several lepidopteran pepper pests, but is recommended for use on small larvae when larvae first appear and before populations reach damaging levels. Rotate with materials from other insecticide classes for resistance management.
  
  
- indoxacarb (Avaunt)
  - Percent acres treated: newer material, data not available.
  
  - Typical rates and frequency of application: 3.5 oz 30WDG/A, 1-2 applications. Do not plant any crop not on the label for food or feed for 30 days after last application. Do not apply more than 14 oz per acre per crop.
  
  - Method of application: Foliar application with ground or aerial equipment.
  
  - REI: 12 hours            PHI: 3 days
  
  - Efficacy: Good.
  
  - Use in IPM and resistance management: Use at threshold levels and rotate with materials from other insecticide classes for resistance management. Helps conserve certain beneficial insect populations.
  
  
- lambdacyhalothrin (Warrior)
  - Percent acres treated: New registration, data not available.
  
  - Typical rates and frequency of application: 2.56-3.84 fl oz/A, 1-2 applications.
  
  - Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours            PHI: 5 days
  - Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
  - Use in IPM and resistance management: For control of 1<sup>st</sup> and 2<sup>nd</sup> instar larvae only. Lambdacyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
- methomyl (Lannate)
    - Percent acres treated: 58.4% (18)
    - Typical rates and frequency of application: 1.5 pt LV/A, or other labeled formulation, 1-2 applications.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 48 hours            PHI: 3 days
    - Efficacy: Inconsistent.
    - Use in IPM and resistance management: Treat at threshold levels and reapply on a 5-7 day spray schedule to maintain control. Use in rotation with materials from other insecticide classes for resistance management.
- methoxyfenozone (Intrepid)
    - Percent acres treated: Newer material, data not available.
    - Typical rates and frequency of application: 4.0-8.0 fl oz/A (early season), 8.0-16.0 fl oz/A (late season); 1-2 applications. Do not apply more than 64 fl oz per acre per season.
    - Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours            PHI: 1 day
- Efficacy: Good.
- Use in IPM and resistance management: Early season rates are for young crops and small plants. Later season rates are recommended for heavier infestations under conditions of larger plants and dense foliage, since larvae need to ingest the material. A 7-14 day re-treatment interval is recommended to protect new growth until moth flights and/or infestations subside. Methoxyfenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Rotate with materials from other insecticide classes for resistance management.
- spinosad (Spintor 2SC, Entrust)
  - Percent acres treated: 29.4% (18)
  - Typical rates and frequency of application:
    - § Spintor 2SC: 4.0-8.0 fl oz 2SC/A, 2-4 applications. Do not exceed 29 total fluid ounces per acre per season.
    - § Entrust: 1.25-2.5 fl oz/A, 2-4 applications. Do not apply more than 9 oz per acre per crop.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 4 hours            PHI: 1 day
  - Efficacy: Good.
  - Use in IPM and resistance management: Spinosad controls multiple lepidopteran species, including European corn borer, as well as thrips and leafminers. It does not affect certain parasites and predators so that secondary pest outbreaks are minimized. Treat at threshold levels and/or time applications to peak egg hatch. Rotate with materials from other insecticide classes for resistance management.
- tebufenozide (Confirm)

- Percent acres treated: 0.7% (18)
- Typical rates and frequency of application: 8.0-16.0 fl oz 2F/A, 1 application.

Do not exceed 64 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 4 hours                      PHI: 7 days
- Efficacy: Fair to good.
- Use in IPM and resistance management: Tebufenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Lower rates are recommended for light infestations and higher rates for moderate to heavy infestations. Application timing is important since the material must be ingested before larvae enter the fruit. Re-application is recommended when insect populations are high and/or the plants are rapidly growing. For resistance management, rotate with materials from other insecticide classes.

- zeta-cypermethrin (Mustang Max)

- Percent acres treated: newer material, data not available.
- Typical rates and frequency of application: 3.2-4.0 fl oz/A, 1-2 applications.
- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours                      PHI: 1 day
- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

**Alternatives:**

There are many alternatives to methomyl for BAW control. Although not recommended for New Jersey commercial growers, neem is another alternative.

**Cultural Control Practices:**

None available.

**Biological Controls:**

Although there are many natural enemies that attack beet armyworms (11), none of the organisms provide reliable control especially under high population levels.

**Other Issues:**

Bifenthrin, emamectin, and tebufenozide may not be used during some harvest periods due to the 7-day PHI.

**Tomato Hornworm, *Manduca quinquemaculata*****Tobacco Hornworm, *Manduca sexta*****Description and Damage:**

The tomato and tobacco hornworms feed on solanaceous crops like peppers, tomatoes, eggplant, and tobacco. Hornworms overwinter in the soil in the pupal stage, emerging as large hawk moths in late June. Adults begin laying eggs in pepper fields in late June and July through the rest of the summer. Females deposit single, spherical, greenish-yellow eggs on the undersides of the leaves. Eggs hatch about 5 days later, and larvae emerge and feed on the leaves and stems for about 3 to 4 weeks, completely consuming plant tissue. Larvae are green with white diagonal stripes on either side and have a characteristic 'horn'

protrusion on the rear end. They develop into very large caterpillars (up to 3.5 inches) that blend well within the pepper plant. They are more easily detected by the large-sized droppings they leave at the base of the plant. Hornworms are controlled with most selective insecticides and do not typically reach economically damaging levels most years, although large numbers can cause significant defoliation if not detected (1, 4).

### **Monitoring:**

Look for signs of defoliation and the presence of larvae and/or the large droppings at the base of the plant when scouting fields for other pests like aphids. No thresholds are available.

### **Chemical Controls:**

- acephate (Orthene, Address, Lancer)
  - Percent acres treated: 61.5% (18)
  - Typical rates and frequency of application: 0.5-1.0 lb 97S/A, or other labeled formulation, 1-2 applications. Do not to exceed 2 lbs active ingredient per acre per season.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours            PHI: 7 days
  - Efficacy: Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations for this pest.
  - Use in IPM and resistance management: Since only two applications of acephate are permitted, it is primarily used for ECB control. This material would be used for above threshold levels of hornworms if ECB is above threshold at the same time.
  
- *Bacillus thuringiensis* (Agree, Biobit, Condor, Crymax, Dipel, Deliver, Javelin WG, Lepinox WDG, Match, or other labeled formulation)
  - Percent acres treated: 0.9% (18)

- Typical rates and frequency of application: Consult label for rates and restrictions.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 4 hours                      PHI: 0 days
  - Efficacy: Good.
  - Use in IPM and resistance management: More effective on small larvae. Use higher rates for heavier infestations and re-apply on a 3-4 day schedule. *B.t.* materials are most effective when temperatures are above 75 °F at application.
- carbaryl (Sevin)
    - Percent acres treated: 2.4% (18)
    - Typical rates and frequency of application: 1.5-2.5 lb 80S/A, or other labeled formulation, 1 application.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 12 hours                      PHI: 0 days
    - Efficacy: Good.
    - Use in IPM and resistance management: This material is not typically recommended for use in IPM programs due to the high mortality of bees and beneficial predators.
- cyfluthrin (Baythroid)
    - Percent acres treated: 11.4% (18)
    - Typical rates and frequency of application: 1.6-2.8 fl oz 2E/A, 1-2 applications. Do not exceed 16.8 total fluid ounces per acre per season.
    - Method of application: Foliar application with ground or aerial equipment.

- REI: 24 hours            PHI: 7 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
- emamectin (Proclaim)
    - Percent acres treated: New registration, data not available.
    - Typical rates and frequency of application: 2.4-4.8 fl oz 5 SG/A, 1-2 applications. Do not exceed 16.8 total fluid ounces per acre per season.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 48 hours            PHI: 7 days
    - Efficacy: Unknown.
    - Use in IPM and resistance management: Emamectin selectively controls several lepidopteran pepper pests, but is recommended for use on small larvae when larvae first appear and before populations reach damaging levels. Rotate with materials from other insecticide classes for resistance management.
- endosulfan (Thionex, Thiodan, Phaser, Endosulfan, etc.)
    - Percent acres treated: 4.3% (18)
    - Typical rates and frequency of application: 1.33-2.67 3EC/A or other labeled formulation, 1-2 applications. Do not exceed 2.0 lbs ai per acre per year.
    - Method of application: Foliar application with ground or aerial equipment.

- REI: 48 hours            PHI: 4 days
  - Efficacy: Unknown.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with materials from other insecticide classes. Endosulfan is labeled for other pepper pests including aphids, flea beetles, pepper maggots, and leafminers.
- lambdacyhalothrin (Warrior)
    - Percent acres treated: New registration, data not available.
    - Typical rates and frequency of application: 1.92-3.20 fl oz/A, 1-2 applications.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 12 hours            PHI: 5 days
    - Efficacy: Good.
    - Use in IPM and resistance management: Lambdacyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
  - methoxyfenozone (Intrepid)
    - Percent acres treated: Newer material, data not available.
    - Typical rates and frequency of application: 4.0-8.0 fl oz/A (early season), 8.0-16.0 fl oz/A (late season); 1-2 applications. Do not apply more than 64 fl oz per acre per season.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 12 hours            PHI: 1 day

- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
  - Use in IPM and resistance management: Early season rates are for young crops and small plants. Later season rates are recommended for heavier infestations under conditions of larger plants and dense foliage, since larvae need to ingest the material. A 7-14 day re-treatment interval is recommended to protect new growth until moth flights and/or infestations subside. Methoxyfenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Rotate with materials from other insecticide classes for resistance management.
- spinosad (Spintor 2SC, Entrust)
    - Percent acres treated: 29.4% (18)
    - Typical rates and frequency of application:
      - § Spintor 2SC: 3.0-6.0 fl oz 2SC/A, 2-4 applications. Do not exceed 29 total fluid ounces per acre per season.
      - § Entrust: 1.0-2.0 fl oz/A, 2-4 applications. Do not apply more than 9 oz per acre per crop.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 4 hours                      PHI: 1 day
    - Efficacy: Good.
    - Use in IPM and resistance management: Spinosad controls multiple lepidopteran species, including European corn borer, as well as thrips and leafminers. It does not affect certain parasites and predators so that secondary pest outbreaks are minimized. Treat at threshold levels and/or time applications to peak egg hatch. Rotate with materials from other insecticide classes for resistance management.
- tebufenozide (Confirm)
    - Percent acres treated: 0.7% (18)

- Typical rates and frequency of application: 8.0-16.0 fl oz 2F/A, 1-2 applications.

Do not exceed 64 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 4 hours                      PHI: 7 days

- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.

- Use in IPM and resistance management: Tebufenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Lower rates are recommended for light infestations and higher rates for moderate to heavy infestations. Application timing is important since the material must be ingested before larvae enter the fruit. Re-application is recommended when insect populations are high and/or the plants are rapidly growing. For resistance management, rotate with materials from other insecticide classes.

- zeta-cypermethrin (Mustang Max)

- Percent acres treated: Newer material, data not available.

- Typical rates and frequency of application: 2.24-4.0 fl oz/A, 1-2 applications.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours                      PHI: 1 day

- Efficacy: Good.

- Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

**Alternatives:**

There are many alternatives to carbaryl and endosulfan for hornworm control. Although not recommended for New Jersey commercial growers, neem is another alternative.

### **Cultural Control Practices:**

Fall plowing will destroy many of the pupae in the soil.

### **Biological Controls:**

A parasitic wasp, *Cotesia congregata*, is an important biological control agent. Protecting these parasites from harmful sprays can build populations capable of effectively managing hornworms (1, 4).

### **Other Issues:**

Cyfluthrin, emamectin, and tebufenozide may not be used during some harvest periods due to the 7-day PHI.

## **Cabbage Looper, *Trichoplusia ni***

### **Description and Damage:**

Cabbage looper larvae are pale green with thin white stripes down the back and sides, and are distinguished by their looping movement. The larvae feed on the underside of leaves, producing ragged holes of various sizes. Feeding begins in late July or early August and usually continues through harvest. Healthy plants can usually sustain feeding injury unless populations become exceedingly large. Several generations can occur during a year. This pest does not typically reach economically damaging levels in

New Jersey, although identification is important so that they are not mistaken for other more serious defoliators like the armyworms.

### **Monitoring:**

When checking fields for other pests, note the presence of holes on the leaves and determine the insect species responsible for the damage.

### **Chemical Controls:**

- acephate (Orthene, Address, Lancer)
  - Percent acres treated: 61.5% (18)
  - Typical rates and frequency of application: 0.5-1.0 lb 97S/A, or other labeled formulation, 1-2 applications. Do not to exceed 2 lbs active ingredient per acre per season.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours            PHI: 7 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Since only two applications are permitted, acephate is primarily used for ECB control. This material would be used for above threshold levels of loopers if ECB is above threshold at the same time.
  
- *Bacillus thuringiensis* (Agree, Biobit, Condor, Crymax, Dipel, Deliver, Javelin WG, Lepinox WDG, Match, or other labeled formulation)
  - Percent acres treated: 0.9% (18)
  - Typical rates and frequency of application: Consult label for rates and restrictions.
  - Method of application: Foliar application with ground or aerial equipment.

- REI: 4 hours                      PHI: 0 days
- Efficacy: Good.
- Use in IPM and resistance management: More effective on small larvae. Use higher rates for heavier infestations and re-apply on a 3-4 day schedule. *B.t.* materials are most effective when temperatures are above 75 °F at application.

- bifenthrin (Capture)

- Percent acres treated: Newer material, data not available.
- Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.

Do not exceed 12.8 fl oz per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours                      PHI: 7 days
- Efficacy: Good.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.

- cyfluthrin (Baythroid)

- Percent acres treated: 11.4% (18)
- Typical rates and frequency of application: 2.8 fl oz 2E/A, 1-2 applications.

Do not exceed 16.8 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 24 hours                      PHI: 7 days
  
- Efficacy: Good.
  
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
  
  
- emamectin (Proclaim)
  - Percent acres treated: New registration, data not available.
  
  - Typical rates and frequency of application: 2.4-4.8 fl oz 5 SG/A, 1-2 applications. Do not exceed 16.8 total fluid ounces per acre per season.
  
  - Method of application: Foliar application with ground or aerial equipment.
  
  - REI: 48 hours                      PHI: 7 days
  
  - Efficacy: Unknown.
  
  - Use in IPM and resistance management: Emamectin selectively controls several lepidopteran pepper pests, but is recommended for use on small larvae when larvae first appear and before populations reach damaging levels. Rotate with materials from other insecticide classes for resistance management.
  
  
- esfenvalerate (Asana XL)
  - Percent acres treated: 6.9% (18)
  
  - Typical rates and frequency of application: 5.8-9.6 fl oz 0.66EC/A, 1-2 applications. Do not exceed 68 total fluid ounces per acre per season.
  
  - Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours            PHI: 7 days
- Efficacy: Good.
- Use in IPM and resistance management: The broad-spectrum contact activity results in its use when multiple pests are present. Rotate with materials from other insecticide classes for resistance management. Repeated use of pyrethroids may flare aphid and mite populations.
  
- indoxacarb (Avaunt)
  - Percent acres treated: newer material, data not available.
  - Typical rates and frequency of application: 2.5-3.5 oz 30 WDG/A, 1-2 applications. Do not plant any crop not on the label for food or feed for 30 days after last application. Do not apply more than 14 oz per acre per crop.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 3 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Use at threshold levels and rotate with materials from other insecticide classes for resistance management. Helps conserve certain beneficial insect populations.
  
- lambdacyhalothrin (Warrior)
  - Percent acres treated: New registration, data not available.
  - Typical rates and frequency of application: 1.9-3.2 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 5 days

- Efficacy: Good.
- Use in IPM and resistance management: Lambdacyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
- methomyl (Lannate)
  - Percent acres treated: 58.4% (18)
  - Typical rates and frequency of application: 1.5 pt LV/A, or other labeled formulation, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 48 hours            PHI: 3 days
  - Efficacy: Inconsistent.
  - Use in IPM and resistance management: Treat at threshold levels and reapply on a 5-7 day spray schedule if populations remain above threshold. Use in rotation with materials from other insecticide classes for resistance management.
- methoxyfenozide (Intrepid)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 4.0-8.0 fl oz/A (early season), 8.0-16.0 fl oz/A (late season); 1-2 applications. Do not apply more than 64 fl oz per acre per season.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 1 day
  - Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.

– Use in IPM and resistance management: Early season rates are for young crops and small plants. Later season rates are recommended for heavier infestations under conditions of larger plants and dense foliage, since larvae need to ingest the material. A 7-14 day re-treatment interval is recommended to protect new growth until moth flights and/or infestations subside. Methoxyfenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Rotate with materials from other insecticide classes for resistance management.

- permethrin (Ambush, Pounce)

- Percent acres treated: 5.6% (1.6% Ambush; 4.0% Pounce) (18)

- Typical rates and frequency of application:

- § Ambush: 6.4-12.8 fl oz 2EC/A or other labeled formulation.

- § Pounce: 4.0-8.0 fl oz 3.2EC/A.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 24 hours            PHI: 3 days

- Efficacy: Good.

- Use in IPM and resistance management: Use in rotation with other classes of insecticides. Overuse of permethrin will impact predators and parasites and may cause a secondary outbreak of aphids.

- spinosad (Spintor 2SC, Entrust)

- Percent acres treated: 29.4% (18)

- Typical rates and frequency of application:

- § Spintor 2SC: 3.0-6.0 fl oz 2SC/A, 2-4 applications. Do not exceed 29 total fluid ounces per acre per season.

§ Entrust: 1.0-2.0 fl oz/A, 2-4 applications. Do not apply more than 9 oz per acre per crop.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 4 hours                      PHI: 1 day
- Efficacy: Good.
- Use in IPM and resistance management: Spinosad controls multiple lepidopteran species, including European corn borer, as well as thrips and leafminers. It does not affect certain parasites and predators so that secondary pest outbreaks are minimized. Treat at threshold levels and/or time applications to peak egg hatch. Rotate with materials from other insecticide classes for resistance management.

- tebufenozide (Confirm)

- Percent acres treated: 0.7% (18)
- Typical rates and frequency of application: 8.0-16.0 fl oz 2F/A, 1 application.

Do not exceed 64 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 4 hours                      PHI: 7 days
- Efficacy: Poor.
- Use in IPM and resistance management: Tebufenozide selectively controls multiple lepidopteran species but does not impact beneficial insect populations and bees. Lower rates are recommended for light infestations and higher rates for moderate to heavy infestations. Application timing is important since the material must be ingested before larvae enter the fruit. Re-application is recommended when insect populations are high and/or the plants are rapidly growing. For resistance management, rotate with materials from other insecticide classes.

- zeta-cypermethrin (Mustang Max)

- Percent acres treated: newer material, data not available.
- Typical rates and frequency of application: 3.2-4.0 fl oz/A, 1-2 applications.
- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours            PHI: 1 day
- Efficacy: Good.
- Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

### **Alternatives:**

There are many alternatives to methomyl for cabbage looper control. Although not recommended for New Jersey commercial growers, neem is another alternative.

### **Cultural Control Practices:**

None available.

### **Biological Controls:**

There are several parasitic wasps and predators that attack the cabbage looper. Also, a nuclear polyhedrosis virus (NPV) can substantially reduce population levels of larvae, especially after a period of precipitation.

### **Other Issues:**

Bifenthrin, cyfluthrin, emamectin, esfenvalerate, and tebufenozide may not be used during some harvest periods due to the 7-day PHI.

### **Leafminers, *Liriomyza sp.***

#### **Description and Damage:**

Leafminers are occasional minor insect pests of peppers. The adult fly is black with yellow strips and very small, about 1/10 inch long, and deposits a single egg just under the leaf surface. Larvae feed between the leaf surfaces, causing serpentine white tunnels or mines that coalesce to appear as blotches. The larvae mature within the leaf, and emerge from the leaf to drop off and pupate usually in the soil. The entire life cycle can be completed in 23 days and several generations can occur within a season. Usually leafminers are not a problem, but an outbreak did occur in New Jersey when the grower purchased southern transplants for a late planting of peppers. The entire planting was destroyed due to excessive leaf mining and leaf drop.

#### **Monitoring:**

Sample 5 plants in 10 locations and count new mines on 2 leaves per plant. Consider control if mines are easily found and numbers are increasing throughout the field (12). Inspect southern-grown transplants for evidence of leafminers.

#### **Chemical Controls:**

- avermectin (Agri-Mek)
  - Percent acres treated: 0.9% (18)
  - Typical rates and frequency of application: 8.0-16.0 fl oz 0.15EC/A, 1-2 applications. Do not apply more than 48 fl oz per acre per season, and do not make more than 2 consecutive applications.
  - Method of application: Foliar application with ground or aerial equipment

- REI: 12 hrs                      PHI: 7 day
- Efficacy: Good.
- Use in IPM and resistance management: Apply when leafminers first appear and use in rotation with other classes of miticides for resistance management.

- bifenthrin (Capture)

- Percent acres treated: Newer material, data not available.
- Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.

Do not exceed 12.8 fl oz per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours                      PHI: 7 days
- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.

- cyromazine (Trigard)

- Percent acres treated: 0.0% (18)
- Typical rates and frequency of application: 0.167 lb 75WSP/A (one packet), 1-2 applications. Do not exceed 6 applications per season.
- Method of application: Foliar application with ground or aerial equipment
- REI: 12 hrs                      PHI: 7 day

- Efficacy: Good.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides.
- endosulfan (Thionex, Thiodan, Phaser, Endosulfan, etc.)
  - Percent acres treated: 4.3% (18)
  - Typical rates and frequency of application: 1.0-2.0 lbs 50WP/A or other labeled formulation, 1-2 applications. Do not exceed 2.0 lbs ai per acre per year.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 48 hours            PHI: 4 days
  - Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with materials from other insecticide classes. Endosulfan is labeled for other pepper pests including aphids, flea beetles, hornworms, and pepper maggots.
- oxamyl (Vydate L)
  - Percent acres treated: 2.6% (18)
  - Typical rates and frequency of application: 2.0-4.0 pt 2L/A, 1 application
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 48 hrs            PHI: 7 day
  - Efficacy: Good.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with

other classes of insecticides. The broad-spectrum activity of this material results in its use when multiple pests are present.

- permethrin (Ambush, Pounce)
  - Percent acres treated: 5.6% (1.6% Ambush; 4.0% Pounce) (18)
  - Typical rates and frequency of application:
    - § Ambush: 6.4-12.8 fl oz 2EC/A, 1-2 applications.
    - § Pounce: 4.0-8.0 fl oz 3.2EC/A or other labeled formulation, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours            PHI: 3 days
  - Efficacy: Poor.
  - Use in IPM and resistance management: Use in rotation with other classes of insecticides. Overuse of permethrin will impact predators and parasites and may cause a secondary outbreak of aphids.
  
- spinosad (Spintor 2SC, Entrust)
  - Percent acres treated: 29.4% (18)
  - Typical rates and frequency of application:
    - § Spintor 2SC: 6.0-8.0 fl oz 2SC/A, 2-4 applications. Do not exceed 29 total fluid ounces per acre per season.
    - § Entrust: 2.0-2.5 fl oz/A, 2-4 applications. Do not apply more than 9 oz per acre per crop.
  - Method of application: Foliar application with ground or aerial equipment.

- REI: 4 hours                      PHI: 1 day
- Efficacy: Good.
- Use in IPM and resistance management: Spinosad controls multiple lepidopteran species, including European corn borer, as well as thrips and leafminers. It does not affect certain parasites and predators so that secondary pest outbreaks are minimized. Treat at threshold levels and rotate with materials from other insecticide classes for resistance management.
- zeta-cypermethrin (Mustang Max)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application (leafminer adults only): 2.24-4.0 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours                      PHI: 1 day
  - Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
  - Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

### **Alternatives:**

Avoid repeated use of a single class of insecticides for resistance management. There are alternatives to oxamyl for leafminer control.

### **Cultural Control Practices:**

Destroy alternate hosts, particularly broad-leaf weeds. Avoid the use of southern-grown transplants.

### **Biological Controls:**

A complex of natural enemies control leafminers, and population outbreaks have been associated with continuous use of broad-spectrum insecticides that destroy the natural enemies.

**Potato Flea Beetle, *Epitrix cucumeris***

**Tobacco Flea Beetle, *E. hirtipennis***

**Palestriped Flea Beetle, *Systema blanda***

### **Description and Damage:**

Flea beetles are a major pest of cole crops, lettuce, sweet corn, eggplant, and tomato plants and an occasionally feed on potatoes, peppers, and other vegetable crops. Flea beetles are minor pests on peppers in New Jersey. Most flea beetles are tiny, darkly colored beetles 2.5 to 4.5 mm long. The body is usually a shiny black or duller brown color, or dark with pale yellow stripes on each wing cover. Flea beetles overwinter as adults in protected areas like hedgerows and emerge in mid-May into June to lay eggs in the soil. Eggs hatch in the soil and larvae feed on plant roots and pupate in 3 to 4 weeks. Adults appear in late June and July. A second generation of beetles matures in August or September. Flea beetles have large hind legs that allow them to jump from plant to plant. Beetles damage pepper plants by chewing tiny round holes in the foliage, resulting in a 'shot-hole' appearance. Seedling or newly transplanted plants are more susceptible to damage at lower population levels. The larvae may also feed on the roots but generally do not cause significant damage to peppers (1).

### **Monitoring:**

Check fields shortly after transplanting for the appearance of the adults and/or flea beetle damage (the beetles are more easily found on warm, calm, sunny days). Monitor field borders since beetles move into the crop during the day and take shelter in hedgerows and weeds at night. Thresholds (7):

Plant Height:

No. Beetles/Plant:

<3 inches

2/plant

3-6 inches

4/plant

>6 inches

8/plant

### **Chemical Controls:**

- azinphos-methyl (Guthion)
  - Percent acres treated: 0.9% (18)
  - Typical rates and frequency of application: 1 qt 2L/A or other labeled formulation, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 5 days                      PHI: 3 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Azinphos-methyl is also labeled for ECB and leafminers, although it is not typically recommended or used for these pests.

- bifenthrin (Capture)

- Percent acres treated: Newer material, data not available.
- Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.

Do not exceed 12.8 fl oz per acre per season.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours            PHI: 7 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
- carbaryl (Sevin)
    - Percent acres treated: 2.4% (18)
    - Typical rates and frequency of application: 1.25 lb 80S/A or other labeled formulation, 1 application.
    - Method of application: Foliar application with ground or aerial equipment.
    - REI: 12 hours            PHI: 0 days
    - Efficacy: Good.
    - Use in IPM and resistance management: This material is not typically recommended for use in IPM programs due to the high mortality of bees and beneficial predators.
  - cyfluthrin (Baythroid)
    - Percent acres treated: 11.4% (18)
    - Typical rates and frequency of application: 2.8 fl oz 2E/A, 1-2 applications.

Do not exceed 16.8 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 24 hours            PHI: 7 days

- Efficacy: Good.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
- endosulfan (Thionex, Thiodan, Phaser, Endosulfan, etc.)
  - Percent acres treated: 4.3% (18)
  - Typical rates and frequency of application: 1.0-2.0 lb 50W/A or other labeled formulation, 1-2 applications. Do not exceed 2.0 lbs ai per acre per year.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 48 hours            PHI: 4 days
  - Efficacy: Fair.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with materials from other insecticide classes. Endosulfan is labeled for other pepper pests including aphids, pepper maggots, hornworms, and leafminers.
- esfenvalerate (Asana XL)
  - Percent acres treated: 6.9% (18)
  - Typical rates and frequency of application: 5.8-9.6 fl oz 0.66EC/A, 1-2 applications. Do not exceed 68 total fluid ounces per acre per season.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 7 days
  - Efficacy: Good.

- Use in IPM and resistance management: The broad-spectrum contact activity results in its use when multiple pests are present. Rotate with materials from other insecticide classes for resistance management. Repeated use of pyrethroids may flare aphid and mite populations.
- imidacloprid (Admire)
  - Percent acres treated: 7.3% (Admire) (18)
  - Typical rates and frequency of application: 16.0-32.0 fl oz 2F/A, 1 application (lower rates provide a shorter residual control). Do not exceed 0.5 pounds active ingredient per acre per season regardless of application method or formulation. A 12-month plant back interval must be observed for crops not on the label.
  - Method of application: Soil application can be applied in-furrow, as a transplant drench, side-dressed, or drip-irrigated.
  - REI: 12 hours            PHI: 21 days
  - Efficacy: Good.
  - Use in IPM and resistance management: The Admire application is used as a preventative treatment for aphids, and will control other minor pepper pests such thrips, flea beetles, and whiteflies.
- lambdacyhalothrin (Warrior)
  - Percent acres treated: New registration, data not available.
  - Typical rates and frequency of application: 2.56-3.84 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 5 days
  - Efficacy: Good.

- Use in IPM and resistance management: Lambda-cyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- permethrin (Ambush, Pounce)
  - Percent acres treated: 5.6% (18)
  - Typical rates and frequency of application:
    - § Ambush: 6.4-12.8 fl oz 2EC/A or other labeled formulation
    - § Pounce: 4.0-8.0 fl oz 3.2EC/A
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours            PHI: 3 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Use in rotation with other classes of insecticides. Overuse of permethrin will impact predators and parasites and may cause a secondary outbreak of aphids.
  
- thiomethoxam (Platinum, Actara)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application:
    - § Platinum: 5.0-8.0 oz 2SC/A (lower rates provide a shorter residual control), 1 application.
    - § Actara: 2.0-3.0 oz 25WDG/A. 1-2 applications.
  - Method of application:

§ Platinum: soil application can be applied in-furrow, as a transplant drench, side-dressed, or drip-irrigated.

§ Actara: Foliar applications by ground or aerial equipment.

- REI: 12 hours            PHI: 30 days (Platinum)

REI: 12 hours            PHI: 0 days (Actara)

- Efficacy: Good
- Use in IPM and resistance management: Thiomethoxam is in the same insecticide class as imidacloprid; rotate with materials from other insecticide classes for resistance management. Apply before pests reach damaging levels, and scout fields and treat again if populations rebuild to potentially damaging levels. Use higher rates for heavy infestations. Actara is highly toxic to bees, both as a direct treatment and on residues of blooming crops and should not be used if bees are active in the area.

- zeta-cypermethrin (Mustang Max)

- Percent acres treated: newer material, data not available
- Typical rates and frequency of application: 2.24-4.0 fl oz/A, 1-2 applications.
- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours            PHI: 1 day
- Efficacy: Good.
- Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

**Alternatives:**

There are alternatives to azinphos-methyl, carbaryl, and endosulfan.

### **Cultural Control Practices:**

Flea beetles migrate from weedy areas, so remove weeds along field margins. After harvest, deeply disc plant residues in infested fields and practice good sanitation by removing any leftover debris. Row covers may be used on small plantings to exclude beetles after transplanting (1).

### **Biological Controls:**

There are some nematodes that are effective agents for the control of flea beetles. Applied to the soil, these nematodes attack the larval stage, preventing root feeding and lowering the number of emerging adults.

### **Pepper Maggot, *Zonosemata electa***

#### **Description and Damage:**

Pepper maggots are an occasionally pest of bell peppers in New Jersey, but not typically found in commercial fields due to pesticides used for other pests active at the same time. Maggot flies prefer hosts with fleshy, round or blocky fruit including horsenettle, cherry, and cheese-type peppers, and are less attracted to thin-walled varieties like banana, long-hots, cayenne, Tabasco, and serrano cultivars (1).

Pepper maggots overwinter in the pupal stage in the soil. The adults emerge in mid to late June over a period of 10 to 14 days, and are active for about a month, through mid-August. The adult flies are amber-colored with yellow stripes on the thorax and clear wings with black bands, and about the size of a housefly. Female flies insert single eggs under the skin of pepper fruit, which hatch in 8 to 14 days. Maggots are legless, about ½ inch in size when fully developed, translucent white to a light yellow color at maturity, with a pointed head but no head capsule. The larvae feed on the spongy tissues inside of the fruit. Larvae mature in about 2 to 3 weeks and emerge from the fruit to enter the soil to pupate. Only one generation occurs each season (1, 4).

Pepper maggot infested fruit may turn prematurely red and rot in the field. High populations may result in crop losses that exceed 90% if not controlled (1). Fruit harvested green may have infestations of maggots that are not detected prior to packing. Maggot infested fruit may go undetected through the market chain, or fruit may rot and/or turn prematurely red resulting in rejection of the load. Like ECB, there is zero tolerance for insect infested fruit in both the fresh and processing markets.

### **Monitoring:**

Pepper maggot flies are difficult to monitor in the field. Growers with a history of pepper maggot damage on their farm are advised to treat for pepper maggots at the same time other pests like ECB and aphids are active. Two methods of monitoring flies have been successfully used in New England (1). Yellow sticky traps baited with a vial of ammonia have been shown to capture flies when the correct field placement is used (1). The threshold is to initiate insecticide sprays when the first fly is captured. Hot cherry pepper plants can be used as a trap crop and as indicator plants as long as the plants are fruiting before the bell pepper plants. A perimeter planting is recommended, and fruit inspected for maggot scars at least twice a week from mid- to late June. Insecticide treatments are initiated when oviposition scars are detected on the cherry pepper fruit (1).

### **Chemical Controls:**

- dimethoate (Dimethoate)
  - Percent acres treated: 28.7% (18)

Typical rates and frequency of application: 0.5-0.67 pt 4EC/A or other labeled formulation.

- Method of application: Foliar application with ground or aerial equipment
- REI: 48 hours            PHI: 0 days
- Efficacy: Good.
- Use in IPM and resistance management: This material is recommended for pepper maggot and may be used for aphid control at the same time.

- endosulfan (Thionex, Thiodan, Phaser, Endosulfan, etc.)
  - Percent acres treated: 4.3% (18)
  - Typical rates and frequency of application: 1.0-2.0 lbs 50WP/A or other labeled formulation, 1-2 applications. Do not exceed 2.0 lbs ai per acre per year.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 48 hours            PHI: 4 days
  - Efficacy: Fair to good.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with materials from other insecticide classes. Endosulfan is labeled for other pepper pests including aphids, flea beetles, hornworms, and leafminers.
  
- malathion (Malathion 8EC, Malathion 5EC)
  - Percent acres treated: 0% (18)
  - Typical rates and frequency of application: 1.5 pt 8E/A or 2.5 pt 5EC/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 12 hours            PHI: 3 days
  - Efficacy: Poor.
  - Use in IPM and resistance management: Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.
  
- zeta-cypermethrin (Mustang Max)

- Percent acres treated: newer material, data not available
- Typical rates and frequency of application (adults only): 2.24-4.0 fl oz/A, 1-2 applications.
- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours            PHI: 1 day
- Efficacy: Poor.
- Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

### **Alternatives:**

No alternative materials are available for pepper maggot larval control. The use of acephate for ECB control will reduce pepper maggot infestations (8), but this material is not labeled for pepper maggot and is also under review. Systemic insecticides, with long residual periods, tend to provide the best control with the fewest applications (1).

### **Cultural Control Practices:**

Crop rotation and elimination of horsenettle and other alternate hosts can lower populations at a site isolated from other sources of infestations. Infested fruit should be removed from the field and destroyed or buried deeply.

### **Biological Controls:**

General predators like robber flies and ground beetles are capable of reducing adult and pupal populations but do not provide consistent and adequate control. A perimeter planting of hot cherry pepper plants can be used as a trap crop to reduce or eliminate pepper maggot populations while sparing beneficials in the main planting (1). Commercially available parasitic nematodes may offer the potential to decrease pepper maggots on chronically infested farms but they have not yet been tested. In addition, floating row covers

may offer control by excluding adult flies as long as crop rotation from previously infested fields is practiced. The fabric would need to be in place for at least 5 weeks to maintain fly exclusion, which may not be practical for larger commercial plantings.

### **Other Issues:**

As broad-spectrum materials are taken off the market, pepper maggot may become more of an economic pest. Pepper maggots have emerged as a significant pest in areas where broad-spectrum pesticide use has been reduced (1).

### **Pepper Weevil, *Anthonomus eugeni***

#### **Description and Damage:**

Pepper weevils are a serious southern area pepper pest, occurring mainly in California, Texas, and Florida. The weevil is an introduced pest in New Jersey, occurring sporadically as long as 30 years ago (1). Outbreaks that have occurred in New Jersey in the southern counties were associated with the importation of southern grown transplants (9). Pepper weevil adults and larvae feed on all varieties of peppers. Adults are reddish-brown to black, about  $\frac{1}{10}$  inch long, with the characteristic weevil curved snout. Adults feed on the foliage, blossom buds, and small fruit. Infested buds and blossoms fall from the plants and are often mistaken for heat or drought related flower and bud drop. The female punctures holes in buds and immature pepper pods to deposit eggs. Eggs hatch in 3 to 4 days and the larvae feed and develop within buds and inside the pepper fruit. Newly hatched C-shaped larvae are white legless grubs which when fully grown are grayish-white with a brown head and about  $\frac{1}{4}$  inch long. With warm temperatures, the entire lifecycle is completed in three weeks, and as populations increase, weevils will migrate to nearby uninfested fields. Early detection and identification is critical because weevil populations can rapidly reach damaging levels. High populations, though rare, can result in 100% yield loss due to fruit and bud drop.

#### **Monitoring:**

While scouting for other pests, look for excessive bud drop and check fallen buds and fruit for weevils and/or weevil damage. Pheromone traps may also be used to monitor adult weevil presence. If weevils

are found, inspect 25 to 100 randomly selected flower bud clusters for weevil punctures twice weekly. Treat if 5% of the bud clusters have holes (1).

### **Chemical Controls:**

- acetmiprid (Assail)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 1.7 oz 70WP/A, 1-2 applications. Do not make more than 4 applications per season or apply more than 7 oz per acre per season.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 12 hours            PHI: 7 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Use in rotation with classes of insecticides other than the neonicotinoids. Lower rates preserve beneficial insect and spider populations and allow for faster rebound of the beneficial populations.
  
- bifenthrin (Capture)
  - Percent acres treated: Newer material, data not available
  - Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.  
  
Do not exceed 12.8 fl oz per acre per acre per season.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 7 days
  - Efficacy: Fair.

- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- cryolite (Kryocide, Prokil)
  - Percent acres treated: 0% (18)
  
  - Typical rates and frequency of application: 8.0-12.0 lb 96W/A, 1 application. Method of application: Foliar application with ground or aerial equipment
  
  - REI: 12 hours            PHI: 0 days
  
  - Efficacy: Unknown.
  
  - Use in IPM and resistance management: This material is not typically used in pepper production since other materials are available that will control pepper weevil and other pests that may be active at the same time. Another disadvantage is a white residue left on fruit after the application.
  
- cyfluthrin (Baythroid)
  - Percent acres treated: 11.4% (18)
  
  - Typical rates and frequency of application: 1.6-2.8 fl oz 2E/A, 1-2 applications.

Do not exceed 16.8 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
  
- REI: 24 hours            PHI: 7 days
  
- Efficacy: Fair.
  
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of

pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.

- esfenvalerate (Asana XL)

- Percent acres treated: 6.9% (18)

- Typical rates and frequency of application: 5.8-9.6 fl oz 0.66EC/A, 1-2 applications. Do not exceed 68 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours            PHI: 7 days

- Efficacy: Poor. Not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pest.

- Use in IPM and resistance management: Rotate with materials from other insecticide classes for resistance management. Repeated use of pyrethroids may flare aphid and mite populations.

- lambdacyhalothrin (Warrior)

- Percent acres treated: New registration, data not available.

- Typical rates and frequency of application: 2.56-3.84 fl oz/A, 1-2 applications.

- Method of application: Foliar application with ground or aerial equipment.

- REI: 12 hours            PHI: 5 days

- Efficacy: For adult suppression only.

- Use in IPM and resistance management: Lambdacyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.

- oxamyl (Vydate L)
  - Percent acres treated: 2.6% (18)
  - Typical rates and frequency of application: 2.0-4.0 pt 2L/A, 1 application
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 48 hrs                      PHI: 7 day
  - Efficacy: Fair.
  - Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity of this material results in its use when multiple pests are present.
  
- permethrin (Ambush, Pounce)
  - Percent acres treated: 5.6% (18)
  - Typical rates and frequency of application:
    - § Ambush: 6.4-12.8 fl oz 2EC/A or other labeled formulation
    - § Pounce: 4.0-8.0 fl oz 3.2EC/A
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 24 hours                      PHI: 3 days
  - Efficacy: Fair.
  - Use in IPM and resistance management: Use in rotation with other classes of insecticides. Overuse of permethrin will impact predators and parasites and may cause a secondary outbreak of aphids.

- thiomethoxam (Actara)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 3.0-4.0 oz 25WDG/A. 1-2 applications. Do not exceed a total of 8.0 oz per acre per season.
  - Method of application: Foliar application by ground or aerial equipment.
  - REI: 12 hours            PHI: 0 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Thiomethoxam is in the same insecticide class as imidacloprid; rotate with materials from other insecticide classes for resistance management. Multiple applications may be necessary to control pepper weevils. Apply before pests reach damaging levels, and scout fields and treat again if populations rebuild to potentially damaging levels. Use higher rates for heavy infestations. Actara is highly toxic to bees, both as a direct treatment and on residues of blooming crops and should not be used if bees are active in the area.
  
- zeta-cypermethrin (Mustang Max)
  - Percent acres treated: newer material, data not available
  - Typical rates and frequency of application: 2.24-4.0 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 1 day
  - Efficacy: Fair.
  - Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

**Alternatives:**

There are alternatives to oxamyl listed for pepper weevil control, but only acetmiprid and thiomethoxam provide acceptable control.

**Cultural Control Practices:**

Avoid the use of southern transplants, especially those with well-developed flowers or buds. After harvest, thoroughly disk and moldboard plow infested pepper fields to bury plant residues.

**Biological Controls:**

No biological controls are available for pepper weevils.

**Post Harvest Control Practices:**

Avoid dumping infested fruit in cull piles. Incorporate fruit into the soil immediately after grading.

**Other Issues:**

Bifenthrin, cyfluthrin, and esfenvalerate may not be used during some harvest periods due to the 7-day PHI. Pyrethroids have not controlled this pest in the southern states.

**Thrips, *Frankliniella* spp., *Thrips* spp.**

## **Description and Damage:**

Several species of thrips occasionally infest peppers as well as numerous other host plants. Adult thrips are small, less than  $\frac{1}{10}$  inch long, and may be black, yellow, or banded yellow and black. Eggs are produced sexually or asexually, and wingless nymphs develop into winged adults within 2 weeks. Thrips pierce plant tissue and extract sap, causing leaves to become rough and distorted. Direct thrips feeding results in silvery or gray markings on the leaves and fruit. Thrips feeding scars reduce the marketability of fruit, particularly on white, yellow, or orange bell pepper varieties where the damage is more visible. Thrips move into pepper fields from adjacent weed or crop hosts, and their development, like spider mites, is favored by prolonged warm and dry conditions. Thrips are an occasional pest, not occurring every year but more likely a problem in some fields during hot dry summers. Cool wet weather conditions will slow thrips development.

In addition to direct feeding damage, certain species vector tomato spotted wilt virus and impatiens necrotic spot virus. Viral transmission usually occurs in the greenhouse during transplant production.

## **Monitoring:**

Several species of thrips spread tomato spotted wilt virus. Rogue diseased plants. Scout for thrips and begin treatments when observed. Inspect plants for evidence of thrips and thrips damage and consider treating if significant fruit damage is occurring (greater than 10%) and weather conditions are favorable for continued development (1).

## **Chemical Controls:**

- avermectin (Agri-Mek)
  - Percent acres treated: 0.9% (18)
  - Typical rates and frequency of application: 8.0-16.0 fl oz 0.15EC/A, 1-2 applications. Do not apply more than 48 fl oz per acre per season, and do not make more than 2 consecutive applications.
  - Method of application: Foliar application with ground or aerial equipment
  - REI: 12 hrs                      PHI: 7 day

- Efficacy: Good.
- Use in IPM and resistance management: Apply when thrips first appear and use in rotation with other classes of insecticides for resistance management.

- bifenthrin (Capture)

- Percent acres treated: Newer material, data not available
- Typical rates and frequency of application: 2.1-6.4 fl oz 2EC/A, 1-2 applications.

Do not exceed 12.8 fl oz per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 12 hours            PHI: 7 days
- Efficacy: Good.
- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.

- cyfluthrin (Baythroid)

- Percent acres treated: 11.4% (18)
- Typical rates and frequency of application: 2.1-2.8 fl oz 2E/A, 1-2 applications.

Do not exceed 16.8 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 24 hours            PHI: 7 days
- Efficacy: Good.

- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- lambdacyhalothrin (Warrior)
  - Percent acres treated: New registration, data not available.
  - Typical rates and frequency of application: 2.56-3.84 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 5 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Lambdacyhalothrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- oxamyl (Vydate L)
  - Percent acres treated: 2.6% (18)
  - Typical rates and frequency of application: 2.0-4.0 qt 2L/A, 1 application.

Do not apply more than 24 pt per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 48 hrs            PHI: 7 day
- Efficacy: Good.

- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity of this material results in its use when multiple pests are present.
  
- spinosad (Spintor 2SC, Entrust)
  - Percent acres treated: 29.4% (18)
  - Typical rates and frequency of application:
    - § Spintor 2SC: 4.0-8.0 fl oz 2SC/A, 2-4 applications. Do not exceed 29 total fluid ounces per acre per season.
    - § Entrust: 1.25-2.5 fl oz/A, 2-4 applications. Do not apply more than 9 oz per acre per crop.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 4 hours                      PHI: 1 day
  - Efficacy: Good
  - Use in IPM and resistance management: Spinosad controls multiple lepidopteran species, including European corn borer, as well as thrips and leafminers. It does not affect certain parasites and predators so that secondary pest outbreaks are minimized. Treat at threshold levels and/or time applications to peak egg hatch. Rotate with materials from other insecticide classes for resistance management.

### **Alternatives:**

There are effective alternatives to oxamyl for thrips control. In addition, the use of acephate for ECB control will reduce thrips populations (8).

### **Cultural Control Practices:**

Avoid growing peppers next to onions, garlic, or cereals because thrips often build up to large numbers on these crops. Do not grow pepper transplants in or near greenhouses with ornamentals (cut flowers, impatiens) as these plants serve as host for the virus and thrips.

### **Biological Controls:**

No effective and reliable biological control is available, although numerous naturally occurring predators will feed on thrips.

### **Other Issues:**

Bifenthrin and cyfluthrin may not be used during some harvest periods due to the 7-day PHI.

### **Green Stinkbug, *Acrosternum hilare***

### **Brown Stinkbug, *Euschistus servus***

### **Description and Damage:**

Stinkbugs have many host plants but are minor pests of peppers in New Jersey. They are shield-shaped with a large triangle on the thorax, ½ inch long, and green or brown in color. Eggs are barrel-shaped and stand on end in double rows. Nymphs are similar to adults in appearance, but smaller. They overwinter in garden debris and other protected areas, emerging in the spring to lay eggs on plant leaves. The adults and nymphs pierce plant tissue with needle-like mouthparts and remove plant juices from all parts of the plant, including fruit. Immature fruit may become deformed and drop off the plant. Mature fruit will have a white to yellow stippled area under the surface of the pepper skin associated with dark pinprick or small dimple at the feeding site. Injury from stinkbugs occurs sporadically in peppers, and usually does not warrant chemical control (1). Injury is usually limited to field margins where they migrate from other hosts such as brambles or legumes, especially during dry weather when adjacent forage crops are harvested.

### **Monitoring:**

Stinkbugs are difficult to monitor due to their mobility and ability to hide in the plant. Treatment is rarely justified and no thresholds are available for peppers.

### **Chemical Controls:**

- carbaryl (Sevin)
  - Percent acres treated: 2.4% (18)
  - Typical rates and frequency of application: 1.25-2.5 lb 80S/A or other labeled formulation, 1 application.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 0 days
  - Efficacy: Suppression only.
  - Use in IPM and resistance management: This material is not typically recommended for use in IPM programs due to the high mortality of bees and beneficial predators.
  
- cyfluthrin (Baythroid)
  - Percent acres treated: 11.4% (18)
  - Typical rates and frequency of application: 1.6-2.8 fl oz 2E/A, 1-2 applications.

Do not exceed 16.8 total fluid ounces per acre per season.

- Method of application: Foliar application with ground or aerial equipment.
- REI: 24 hours            PHI: 7 days
- Efficacy: Good.

- Use in IPM and resistance management: Treat at threshold levels and use in rotation with other classes of insecticides. The broad-spectrum activity results in its use when multiple pests are present. Use in rotation with other classes of insecticides for resistance management. Overuse of pyrethroid related materials impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- **lambda-cyhalothrin (Warrior)**
  - Percent acres treated: New registration, data not available.
  - Typical rates and frequency of application: 2.56-3.84 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 5 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Lambda-cyhalothrin has broad-spectrum activity for multiple pest species, including all of the lepidopteran pepper pests. Rotate with materials from other insecticide classes for resistance management. Overuse of pyrethroids impacts predators and parasites and may cause a secondary outbreak of aphids.
  
- **thiomethoxam (Actara)**
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 3.0-4.0 oz 25WDG/A. 1-2 applications. Do not exceed a total of 8.0 oz per acre per season.
  - Method of application: Foliar application by ground or aerial equipment.
  - REI: 12 hours            PHI: 0 days
  - Efficacy: Unknown.
  - Use in IPM and resistance management: Rotate with materials from other insecticide classes

for resistance management. Actara is highly toxic to bees, both as a direct treatment and on residues of blooming crops and should not be used if bees are active in the area.

- zeta-cypermethrin (Mustang Max)
  - Percent acres treated: newer material, data not available
  - Typical rates and frequency of application: 3.2-4.0 fl oz/A, 1-2 applications.
  - Method of application: Foliar application with ground or aerial equipment.
  - REI: 12 hours            PHI: 1 day
  - Efficacy: Good.
  - Use in IPM and resistance management: Zeta-cypermethrin has broad-spectrum activity for multiple pest species. Rotate with materials from other insecticide classes for resistance management. Overuse of permethrin impacts predators and parasites and may cause a secondary outbreak of aphids.

### **Alternatives:**

All materials listed above are effective alternatives to carbaryl. The use of esfenvalerate or methomyl for other pests will help reduce stinkbug populations.

### **Cultural Control Practices:**

Maintain good weed control in and around the field and avoid planting near other host crops, especially forage crops.

**Biological Controls:** No effective natural enemies are known.

## Other Issues:

Cyfluthrin may not be used during some harvest periods due to the 7-day PHI.

## Weeds

The major weeds that infest peppers are summer annual broadleaves including common cocklebur, common lambsquarters, common purslane, common ragweed, hairy galinsoga, ivyleaf morningglory, jimsonweed, smooth pigweed, and velvetleaf. Summer annual grasses include barnyardgrass, giant foxtail, green foxtail, yellow foxtail, fall panicum, large crabgrass, and goosegrass. The main perennial weed affecting peppers is yellow nutsedge.

## General Monitoring Scheme:

All weeds listed below are monitored and treated at the same threshold levels. Most growers will use this type of scheme for the perennial weeds. Using a county soil map, identify the different soils in the field. Take a sample from each area where soil types differ and obtain an analysis of texture and organic matter. This information is used to develop a cultural and/or chemical control program for each soil type.

Scout fields in a zigzag pattern sampling 10 random locations. Sample either 1 square yard or 10 foot of row at each location depending on which scheme works best with the field. Note the weed species and whether they are scattered throughout the field or predominate in one area. Sample in late summer prior to planting peppers the following year to develop a control strategy for the following season. Threshold guidelines (15):

Number of Weeds:

<1

Threshold:

Very light

1 - 4	Light
4 - 10	Medium
10 - 100	Heavy
>100	Very heavy

After transplanting the following year, repeat the same pattern except sample 5 locations with the 1 square yard method and 5 locations with the 10 foot of row method. Note which weeds could be controlled by cultivation between the rows and which would not. Sample fields once 15 to 20 days after transplanting. Threshold guidelines (15):

<u>Average Number of Weeds:</u>	<u>Threshold:</u>
<0.25	No control required
0.25 – 1.0	Some control may be required
>1.0	Control required

## ANNUAL BROADLEAF WEEDS

### Common Cocklebur, *Xanthium strumarium*

#### **Description and Damage:**

This summer annual reproduces by seed from early spring through summer. Seed can germinate from as deep as 6 inches in the soil. The cotyledons and first leaves are opposite. Later leaves are alternate with a triangular shape, green in color with purple to brown spots and at maturity may be 6 inches long. The stem is hairy with dark spots. The flowers are found in the upper part of the plant and the male and

female flowers are separate. The male flower falls off leaving the female flower enclosed within a bur. The burs are elliptical to egg-shaped, woody, covered with hooked trichomes and contain many seeds (22, 23, 24).

On pepper grown without plastic mulch, cocklebur can compete shortly after planting if not controlled. At harvest, the weeds can interfere with the laborers as the burs stick to clothing and slow down harvesting.

### **Chemical Controls:**

- clomazone (Command 3ME)
  - Percent acres treated: 13.3% (18)
  - Typical rates, frequency of application for each method of application:
    - § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.
    - § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.
    - § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours      PHI: Not available
- Efficacy: Suppresses cocklebur.
- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- halosulfuron-methyl (Sanda)
  - Percent acres treated: Newer material, data not available.

- Typical rates and frequency of application: 0.5-1.0 oz/A, 1-4 applications depending on rate. Do not exceed 2 oz/A per 12-month period. Up to an 18 month, plant-back interval applies depending on the rotational crop.
  - Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.
  - REI: 12 hours            PHI: 30 days
  - Efficacy: Good.
  - Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. This material is used when cocklebur is present but less than 3 inches tall. Since it is applied only when the weed is present, resistance development is reduced. However, weeds can become resistant to this herbicide if used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicide classes.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
    - Percent acres treated: 8.4% (18)
    - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
    - Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
    - REI: 12 hours            PHI: 30 days
    - Efficacy: Good
    - Use in IPM and resistance management: This material is used when cocklebur is present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.

**Alternatives:**

There are only three chemicals available for common cocklebur control. The possibility of chemical resistance to halosulfuron-methyl restricts flexibility to control this weed. Monitoring weeds the summer before planting peppers will help identify cocklebur and allow spot treatment to reduce the weed population. However, with only three options for control the chance of building up resistance is increased.

### **Cultural Control Practices:**

Monitoring the weeds in the previous crop followed by cultivation will help reduce cocklebur, but seeds can survive for one to several years in the soil (22). Cultivation is only practical for approximately one month after transplanting since the plants are too large to allow equipment to pass between the rows.

### **Biological Controls:**

None available.

### **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting. If practical, leave weeds to regrow, then map the field and develop weed management strategies for the following year.

### **Common Lambsquarters, *Chenopodium album***

#### **Description and Damage:**

This erect summer annual reproduces by seed and emerges from spring to early summer from near the soil surface (down to approximately 1 inch). The first set of leaves is opposite then alternate for all others. Young leaves have either smooth or toothed margins that are light green on top and maroon on the underside. As the plant grows, the leaves become more toothed in appearance. Young leaves and older leaves on mature plants have a gray to white mealy coating that feels oily to the touch. Stems are gray in color and are fragile when the plants are young, but are erect, vertically ridged and have maroon

stripes at maturity. Flowers develop from June to September in spiked groupings. The seeds are small and persist in the soil for many years (6, 22, 23, 24).

Lambsquarters emerge in groups of plants shortly after the soil is tilled and continue to emerge each time the soil is disturbed. If not controlled, this weed competes directly with peppers early in the season for light, nutrients and moisture.

### **Chemical Controls:**

- bensulide (Prefar 4E)
  - Percent acres treated: 0.5% (18)
  - Typical rates and frequency of application: 5.0-6.0 qts/A, 1 application.
  - Method of application: Broadcast preplant (incorporate 1-2 inches) or preemergence (irrigate within 36 hours with ½ inch water).
  - REI: 12 hours      PHI: Not available
  - Efficacy: Fair to good
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
  
- clomazone (Command 3ME)
  - Percent acres treated: 13.3% (18)
  - Typical rates, frequency of application for each method of application:
    - § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.
    - § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.

§ Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours            PHI: Not available

- Efficacy: Fair.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- DCPA (Dacthal 6F)

- Percent acres treated: 0.0% (18)

- Typical rates and frequency of application: 8.0-14.0 pts/A, 4-6 weeks after transplanting; 1 application.

- Method of application: Spray broadcast treatment over plants that are grown without plastic mulch, or directed spray between rows with plastic mulch as a preemergent weed treatment.

- REI: 12 hours            PHI: Not available

- Efficacy: Good.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- halosulfuron-methyl (Sanda)

- Percent acres treated: Newer chemical, data not available

- Typical rates and frequency of application: 0.5-1.0 oz/A, 1-4 applications depending on rate. Do not exceed 2 oz/A per 12-month period. Up to an 18 month, plant-back interval applies depending on the rotational crop. Will not control lambsquarters post emergence.

- Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.
  - REI: 12 hours          PHI: 30 days
  - Efficacy: Good.
  - Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicides classes.
- napropamide (Devrinol 50-DF, Devrinol 2-EC)
    - Percent acres treated: 21.4% (18)
    - Typical rates and frequency of application: 2.0-4.0 lbs/A (Devrinol 50-DF) or 2.0-4.0 qts/A (Devrinol 2-EC), 1-2 applications. Do not apply more than 4.0 lbs/A 50-DF or 4.0 qts/A 2-EC per crop cycle. Up to a 12-month plant back restriction applies depending on the rotational crop.
    - Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches before transplanting.
    - REI: 12 hours          PHI: Not available
    - Efficacy: Fair to good.
    - Use in IPM and resistance management: Best chemical to use during periods of wet weather. Good for rotation with the other herbicides to reduce chance of resistance.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
    - Percent acres treated: 8.4% (18)
    - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.

- Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
  - REI: 12 hours            PHI: 30 days
  - Efficacy: Fair to good.
  - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)
    - Percent acres treated: 1.9% (18)
    - Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application
    - Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
    - REI: 12 hours            PHI: Not available
    - Efficacy: Fair to good.
    - Use in IPM and resistance management: Avoid planting during periods of cold wet weather to reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

**Alternatives:**

There are several chemical options to control lambsquarters.

**Cultural Control Practices:**

Cultivation for up to approximately one month after transplanting will help reduce weed populations.

**Biological Control:**

None available.

**Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

**Common Purslane, *Portulaca oleracea*****Description and Damage:**

This summer annual reproduces by seed and stem segments that root at individual nodes. Seeds germinate from May through August. The plant has a prostrate mat-forming habit with thick succulent leaves and stems. Leaves are green on the upper side with a maroon color on the underside. Stems are green when young, turning maroon as the plant matures. Flowers appear from July through September, have yellow petals, and are only open when it is sunny. The leaves decay after a frost, but the maroon stems remain (6, 22, 23, 24).

Purslane is common in all of New Jersey and can spread easily from field to field on equipment. Each time a field is cultivated plants are broken up and each stem piece has the potential to produce a new plant at the node. This weed is more of a potential problem early in the season since it prefers high light intensity. As pepper plants grow, the purslane is shaded.

**Chemical Controls:**

- bensulide (Prefar 4E)

- Percent acres treated: 0.5% (18)
  - Typical rates and frequency of application: 5.0–6.0 qts/A, 1 application
  - Method of application: Broadcast preplant (incorporate 1-2 inches) or preemergence (irrigate within 36 hours with ½ inch water).
  - REI: 12 hours            PHI: Not available
  - Efficacy: Poor.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- clomazone (Command 3ME)
    - Percent acres treated: 13.3% (18)
    - Typical rates, frequency of application for each method of application:
      - § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.
      - § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.
      - § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours            PHI: Not available
  - Efficacy: Fair.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- DCPA (Dacthal 6F)

- Percent acres treated: 0.0% (18)
  - Typical rates and frequency of application: 8.0-14.0 pts/A, 4-6 weeks after transplanting; 1 application.
  - Method of application: Spray broadcast treatment over plants that are grown without plastic mulch, or directed spray between rows with plastic mulch as a preemergent weed treatment.
  - REI: 12 hours            PHI: Not available
  - Efficacy: Excellent.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- halosulfuron-methyl (Sanda)
  - Percent acres treated: Newer chemical, data not available.
  - Typical rates and frequency of application: 0.5 –1.0 oz/A, 1-4 applications depending on rate. Do not exceed 2.0 oz/A per 12-month period. Up to an 18-month plant-back interval applies depending on the rotational crop.
  - Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.
  - REI: 12 hours            PHI: 30 days
  - Efficacy: Poor to fair.
  - Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicide classes.
- napropamide (Devrinol 50-DF, Devrinol 2-EC)

- Percent acres treated: 21.4% (18)
  - Typical rates and frequency of application: 2-4 lbs/A (Devrinol 50-DF) or 2.0-4.0 qts/A (Devrinol 2-EC), 1-2 applications. Do not apply more than 4 lbs/A 50-DF or 4 qts/A 2-EC per crop cycle. Up to a 12 month plant back restriction applies depending on the rotational crop.
  - Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches before transplanting.
  - REI: 12 hours            PHI: Not available
  - Efficacy: Fair.
  - Use in IPM and resistance management: Best chemical to use during periods of wet weather. Good for rotation with the other herbicides to reduce chance of resistance.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
    - Percent acres treated: 8.4% (18)
    - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
    - Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
    - REI: 12 hours            PHI: 30 days
    - Efficacy: Fair.
    - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
- S-metolachlor (Dual Magnum 7.62E)

- Percent acres treated: 10.3% (18)
- Typical rates and frequency of application: 0.67-1.0 pts/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture only, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.
- REI: 24 hours            PHI: 65 days
- Efficacy: Fair.
- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.

- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)

- Percent acres treated: 1.9% (18)
- Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application.
- Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
- REI: 12 hours            PHI: Not available
- Efficacy: Fair.
- Use in IPM and resistance management: Avoid planting during periods of cold wet weather to reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

**Alternatives:**

There are several effective options to control purslane.

### **Cultural Control Practices:**

Cultivation up to approximately one month after transplanting will help reduce weed populations. Cultivation should be done during sunny dry periods to reduce the chance of the plant re-rooting.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

## **Common Ragweed, *Ambrosia artemisiifolia***

### **Description and Damage:**

Ragweed is a summer annual with an erect plant habit from 1 to 7 feet tall. This weed reproduces from seed that germinates from May to late June. Germination is inhibited with high temperatures (86 °F or above). The leaves have rounded margins and are hairy and deeply cut when small. As the plant matures, the tips become less rounded. Leaves are opposite up to the fourth node then alternate. Stems are branched with long rough hairs. Stems with some desiccated leaves will persist through the winter. Flowers are present from August to October with the male flowers in the top of the plant and female flowers on the lower portions. The seed can survive up to 80 years (22, 23, 24). This weed can compete with peppers through the production season if not controlled. Ragweed will germinate and overtake the peppers during the season. It also affects the labor force since it produces large amount of pollen, of which many people are allergic.

## Chemical Controls:

- clomazone (Command 3ME)

- Percent acres treated: 13.3% (18)

- Typical rates, frequency of application for each method of application:

- § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.

- § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.

- § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours      PHI: Not available

- Efficacy: Poor.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- halosulfuron-methyl (Sanda)

- Percent acres treated: Newer chemical, data not available.

- Typical rates and frequency of application: 0.5-1.0 oz/A, 1-4 applications depending on rate. Do not exceed 2.0 oz/A per 12-month period. Up to an 18 month plant-back interval applies depending on the rotational crop.

- Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.

- REI: 12 hours      PHI: 30 days

- Efficacy: Good.

- Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control.
  
- napropamide (Devrinol 50-DF, Devrinol 2-EC)
  - Percent acres treated: 21.4% (18)
  
  - Typical rates and frequency of application: 2.0-4.0 lbs/A (Devrinol 50-DF), or 2.0-4.0 qts/A (Devrinol 2-EC), 1-2 applications. Do not apply more than 4.0 lbs/A 50-DF or 4.0 qts/A 2-EC per crop cycle. Up to a 12 month plant back restriction applies depending on the rotational crop.
  
  - Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches prior to transplanting.
  
  - REI: 12 hours            PHI: Not available
  
  - Efficacy: Poor.
  
  - Use in IPM and resistance management: Best chemical to use during periods of wet weather. Suppresses weeds only, which may lead to resistance.
  
- paraquat (Gramoxone Max, Gramoxone Super Tres)
  - Percent acres treated: 8.4% (18)
  
  - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
  
  - Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
  
  - REI: 12 hours            PHI: 30 days
  
  - Efficacy: Good.

- Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.

### **Alternatives:**

There are few chemical alternatives for common ragweed. If any of the above materials are lost, or no new herbicides developed, ragweed control will be difficult.

### **Cultural Control Practices:**

Cultivation up to approximately one month after transplanting will help reduce weed populations.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

### **Hairy Galinsoga, *Galinsoga ciliata***

### **Description and Damage:**

Hairy galinsoga is an erect plant with a branching stem approximately 4 to 30 inches tall. The leaves are opposite, triangular with a pointed tip, and slightly toothed on the margins. The seed is produced from early spring through September and has no dormancy thus there can be several generations in a season. The leaves and stem are green and covered with hair. Flowers are present from June to October. They have 4 to 5 white three-toothed petals around several yellow center flowers. One plant can produce thousands of seed, but they survive only for a few years (23, 24). Galinsoga is more of a problem for bare ground culture peppers than for peppers grown with plastic mulch.

### **Chemical Controls:**

- clomazone (Command 3ME)

- Percent acres treated: 13.3% (18)

- Typical rates, frequency of application for each method of application:

- § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.

- § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.

- § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours      PHI: Not available

- Efficacy: Fair.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- halosulfuron-methyl (Sanda)

- Percent acres treated: Newer chemical, data not available.

- Typical rates and frequency of application: 0.5–1.0 oz/A, 1-4 applications depending on rate.

Do not exceed 2.0 oz/A per 12-month period. Up to an 18 month plant-back interval applies depending on the rotational crop.

- Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.

- REI: 12 hours            PHI: 30 days

- Efficacy: Good.

- Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicide classes.

- paraquat (Gramoxone Max, Gramoxone Super Tres)

- Percent acres treated: 8.4% (18)

- Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.

- Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.

- REI: 12 hours            PHI: 30 days

- Efficacy: Good.

- Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.

- S-metolachlor (Dual Magnum 7.62E)

- Percent acres treated: 10.3% (18)

- Typical rates and frequency of application: 0.67-1.0 pt/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.
- REI: 24 hours            PHI: 65 days
- Efficacy: Good.
- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.

### **Alternatives:**

There are few chemical controls for galinsoga. Additional post emergence control options are needed for this weed species.

### **Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

### **Biological Control:**

None available.

## **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

## **Ivyleaf Morningglory, *Ipomoea hederacea***

### **Description and Damage:**

The plant is a long vining summer annual with deeply three-lobed leaves and erect hairs on the stems, petioles, and leaves. The cotyledons are “butterfly shaped” and similar to other morningglories before taking on the typical ivy-shape. The vining stems twine around other plants or grow along the ground. Flower petals are white or pale blue to purple and form a trumpet or funnel shape. Plants die with the first frost, but the dry vines can be found in undisturbed fields through the winter (22, 23, 24). Morningglory can grow over the top of peppers any time during the season. If not controlled this weed can take over a whole field, reducing yields or making the field unharvestable. Field margins are more prone to initial infestations.

### **Chemical Controls:**

- halosulfuron-methyl (Sandea)
  - Percent acres treated: Newer chemical, data not available.
  - Typical rates and frequency of application: 0.5-1.0 oz/A, 1-4 applications depending on the rate. Do not exceed 2.0 oz/A per 12-month period. Up to an 18 month plant-back interval applies depending on the rotational crop.
  - Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.
  - REI: 12 hours      PHI: 30 days
  - Efficacy: Poor; suppression only with applications at the higher rate.

- Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicide classes.
  
- paraquat (Gramoxone Max, Gramoxone Super Tres)
  - Percent acres treated: 8.4% (18)
  
  - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
  
  - Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
  
  - REI: 12 hours          PHI: 30 days
  
  - Efficacy: Fair to good.
  
  - Use in IPM and resistance management: This material is used when morningglory is present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
  
- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)
  - Percent acres treated: 1.9% (18)
  
  - Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application.
  
  - Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
  
  - REI: 12 hours          PHI: Not available
  
  - Efficacy: Poor to fair.
  
  - Use in IPM and resistance management: Avoid planting during periods of cold wet weather to

reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

### **Alternatives:**

There are few effective chemical controls for morningglory. Other chemical options should be explored.

### **Cultural Control Practices:**

Cultivation around field edges will help reduce movement of morningglory into the field.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Spot treating at the end of the season will reduce the weed population.

### **Jimsonweed, *Datura stramonium***

#### **Description and Damage:**

This large summer annual is erect with a branching stem. The plant grows 12 to 60 inches tall with egg-shaped fruit covered with green spines that turn light brown at maturity. Plants emerge from May until late summer. The cotyledons are opposite, narrow, and pointed, with the first true leaves being complete with no toothed margins. Later leaves are large toothed and pointed at the tip, resembling oak leaves. The plant has a thick, large taproot, which makes it difficult to pull. Flowers are produced from June until frost and open in the late afternoon and evening. The flowers are white to purple and funnel shaped. The

seeds are enclosed in a capsule that is divided into four segments with many seeds in each (6, 22, 23, 24). Jimsonweed competes with peppers for nutrients, water, and light, and can interfere with harvesting since the seed capsules have sharp spines. This weed is found in groups and can reduce yields, but generally is not found over a whole field.

### **Chemical Controls:**

- clomazone (Command 3ME)

- Percent acres treated: 13.3% (18)

- Typical rates, frequency of application for each method of application:

- § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.

- § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.

- § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours      PHI: Not available

- Efficacy: Fair.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- halosulfuron-methyl (Sanda)

- Percent acres treated: Newer chemical, data not available.

- Typical rates and frequency of application: 0.5-1.0 oz/A, 1-4 applications depending on rate. Do not exceed 2.0 oz/A per 12-month period. Up to an 18 month plant-back interval applies depending on the rotational crop.

- Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.
  - REI: 12 hours            PHI: 30 days
  - Efficacy: Poor to fair.
  - Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicide classes.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
    - Percent acres treated: 8.4% (18)
    - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
    - Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
    - REI: 12 hours            PHI: 30 days
    - Efficacy: Good on seedlings.
    - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.

### **Alternatives:**

There are few effective materials for jimsonweed control. Other chemical control options should be explored.

### **Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Since this weed is found in groups, spot treating at the end of the season helps reduce the population. Incorporate plant residue after spot treating to reduce weed seed production. Planting a cover crop will help keep weeds under control.

### **Smooth Pigweed, *Amaranthus hybridus***

### **Description and Damage:**

The plant is erect and 1 to 7 feet tall with many branches. The stems are slender with dense short hairs on the upper part. The leaves are simple, alternate, oval, and egg-shaped with a green color above and light green to magenta on the underside. The cotyledons are narrow and pointed dark green on the top surface, and bright red below. Seedling stems are green, very hairy, and may be red at the base. The plants have a shallow taproot and may be pink or red in color. Flowers and seed heads are mainly located at the top of the plant. The plants persist in the field after frost (6, 22, 23). Several other species that are found in New Jersey have similar descriptive characteristics. Among these are redroot pigweed (*Amaranthus retroflexus*) and Powell amaranth (*Amaranthus powellii*). All three species may be found in the same field (6). Pigweed can compete with peppers throughout the growing season, especially for bare ground plantings. Harvesting can be slowed if weeds are not controlled between the rows. Pigweed has the potential to completely infest a field.

## Chemical Controls:

- bensulide (Prefar 4E)
  - Percent acres treated: 0.5% (18)
  - Typical rates and frequency of application: 5.0-6.0 qts/A, 1 application.
  - Method of application: Broadcast preplant (incorporate 1–2 inches) or preemergence (irrigate within 36 hours with ½ inch water).
  - REI: 12 hours      PHI: Not available
  - Efficacy: Fair.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
  
- DCPA (Dacthal 6F)
  - Percent acres treated: 0.0% (18)
  - Typical rates and frequency of application: 8.0–14.0 pts/A, 4-6 weeks after transplanting; 1 application.
  - Method of application: Spray broadcast treatment over plants when peppers are grown without plastic mulch, or directed spray between rows with plastic mulch as a preemergent weed treatment.
  - REI: 12 hours      PHI: Not available
  - Efficacy: Good depending on the species.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
  
- halosulfuron-methyl (Sanda)

- Percent acres treated: Newer chemical, data not available.
  - Typical rates and frequency of application: 0.5-1.0 oz/A, 1-4 applications depending on rate. Do not exceed 2.0 oz/A per 12-month period. Up to an 18 month plant-back interval applies depending on the rotational crop.
  - Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.
  - REI: 12 hours            PHI: 30 days
  - Efficacy: Good.
  - Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicide classes.
- napropamide (Devrinol 50-DF, Devrinol 2-EC)
    - Percent acres treated: 21.4% (18)
    - Typical rates and frequency of application: 2.0-4.0 lbs/A (Devrinol 50-DF), 2.0-4.0 qts/A (Devrinol 2-EC), 1-2 applications. Do not apply more than 4.0 lbs/A 50-DF or 4.0 qts 2-EC per crop cycle. Up to a 12-month plant back restriction applies depending on the rotational crop.
    - Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches prior to transplanting.
    - REI: 12 hours            PHI: Not available
    - Efficacy: Fair to good.
    - Use in IPM and resistance management: Best chemical to use during periods of wet weather. Good for rotation with the other herbicides to reduce chance of resistance.
- paraquat (Gramoxone Max, Gramoxone Super Tres)

- Percent acres treated: 8.4% (18)
  - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
  - Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
  - REI: 12 hours            PHI: 30 days
  - Efficacy: Good.
  - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
- S-metolachlor (Dual Magnum 7.62E)
    - Percent acres treated: 10.3% (18)
    - Typical rates and frequency of application: 0.67-1.0 pts/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture only, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.
- REI: 24 hours            PHI: 65 days
- Efficacy: Good.
- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.

- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)
  - Percent acres treated: 1.9% (18)
  - Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application.
  - Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
  - REI: 12 hours            PHI: Not available
  - Efficacy: Good.
  - Use in IPM and resistance management: Avoid planting during periods of cold wet weather to reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

### **Alternatives:**

S-metolachlor is available in New Jersey through a Special Local Needs Label 24(c). This material and halosulfuron-methyl are the only two effective materials for control of pigweed, and halosulfuron-methyl is not recommended for bare ground culture.

### **Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

### **Biological Control:**

None available.

## **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

## **Velvetleaf, *Abutilon theophrasti***

### **Description and Damage:**

This summer annual is erect (3 to 5 feet) with an unbranched hairy stem. The large leaves are heart shaped, covered with soft hairs which gives it a velvety texture. Seeds emerge from mid to late May. The cotyledons are heart shaped, alternate, and hairy, as are the young leaves, which point downward. The plant flowers from July into the fall. Flowers are produced on small stalks in the upper leaf axils and have five yellow petals. The fruits have a distinct appearance of a circular cup-shaped disk that is ribbed and pointed at the end of each rib. Seeds remain viable for many years in the soil (6, 22, 23, 24). Velvetleaf can compete with peppers throughout the production season. The plants can grow above pepper plants and shade a field if the population is high. Velvetleaf is more of a problem in fields that have been in a short rotation with corn or where improperly composted manure is applied.

### **Chemical Controls:**

- clomazone (Command 3ME)
  - Percent acres treated: 13.3% (18)
  - Typical rates, frequency of application for each method of application:
    - § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.
    - § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.
    - § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours            PHI: Not available
  - Efficacy: Excellent.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
    - Percent acres treated: 8.4% (18)
    - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
    - Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
    - REI: 12 hours            PHI: 30 days
    - Efficacy: Good on seedlings.
    - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
  - halosulfuron-methyl (Sanda)
    - Percent acres treated: Newer chemical, data not available.
    - Typical rates and frequency of application: 0.5-1.0 oz/A, 1-4 applications depending on rate. Do not exceed 2.0 oz/A per 12-month period. Up to an 18 month plant-back interval applies depending on the rotational crop.
    - Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.
    - REI: 12 hours            PHI: 30 days

- Efficacy: Fair.
- Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicide classes.

### **Alternatives:**

There are few effective preemergence materials for velvetleaf control. This is an area where additional herbicides are needed.

### **Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

### **Other Issues:**

If manure is applied it should be well composted. Velvetleaf seeds pass through animal digestive systems and the seeds are spread in the manure.

## ANNUAL GRASS WEEDS

### Barnyardgrass, *Echinochloa crus-galli*

#### **Description and Damage:**

This summer annual is erect (up 5 feet) and grows in clumps. The seed germinates from early spring to midsummer. When the weed emerges, the leaf opens parallel to the ground. The sheaths are tinted maroon near the base. The leaves have no auricles or ligules and have a smooth green collar. After the first leaves, the remainder are upright. Mature plants are similar to the seedlings with blades that are 4 to 8 inches in length. The sheaths are open and smooth with a collar that is whitish and smooth. Flowers occur from July through September. The seed heads come out of the top sheath and are branched with green to purple panicles. Barnyardgrass is killed by the first frost, but the thick stem remains standing through the winter (6, 22, 23, 24). Barnyardgrass can compete with peppers early in the season especially if not grown on plastic mulch. Within row, competition is more of a concern if soil is not thrown around the plants during cultivation.

#### **Chemical Controls:**

- bensulide (Prefar 4E)
  - Percent acres treated: 0.5% (18)
  - Typical rates and frequency of application: 5.0-6.0 qts/A, 1 application.
  - Method of application: Broadcast preplant (incorporate 1–2 inches) or preemergence (irrigate within 36 hours with ½ inch water).
  - REI: 12 hours      PHI: Not available
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce

chance of resistance.

- clethodim (Select 2EC)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 6.0–8.0 oz/A when the weed is at most 2–8 inches tall; 1–2 applications. Do not apply more than 8.0 fl oz/A in a single application.
  - Method of application: Broadcast post emergence to the weeds and peppers.
  - REI: 24 hours      PHI: 20 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.
  
- clomazone (Command 3ME)
  - Percent acres treated: 13.3% (18)
  - Typical rates, frequency of application for each method of application:
    - § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.
    - § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.
    - § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours      PHI: Not available
- Efficacy: Good.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
  
- DCPA (Dacthal 6F)
  - Percent acres treated: 0.0% (18)
  
  - Typical rates and frequency of application: 8.0-14.0 pts/A, 4 to 6 weeks after transplanting; 1 application.
  
  - Method of application: Spray broadcast treatment over plants when peppers are grown without plastic mulch, or directed spray between rows with plastic mulch as a preemergent weed treatment.
  
  - REI: 12 hours            PHI: Not available
  
  - Efficacy: Good.
  
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
  
- napropamide (Devrinol 50-DF, Devrinol 2-EC)
  - Percent acres treated: 21.4% (18)
  
  - Typical rates and frequency of application: 2.0-4.0 lbs/A (Devrinol 50-DF), 2.0-4.0 qts/A (Devrinol 2-EC), 1-2 applications. Do not apply more than 4.0 lbs/A 50-DF or 4.0 qts/A of 2-EC per crop cycle. Up to a 12 month plant back restriction applies depending on the rotational crop.
  
  - Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches prior to transplanting.
  
  - REI: 12 hours            PHI: Not available
  
  - Efficacy: Good.
  
  - Use in IPM and resistance management: Best chemical to use during periods of wet weather.

Good for rotation with the other herbicides to reduce chance of resistance.

- paraquat (Gramoxone Max, Gramoxone Super Tres)
  - Percent acres treated: 8.4% (18)
  - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
  - Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
  - REI: 12 hours          PHI: 30 days
  - Efficacy: Good.
  - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
  
- sethoxydim (Poast 1.5EC)
  - Percent acres treated: 7.5% (18)
  - Typical rates and frequency of application: 1.0-1.5 pts/A, 3-4 applications.

Do not apply more than 4.5 pts/A per season

- Method of application: Broadcast for weeds up to 8 inches tall.
- REI: 12 hours          PHI: 20 days
- Efficacy: Good
- Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.

- S-metolachlor (Dual Magnum 7.62E)

- Percent acres treated: 10.3% (18)
- Typical rates and frequency of application: 0.67-1.0 pt/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture only, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.
- REI: 24 hours            PHI: 65 days
- Efficacy: Good.
- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.

- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)

- Percent acres treated: 1.9% (18)
- Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application.
- Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
- REI: 12 hours            PHI: Not available
- Efficacy: Good.
- Use in IPM and resistance management: Avoid planting during periods of cold wet weather to reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

**Alternatives:**

There are effective chemical controls for barnyardgrass.

**Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

**Biological Control:**

None available.

**Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

**Giant Foxtail, *Setaria faveri***

**Green Foxtail, *Setaria viridis***

**Yellow Foxtail, *Setaria glauca***

**Description and Damage:**

These three species are similar in general characteristics. They have a clump forming erect habit. These summer annuals reproduce by seed that germinates from late spring through summer. The first leaf opens parallel to the ground and is much longer than its width. The leaves emerge rolled, auricles are absent,

and the ligule is fringed with hairs. The leaves are smooth on the lower surface. Giant foxtail has short numerous hairs on the upper surface of the blade and the margin of the sheath, whereas green foxtail has rough blades and no hairs, and the sheaths have hairy margins. Yellow foxtail is covered with long hairs at the base of the upper surface. The collar is green and smooth on all species. At maturity the plants appear very similar as the seedlings except the sheathes are often reddish at the base and have a prominent midvein. Roots are fibrous and tillers will root at the base of the plant. Foxtails flower from mid to late summer with seed heads present from late summer through fall. The seed heads are coarse, bristly in appearance, and approximately 0.8 to 6.0 inches in length. The giant foxtail seed head is the largest of the three with a green to purple color. Green foxtail has a seed head larger and greener than yellow foxtail. The yellow foxtail seed head has a yellowish color. The seed head remains yellow through early winter, which helps distinguish it from the other foxtails that turn brown (22, 23, 24). All three foxtails can compete with peppers early in the season if not controlled, especially within the row when plastic mulch is not used.

### **Chemical Controls:**

- bensulide (Prefar 4E)
  - Percent acres treated: 0.5% (18)
  - Typical rates and frequency of application: 5.0-6.0 qts/A, 1 application.
  - Method of application: Broadcast preplant (incorporate 1–2 inches) or preemergence (irrigate within 36 hours with ½ inch water).
  - REI: 12 hours            PHI: Not available
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
  
- clethodim (Select 2EC)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 6.0-8.0 oz/A when the weed is 2–8 inches tall (green and yellow foxtail), or 2–12 inches tall (giant foxtail); 1–2 applications.

- Method of application: Broadcast post emergence to the weeds and peppers.
  - REI: 24 hours            PHI: 20 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.
- clomazone (Command 3ME)
    - Percent acres treated: 13.3% (18)
    - Typical rates, frequency of application for each method of application:
      - § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.
      - § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.
      - § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours            PHI: Not available
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- DCPA (Dacthal 6F)
    - Percent acres treated: 0.0% (18)

- Typical rates and frequency of application: 8.0-14.0 pts/A, 4-6 weeks after transplanting; 1 application.
  - Method of application: Spray broadcast treatment over plants that are grown without plastic mulch, or directed spray between rows with plastic mulch as a preemergent weed treatment.
  - REI: 12 hours            PHI: Not available
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- napropamide (Devrinol 50-DF, Devrinol 2-EC)
    - Percent acres treated: 21.4% (18)
    - Typical rates and frequency of application: 2.0-4.0 lbs/A (Devrinol 50-DF) or 2.0-4.0 qts/A (Devrinol 2-EC), 1-2 applications. Do not apply more than 4.0 lbs/A 50-DF or 4.0 qts/A 2-EC per crop cycle. Up to a 12 month plant back restriction applies depending on the rotational crop.
    - Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches prior to transplanting.
    - REI: 12 hours            PHI: Not available
    - Efficacy: Good.
    - Use in IPM and resistance management: Best chemical to use during periods of wet weather. Good for rotation with the other herbicides to reduce chance of resistance.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
    - Percent acres treated: 8.4% (18)
    - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray);

1-3 applications. Do not apply more than 3 applications per season.

- Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.
  - REI: 12 hours            PHI: 30 days
  - Efficacy: Good.
  - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
- sethoxydim (Poast 1.5EC)
    - Percent acres treated: 7.5% (18)
    - Typical rates and frequency of application: 1.0-1.5 pts/A, 3-4 applications.

Do not apply more than 4.5 pts/A per season

- Method of application: Broadcast for weeds up to 16 inches tall.
  - REI: 12 hours            PHI: 20 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.
- S-metolachlor (Dual Magnum 7.62E)
    - Percent acres treated: 10.3% (18)
    - Typical rates and frequency of application: 0.67-1.0 pts/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture only, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.
  - REI: 24 hours            PHI: 65 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.
- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)
    - Percent acres treated: 1.9% (18)
    - Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application.
    - Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
    - REI: 12 hours            PHI: Not available
    - Efficacy: Good.
    - Use in IPM and resistance management: Avoid planting during periods of cold wet weather to reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

### **Alternatives:**

There are several chemicals labeled with good efficacy for foxtail control.

### **Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

### **Fall Panicum, *Panicum dichotomiflorum***

#### **Description and Damage:**

The plant growth habit varies from erect to sprawling. Seeds germinate from late spring to midsummer. The first leaves are parallel to the ground, rolled in a bud and lack auricles. The ligule has a fringe of hair and the first few leaves and sheaths are hairy on the underside, but become hairless with age. The collar is very hairy. The mature plants appear waxy with enlarged nodes and red to purplish sheaths. Plants grow 20 to 40 inches tall. The roots are fibrous and can root from the lower nodes. Fall panicum flowers from July to October. The large seed heads are red to purple with an open branching appearance (22, 23, 24). As with the foxtails, fall panicum can compete with peppers early in the season, especially for small transplants and fields without plastic mulch.

#### **Chemical Controls:**

- bensulide (Prefar 4E)
  - Percent acres treated: 0.5% (18)

- Typical rates and frequency of application: 5.0-6.0 quarts/A, 1 application.
  - Method of application: Broadcast preplant (incorporate 1–2 inches) or preemergence (irrigate within 36 hours with ½ inch water).
  - REI: 12 hours            PHI: Not available
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- clethodim (Select 2EC)
    - Percent acres treated: Newer material, data not available.
    - Typical rates and frequency of application: 6.0-8.0 oz/A when the weed is 2-8 inches tall; 1-2 applications.
    - Method of application: Broadcast post emergence to the weeds and peppers.
    - REI: 24 hours            PHI: 20 days
    - Efficacy: Good.
    - Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.
  - clomazone (Command 3ME)
    - Percent acres treated: 13.3% (18)
    - Typical rates, frequency of application for each method of application:
      - § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.

§ Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.

§ Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours      PHI: Not available

- Efficacy: Good.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- DCPA (Dacthal 6F)

- Percent acres treated: 0.0% (18)

- Typical rates and frequency of application: 8.0-14.0 pts/A, 4-6 weeks after transplanting; 1 application.

- Method of application: Spray broadcast over plants when peppers are grown without plastic mulch, or direct spray between rows with plastic mulch as a preemergent weed treatment.

- REI: 12 hours      PHI: Not available

- Efficacy: Fair to good.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- napropamide (Devrinol 50-DF, Devrinol 2-EC)

- Percent acres treated: 21.4% (18)

- Typical rates and frequency of application: 2.0-4.0 lbs/A (Devrinol 50-DF) or 2.0-4.0 qts/A

(Devrinol 2-EC), 1-2 applications. Do not apply more than 4.0 lbs/A 50-DF or 4.0 qts/A 2-EC per crop cycle. Up to a 12 month plant back restriction applies depending on the rotational crop.

- Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches prior to transplanting.

- REI: 12 hours            PHI: Not available

- Efficacy: Good.

- Use in IPM and resistance management: Best chemical to use during periods of wet weather. Good for rotation with the other herbicides to reduce chance of resistance.

- paraquat (Gramoxone Max, Gramoxone Super Tres)

- Percent acres treated: 8.4% (18)

- Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.

- Method of application: Broadcast prior to planting or apply as a directed shielded spray between rows when weeds are succulent and less than 6 inches high.

- REI: 12 hours            PHI: 30 days

- Efficacy: Good.

- Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.

- sethoxydim (Poast 1.5EC)

- Percent acres treated: 7.5% (18)

- Typical rates and frequency of application: 1.0-1.5 pts/A, 3-4 applications.

Do not apply more than 4.5 pts/A per season.

- Method of application: Broadcast for weeds up to 12 inches tall.
  - REI: 12 hours            PHI: 20 days
  - Efficacy: Good
  - Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.
- S-metolachlor (Dual Magnum 7.62E)
    - Percent acres treated: 10.3% (18)
    - Typical rates and frequency of application: 0.67-1.0 pt/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture only, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.
  - REI: 24 hours            PHI: 65 days
  - Efficacy: Good
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.
- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)
    - Percent acres treated: 1.9% (18)
    - Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application.

- Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
- REI: 12 hours      PHI: Not available
- Efficacy: Good
- Use in IPM and resistance management: Avoid planting during periods of cold wet weather to reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

### **Alternatives:**

There are several good chemical alternatives for fall panicum control.

### **Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

**Large Crabgrass, *Digitaria sanguinalis***

## **Description and Damage:**

This summer annual grows mainly prostrate, but as the plant matures the stem may turn upward to 40 inches. Seeds germinate from mid spring through late summer. Seedlings are upright and the leaves taper to the tip. The leaves are rolled in the bud, lack auricles, but have a jagged membranous ligule. Stiff hairs are found on the blade and sheath at a 90° angle to the plant surface. The collar has long hairs at the margin. On mature plants, hairs are found on both blade surfaces and on the sheath. Plants tiller at the four or five leaf stage and elongate later in the summer. Older sheaths and leaves may turn dark red to maroon. The plant has fibrous roots and may root from nodes after tiller elongation. The seed heads are at the top of the plant and consist of 3-5 spikes. The individual spikes have two rows of seedpods. Large crabgrass is killed by the first frost, but brown patches of plants can remain in uncultivated areas (6, 22, 23, 24). Large crabgrass is only a problem early in the season when peppers are planted on bare ground.

## **Chemical Controls:**

- bensulide (Prefar 4E)
  - Percent acres treated: 0.5% (18)
  - Typical rates and frequency of application: 5.0-6.0 qts/A, 1 application.
  - Method of application: Broadcast preplant (incorporate 1–2 inches) or preemergence (irrigate within 36 hours with ½ inch water).
  - REI: 12 hours            PHI: Not available
  - Efficacy: Fair to good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
  
- clethodim (Select 2EC)
  - Percent acres treated: Newer material, data not available.

- Typical rates and frequency of application: 6.0-8.0 oz/A, 1-2 applications.
  - Method of application: Broadcast post emergence to the weeds and peppers when the weed is 1-4 inches tall.
  - REI: 24 hours          PHI: 20 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.
- clomazone (Command 3ME)
    - Percent acres treated: 13.3% (18)
    - Typical rates, frequency of application for each method of application:
      - § Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.
      - § Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.
      - § Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours          PHI: Not available
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- DCPA (Dacthal 6F)

- Percent acres treated: 0.0% (18)
  - Typical rates and frequency of application: 8.0-14.0 pts/A, 4-6 weeks after transplanting; 1 application.
  - Method of application: Spray broadcast treatment over plants that are grown without plastic mulch, or directed spray between rows with plastic mulch as a preemergent weed treatment.
  - REI: 12 hours            PHI: Not available
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
- napropamide (Devrinol 50-DF, Devrinol 2-EC)
    - Percent acres treated: 21.4% (18)
    - Typical rates and frequency of application: 2.0-4.0 lbs/A (Devrinol 50-DF) or 2.0-4.0 qts/A (Devrinol 2-EC), 1-2 applications. Do not apply more than 4.0 lbs/A 50-DF or 4.0 qts/A 2-EC per crop cycle. Up to a 12 month plant back restriction applies depending on the rotational crop.
    - Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches prior to transplanting.
    - REI: 12 hours            PHI: Not available
    - Efficacy: Good.
    - Use in IPM and resistance management: Best chemical for use during periods of wet weather. Good for rotation with the other herbicides to reduce chance of resistance.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
    - Percent acres treated: 8.4% (18)

- Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
  - Method of application: Broadcast prior to planting or directed spray between rows when weeds are succulent and less than 6 inches high.
  - REI: 12 hours            PHI: 30 days
  - Efficacy: Good.
  - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
- sethoxydim (Poast 1.5EC)
    - Percent acres treated: 7.5% (18)
    - Typical rates and frequency of application: 1.0-1.5 pts/A, 3-4 applications.

Do not apply more than 4.5 pts/A per season.

- Method of application: Broadcast up to maximum weed height of 6 inches.
  - REI: 12 hours            PHI: 20 days
  - Efficacy: Good
  - Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.
- S-metolachlor (Dual Magnum 7.62E)
    - Percent acres treated: 10.3% (18)
    - Typical rates and frequency of application: 0.67-1.0 pts/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture only, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.
  - REI: 24 hours            PHI: 65 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.
- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)
    - Percent acres treated: 1.9% (18)
    - Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application.
    - Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
    - REI: 12 hours            PHI: Not available
    - Efficacy: Good.
    - Use in IPM and resistance management: Avoid planting during periods of cold wet weather to reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

### **Alternatives:**

There are good pre and post emergent weed control options for large crabgrass.

**Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

**Biological Control:**

None available.

**Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

**Goosegrass, *Eleusine indica*****Description and Damage:**

The plant grows prostrate forming a rosette, but as it matures the stems may turn upward to approximately 24 inches. The leaf sheaths are flattened and have a whitish to silver color in the center. Seeds germinate from early to midsummer when soil temperatures are above 65 °F. Leaves grow parallel to the ground, lack auricles, and have a short, membranous, unevenly toothed ligule that is gapped in the center. The blades are smooth and distinctly formed at the midrib. The collar is broad and hairless. Mature plants are similar to the seedlings except there may be some hairs on the blades, toward the ligule on the sheath, and on the collar edge. The roots are fibrous and do not root at the nodes. Goosegrass flowers in June through September and seed heads mature from late summer through early autumn. The seed heads are at the top of the plant and consist of 2 to 6 spikes. The individual spikes have two rows of seedpods. The plants die with the first hard freeze (6, 22, 23, 24). Goosegrass can compete with peppers early in the season, especially in fields without plastic mulch. Within row, competition is more of a concern if soil is not thrown around the plants during cultivation.

**Chemical Controls:**

- bensulide (Prefar 4E)
  - Percent acres treated: 0.5% (18)
  - Typical rates and frequency of application: 5.0-6.0 qts/A, 1 application.
  - Method of application: Broadcast preplant (incorporate 1–2 inches) or preemergence (irrigate within 36 hours with ½ inch water).
  - REI: 12 hours            PHI: Not available
  - Efficacy: Fair.
  - Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.
  
- clethodim (Select 2EC)
  - Percent acres treated: Newer material, data not available.
  - Typical rates and frequency of application: 6.0-8.0 oz/A, 1-2 applications
  - Method of application: Broadcast, post emergence to the weeds and peppers when the weed is 2-6 inches tall.
  - REI: 24 hours            PHI: 20 days
  - Efficacy: Fair to good.
  - Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.
  
- clomazone (Command 3ME)
  - Percent acres treated: 13.3% (18)

- Typical rates, frequency of application for each method of application:

§ Plastic culture, pretransplant: 0.66-1.33 pts/A, 1 application.

§ Between plastic, shielded, directed spray: 0.66-2.0 pts/A, 1 application.

§ Bare ground, pretransplant: 0.66-2.0 pts/A, 1 application.

Do not make more than one application per season. Up to 16 months plant back interval applies depending on the rotational crop.

- REI: 12 hours      PHI: Not available

- Efficacy: Fair to good.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- DCPA (Dacthal 6F)

- Percent acres treated: 0.0% (18)

- Typical rates and frequency of application: 8.0-14.0 pts/A, 4-6 weeks after transplanting; 1 application.

- Method of application: Broadcast over plants when peppers are grown without plastic mulch, or directed spray between rows with plastic mulch as a preemergent weed treatment.

- REI: 12 hours      PHI: Not available

- Efficacy: Fair to good.

- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance.

- napropamide (Devrinol 50-DF, Devrinol 2-EC)

- Percent acres treated: 21.4% (18)
  - Typical rates and frequency of application: 2.0-4.0 lbs/A (Devrinol 50-DF) or 2.0-4.0 qts/A (Devrinol 2-EC), 1-2 applications. Do not apply more than 4.0 lbs/A 50-DF or 4.0 qts/A 2-EC per crop cycle. Up to a 12 month plant back restriction applies depending on the rotational crop.
  - Method of application: For plastic culture, apply banded under the plastic or banded directed shielded spray between the plastic and incorporated with irrigation. For bare ground culture, broadcast and incorporate 1-2 inches prior to transplanting.
  - REI: 12 hours            PHI: Not available
  - Efficacy: Fair to good.
  - Use in IPM and resistance management: Best chemical to use during periods of wet weather. Good for rotation with the other herbicides to reduce chance of resistance.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
    - Percent acres treated: 8.4% (18)
    - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
    - Method of application: Broadcast prior to planting or directed shielded spray between rows when weeds are succulent and less than 6 inches high.
    - REI: 12 hours            PHI: 30 days
    - Efficacy: Good.
    - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. Since it is applied only when the weed is present, the development of resistance is reduced.
- sethoxydim (Poast 1.5EC)

- Percent acres treated: 7.5% (18)
- Typical rates and frequency of application: 1.0-1.5 pts/A, 3-4 applications

Do not apply more than 4.5 pts/A per season.

- Method of application: Broadcast up to maximum weed height of 8 inches.
- REI: 12 hours      PHI: 20 days
- Efficacy: Good.
- Use in IPM and resistance management: Must use an oil concentrate or nonionic surfactant for good control, however during periods of hot or humid weather crop injury may occur and control may be reduced. For best control the weed should be actively growing and before tillers are present.

- S-metolachlor (Dual Magnum 7.62E)

- Percent acres treated: 10.3% (18)
- Typical rates and frequency of application: 0.67-1.0 pts/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture only, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.
- REI: 24 hours      PHI: 65 days
- Efficacy: Fair to good.
- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.

- trifluralin (Treflan HFP, Treflan 4L, Trifluralin HF, Trilin)

- Percent acres treated: 1.9% (18)
- Typical rates and frequency of application: 1.0-2.0 pts/A, 1 application.
- Method of application: Broadcast and incorporate within 24 hours prior to transplanting. Do not use under plastic mulch.
- REI: 12 hours          PHI: Not available
- Efficacy: Good.
- Use in IPM and resistance management: Avoid planting during periods of cold wet weather to reduce the risk of temporary stunting. Good for rotation with the other herbicides to reduce chance of resistance.

### **Alternatives:**

There are good pre and post emergence weed control options for goosegrass.

### **Cultural Control Practices:**

Cultivation between the rows up to approximately one month after transplanting will help reduce weed populations.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Incorporate plant residue immediately after harvesting to reduce weed seed production. Planting a cover crop will help keep weeds under control.

## PERENNIAL WEEDS

### Yellow Nutsedge, *Cyperus esculentus*

#### **Description and Damage:**

Yellow nutsedge has triangular stems, yellowish green foliage, and has a grass appearance before maturity. Tubers, the main form of reproduction, sprout from May until mid-July. Rhizomes spread from the plants that emerge producing new plants until the day length reaches a critical length (late June). The plants produce 0.4 to 0.8 inch tubers and most are located in the top 6 inches of soil. They require a cold period to break dormancy, but remain viable for at least 10 years. Nutsedge leaves are shiny, flat or ridged and formed in groups of three, which give it the triangular shape. Flowers are inconspicuous and are organized on yellow to brown spikelets. These are located on stems and visible from July to September. After the first killing frost foliage and rhizomes die, but the tubers survive in the soil (6, 22, 23, 24). Yellow nutsedge has the potential to reduce yields in peppers under any management system. The stems will even push through plastic mulch as the plants emerge from the soil. Nutsedge does not tolerate shading once the plant is established. It is mainly a problem shortly after transplanting through mid season.

#### **Chemical Controls:**

- halosulfuron-methyl (Sanda)
- Percent acres treated: Newer chemical, data not available.
- Typical rates and frequency of application: 0.5-1.0 oz/A, 1-4 applications depending on rate. Do not exceed 2.0 oz/A per 12-month period. Up to an 18 month plant-back interval applies depending on the rotational crop.
- Method of application: For plastic culture only, apply as a banded directed shielded spray between rows as a preemergent application.
- REI: 4 hours                      PHI: 30 days

- Efficacy: Excellent (between the rows of plastic only).
- Use in IPM and resistance management: More than one application may be necessary to control multiple flushes of weeds. Weeds can become resistant to this herbicide if it is used with herbicides with the same mode of action (ALS/AHAS materials). Use mechanical control and chemical weed control from other herbicide classes.
- paraquat (Gramoxone Max, Gramoxone Super Tres)
  - Percent acres treated: 8.4% (18)
  - Typical rates and frequency of application: 1.3-2.7 pts/A (preplant), 1.3 pts/A (directed spray); 1-3 applications. Do not apply more than 3 applications per season.
  - Method of application: Broadcast prior to planting or directed spray between rows when weeds are succulent and less than 6 inches high.
  - REI: 12 hours          PHI: 30 days
  - Efficacy: Poor to fair.
  - Use in IPM and resistance management: This material is used when weeds are present but less than 6 inches tall. The foliage is burnt back, but there is no control of the tubers. Tubers will sprout later.
- S-metolachlor (Dual Magnum 7.62E)
  - Percent acres treated: 10.3% (18)
  - Typical rates and frequency of application: 0.67-1.0 pts/A, 1 application.

Do not make more than one application per season.

- Method of application: For bare ground culture only, broadcast preemergence to the weeds prior to transplanting. For plastic culture, apply as a directed shielded spray between beds after plant establishment.

- REI: 24 hours      PHI: 65 days
- Efficacy: Fair to good.
- Use in IPM and resistance management: Good for rotation with the other herbicides to reduce chance of resistance. This material is available in New Jersey through a Special Local Needs Label 24(c), and may not be available as a national label in the future.

### **Alternatives:**

There are few alternatives for controlling nutsedge. This is an area where additional options are needed.

### **Cultural Control Practices:**

The use of green plastic mulch will help control the emerging plants. The mulch allows some light through which permits the plants to emerge, but not develop completely.

### **Biological Control:**

None available.

### **Post Harvest Control Practices:**

Post harvest applications of glyphosate in August will reduce tuber survival.

## **Diseases**

The two main diseases are phytophthora blight and bacterial leaf spot. Occasional diseases include bacterial soft rot, damping-off, anthracnose fruit rot, verticillium wilt, viruses, and southern blight. Blossom end rot and sunscald are common physiological disorders.

### **Phytophthora Blight, *Phytophthora capsici***

#### **Description and Damage:**

Phytophthora blight is a soil-borne fungal disease that attacks pepper plants throughout the production season causing collar rot, stem canker, leaf blight, and fruit rot. Infections usually begin in fields with low spots or areas of poor drainage and/or where phytophthora has been a problem in the past. Initial infections appear as brown to black lesions on the stem at the soil line, which becomes soft and water soaked. Infected stems collapse causing the plant to wilt and eventually die. The disease spreads within a field primarily through water movement via irrigation (overhead or drip) and rainstorms, and can spread from field to field on contaminated tools and equipment. Plants often die in groups in areas of poor drainage. In plastic mulch culture, spores spread under the plastic due to high moisture levels. The aerial phase occurs from spores splashing from infected plants and soil onto the stems, leaves, and fruit, causing both stem and leaf lesions, and fruit rots. Symptoms of fruit infection are typically round, dark brown areas with an expanding light tan border. A white to gray fungal growth may be present on the lesion, especially during periods of high humidity and moisture.

Phytophthora is present every year in New Jersey where peppers, eggplants, tomatoes, and/or cucurbits are grown. *Phytophthora capsici* produces a thick-walled oospore that allows it to survive on plant debris in the soil between seasons and for extended periods even with proper crop rotation. Losses can be as great as 100% if inoculum levels are high and favorable environmental conditions are present (in particular, prolonged periods of saturated soils). The disease is more prevalent in southern counties, potentially affecting all pepper acreage in this area each year when environmental conditions are favorable. In the northern counties, this disease affects less than 50% of the pepper crop.

#### **Monitoring:**

Look for wilting plants in the field, especially in low spots and at ends of rows where water can collect after rain or irrigation.

## Chemical Controls:

- dimethomorph (Acrobat)
  - Percent acres treated: New material, no data available.
  - Typical rates and frequency of application: 6.4 oz 50WG/A
  - Method of application: foliar application with ground equipment
  - REI: 12 hours          PHI: 4 days
  - Efficacy: There is little data available in the Mid-Atlantic region.
  - Use in IPM and resistance management: There is little data available on efficacy of this material in the Mid-Atlantic region. For best results, apply prior to onset of disease and tank mix with a copper containing fungicide (8).
  
- famoxodone + cymoxanil (Tanos)
  - Percent acres treated: new material, no data available.
  - Typical rates and frequency of application: 8.0-10.0 oz 50W/A
  - Method of application: foliar application with ground equipment
  - REI: 12 hours          PHI: 3 days
  - Efficacy: There is little information on efficacy in the Mid-Atlantic region.
  - Use in IPM and resistance management: This material has not been tested in the mid-Atlantic region. For best results tank mix with a copper containing fungicide.
  
- fixed copper (Basicop, Champ, Champion, Copper-Count-N, Cuprofix Disperss, Kocide, Super CU, Tenn-Cop, Top Cop with Sulfur, Top Cop Tri-Basic, Tri-Basic Copper Sulfate)

- Percent acres treated: 81.3% (18)
  - Typical rates and frequency of application: 2 lb 77WP/A or other labeled formulation, 8-10 applications
  - Method of application: foliar application with ground equipment
  - REI: 24 hours            PHI: 0 days
  - Efficacy: Good
  - Use in IPM and resistance management: Use this material with a spreader sticker on a 7-10 day schedule to prevent the stem, leaf, and fruit rot phases. Chemical control must be used in combination with cultural controls for water management. Avoid applications during periods of high temperatures (>90 °F).
- mefenoxam (Ridomil Gold, Ultra Flourish)
    - Percent acres treated: 59.0% (18)
    - Typical rates and frequency of application:
      - § Ridomil Gold: 1 pt 4E/A, 3 applications OR
      - § Ultra Flourish: 1 qt 2E/A, 3 applications
    - Method of application: The first application is applied broadcast prior to planting or in a 12-16 inch band over the row before or after transplanting. Two additional post-directed applications are made to 6 – 10 inches of soil on either side of the plants at 30-day intervals (8). For polyethylene mulch culture, the above rates are injected into the trickle irrigation system. Ridomil Gold 4E should be diluted before injection to prevent damage to injector pump.
    - REI: 12 hours            PHI: 7 days`
    - Efficacy: Poor to good depending on local resistance levels
    - Use in IPM and resistance management: These materials are used for the prevention of collar rot and must be applied to the soil before the plants are infected to obtain satisfactory control. Chemical control must be used in combination with cultural controls for water management.

- mefenoxam + copper hydroxide (Ridomil Gold Copper)
  - Percent acres treated: 7.7% (18)
  - Typical rates and frequency of application: 2.5 lb 65 WP/A, 3-4 applications at 10-14 day intervals (only apply Ridomil Gold 4E at planting and 30 days later; the third application of Ridomil Gold 4E cannot be made when Ridomil Gold Copper is applied.)
  - Method of application: foliar application with ground equipment.
  - REI: 48 hours            PHI: 7 days
  - Efficacy: Good.
  - Use in IPM and resistance management: Chemical control must be used in combination with cultural controls for water management.
  
- metam-sodium (Vapam), metam-potassium (K-PAM)
  - Percent acres treated: 1.9% (18)
  - Typical rates and frequency of application:
    - § Vapam: 56–75 gal HL/A, once
    - § K-PAM: 30–60 gal HL/A, once
  - Method of application: At least 2-3 weeks prior to planting, inject fumigant 6–8 inches into the soil and work the soil immediately after application to reduce fumigant loss; OR apply via irrigation systems (solid set sprinkler or drip/trickle), injecting fumigant in one inch of water per acre.
  - REI: 48 hours            PHI: Not applicable
  - Efficacy: Good.

- Use in IPM and resistance management: Fumigation must be combined with cultural control practices for effective management of this disease.

### **Alternatives:**

Chemical controls including fumigation must be combined with cultural control practices for effective management of this disease.

### **Cultural Control Practices:**

A key management strategy to reduce the threat of phytophthora blight is rotation from susceptible crops (cucurbits, peppers, eggplants, and tomatoes) for as long as possible or at least 3 years (1, 19). For many New Jersey growers, proper crop rotations are not feasible due to the lack of land available from other host crops. Other important cultural controls to reduce the development and incidence of phytophthora involve water management in the field, with the primary goal of allowing water movement away from the base of plants. Methods to improve water movement and drainage include subsoiling, planting on ridges or high (minimum 9”) raised dome-shaped beds, constructing drainage ditches and waterways to remove excess water (including the ends of the rows), avoiding planting low spots where water collects, and filling the transplant holes with clean soil. When collar rot occurs in plastic mulch fields, infected plants should be rogued out, and plastic mulch and healthy plants removed around the infected area. Use of phytophthora-resistant or tolerant varieties (i.e., Paladin, Aristotle, Revolution) in infested fields or in the low-lying areas is an effective method of reducing potential losses from this disease. However, many of the resistant/tolerant varieties commercially available are prone to a condition that causes skin separation and silvering.

### **Biological Controls:**

None available.

### **Post Harvest Control Practices:**

Chlorine wash or other labeled disinfectants used during packing may reduce post harvest losses.

## **Bacterial Leaf Spot, *Xanthomonas spp.***

### **Description and Damage:**

Bacterial leaf spot (BLS) is a seed-borne pathogen that infects all above ground parts of the plant. The bacteria enter plants through natural leaf openings and wounds. The leaf spots begin as small (<3 mm in diameter), water-soaked lesions that turn brown and become necrotic in the center. The spots appear water-soaked during rainy periods or when dew is present. As infections progress, infected leaves turn yellow and drop off. Fruit lesions begin as circular green spots that turn brown and become slightly raised scab-like spots on the fruit surface. Yield loss occurs from defoliation and from unmarketable fruit due to severe spotting or sunscald injury.

Although infected seed is the most common source of the bacterium, the pathogen may also be introduced into a field through infected Solanaceous weeds or crop debris. High night temperatures (75-85 °F) in combination with high moisture favor disease development. Wind-driven rain and overhead irrigation helps spread the disease through the field, as well as, from individuals and machinery working in infected fields when plants are wet. BLS occurs every year in New Jersey, and can result in complete yield loss on susceptible varieties.

### **Monitoring:**

Scout fields weekly for the presence of BLS symptoms, and begin a 7-10 day spray program when symptoms are first observed on resistant varieties and conditions are favorable for disease development. All susceptible varieties should be treated preventatively on a 7-10 day spray program beginning shortly after transplanting. Spray schedules may be extended when conditions are not favorable for disease development (long periods of dry weather). Continue monitoring fields to determine the effectiveness of the control methods.

### **Chemical Controls:**

- fixed copper (Basicop, Champ, Champion, Copper-Count-N, Cuprofix Disperss, Kocide, Super CU, Tenn-Cop, Top Cop with Sulfur, Top Cop Tri-Basic, Tri-Basic Copper Sulfate)

- Percent acres treated: 81.3% (18)
  - Typical rates and frequency of application: 2 lb 77WP/A or other labeled formulation, 8-10 applications
  - Method of application: foliar application with ground equipment
  - REI: 24 hours            PHI: 0 days
  - Efficacy: Good in combination with maneb.
  - Use in IPM and resistance management: Use this material with a spreader sticker and with maneb on a 7-10 day schedule to prevent bacterial leaf spot especially on susceptible varieties. Spray schedules may be extended when conditions are not favorable for disease development (long periods of dry weather).
- hydrogen dioxide (OxiDate)
    - Percent acres treated: new material, data not available
    - Typical rates and frequency of application: 128 oz/100 gal water, 4-5 applications.
    - Method of application: foliar application with ground equipment
    - REI: 0 hr                    PHI: 4 hrs or until plants are dry
    - Efficacy: Good, although not listed in the 2005 New Jersey Commercial Vegetable Production Recommendations book for this pathogen.
    - Use in IPM and resistance management: This material is used as a contact disinfectant at the first appearance of BLS or on a 7-day spray schedule when conditions are favorable for disease development. Because of the lack of residual, this material should be alternated with the copper plus maneb treatment. Under severe disease conditions and during periods of rainy weather, apply immediately after each rain event, shorten spray intervals, and use the high rate.
- maneb (Manex)

- Percent acres treated: 53.7% (18)
  - Typical rates and frequency of application: 1.5 lb 80 WP/A, 8-10 applications.
  - Method of application: foliar application with ground equipment
  - REI: 24 hr                      PHI: 7
  - Efficacy: Good in combination with fixed copper.
  - Use in IPM and resistance management: Use in combination with fixed copper fungicides. Treat preventatively on susceptible varieties starting shortly after transplanting and maintain a 7-10 day schedule. Spray schedules may be extended when conditions are not favorable for disease development (long periods of dry weather).
- streptomycin (Agri-Mycin 17, Agri-Strep)
    - Percent transplants treated: approximately 90%
    - Typical rates and frequency of application: 1 lb per 100 gallons, 8-10 applications; do not combine or mix with any other pesticide or fertilizer.
    - Method of application: greenhouse foliar application with ground equipment
    - REI: 12 hr                      PHI: not applicable – only used in the greenhouse
    - Efficacy: Good.
    - Use in IPM and resistance management: Use only in the greenhouse for transplant production. Apply when the first true leaves appear and continue every 4 to 5 days until transplanting. Resistance is a concern since the pathogen is exposed to constant preventative treatments.

**Alternatives:**

The fixed copper fungicides are most effective when used in combination with maneb. Hydrogen dioxide is an effective alternative to maneb, except that there is no residual control.

## **Cultural Control Practices:**

The most effective cultural control is to plant varieties that have resistance to all three races (races 1, 2, & 3) of the pathogen (i.e. Boynton Bell, X3R Aladdin, X3R Camelot, X3R Key West, X3R Wizard, Commandant, and Enterprise). Purchase treated seed, or treat seeds with Clorox when producing transplants, or use certified transplants. Avoid using southern-produced transplants. Do not rotate peppers with tomatoes or other susceptible crops for at least 2-3 years. Do not work in fields when plant surfaces are wet. Disk field as soon as possible at the end of the growing season to hasten breakdown of the crop debris and minimize overwintering of bacteria in the field. In infected fields, maintain a high level of fertility to replace leaves lost to infection and rogue infected plants.

## **Biological Controls:**

No biological controls are available for BLS.

## **Post Harvest Control Practices:**

Locate cull piles well away from fields or greenhouses.

## **Damping-Off and Root Rot, *Pythium* spp., *Rhizoctonia* sp.**

### **Description and Damage:**

Common soil-borne fungal pathogens that cause damping-off in pepper include *Pythium* spp. and *Rhizoctonia* sp.. Most losses from damping-off and root rot occur in greenhouse transplant production or soon after transplant in the field. Symptoms depend on the time of infection. Seeds or seedlings may rot before emergence, resulting in reduced plant stands. Post-emergence damping off is characterized by lesions that girdle the stem at the base of the plant and cause the seedling plant to wilt and die.

Fungi survive for long periods in soil and may persist in plant debris or on roots of weeds. Conditions of high soil moisture, overcrowding, compaction, poor ventilation, and cool, damp, cloudy weather promote damping off. Spread occurs from infected to healthy plants through splashing water. The potential exists for damping off to occur every year in greenhouse pepper transplant production. The extent of the damage depends on greenhouse management.

### **Monitoring:**

Growers monitor the transplants as they water the greenhouses.

### **Chemical Controls:**

- thiram (Thiram)
  - Percent acres treated: Not reported.
  - Typical rates and frequency of application: 8.0 oz 75 WP per 100 lbs of seed (1 tsp/lb seed), 1 application.
  - Method of application: Slurry or dust seed with thiram.
  - REI: 12 hours            PHI: not applicable
  - Efficacy: Good
  - Use in IPM and resistance management: Seed treatments are recommended for disease prevention.
  
- mefenoxam (Ridomil Gold, Ultra Flourish)
  - Percent acres treated: 59.0% (18)
  - Typical rates and frequency of application:
    - §    Ridomil Gold: 1 pt 4E/A, 1 application OR

§ Ultra Flourish: 1 qt 2E/A, 1 application

– Method of application: Broadcast prior to planting or in a 12-16 inch band over the row before or after transplanting. For polyethylene mulch culture, inject the material into the trickle irrigation system. Ridomil Gold 4E should be diluted before injection to prevent damage to injector pump.

– REI: 12 hours            PHI: 7 days

– Efficacy: Unknown.

– Use in IPM and resistance management: The use of mefenoxam for phytophthora blight will also control damping-off.

• metam-sodium (Vapam), metam-potassium (K-PAM)

– Percent acres treated: data not available

– Typical rates and frequency of application: 0.75 qt HL/100 square feet, one application

– Method of application: In the greenhouse, apply to the seed beds via sprinkler irrigation or soil injection prior to seeding.

– REI: 48 hours            PHI: Not applicable

– Efficacy: Good.

– Use in IPM and resistance management: Soil fumigation would be used in the greenhouse if soilless planting mix is not used. Fumigation is recommended when producing bare root transplants or placing trays directly on the soil. Soil fumigation in the field for other diseases will provide damping off control.

**Alternatives:**

SoilGard (see below) is an effective alternative for plants grown in soilless mix.

## **Cultural Control Practices:**

Good sanitation (sterilized planting trays, proper soil pasteurization, and weed control in and around the greenhouse) will help reduce damping off incidence. Soilless planting mixes are recommended. Maintain low humidity and adequate but not excessive fertility.

## **Biological Controls:**

Soilless mixes are available that contain microorganisms that suppress damping off fungi. SoilGard (*Gliocladium virens*) is a commercially available naturally occurring soil fungus that is an antagonist to the fungi that cause damping off. SoilGard 12G (1-1.5 lb/cu yd of soilless mix) is added during the blending of soilless mixes. One day of incubation is needed prior to seeding or transplanting. Other biological controls are commercially available for controlling *Rhizoctonia* and *Pythium* in the greenhouse, but their efficacy has not been well established. *Streptomyces*, a bacterium, is reported to provide suppression and *Gliocladium spp.* is a fungus sold as a substitute for conventional fungicides. These control agents should be applied preventatively and reapplied at appropriate intervals (1).

## **Bacterial Soft Rot, *Erwinia spp.***

### **Description and Damage:**

Soft rot bacteria are present wherever peppers are grown, as they are commonly associated with plant debris, soil, and water. Some losses may occur in the field, particularly during extended periods of humid weather, but soft rot is primarily a post harvest problem for pepper. The bacteria enter fruit through cuts, breaks, insect damaged areas, and abrasions, and dissolve the pectin that holds plant cells together. As the tissue decays it turns brown, soft, and slimy. At the favorable temperature range for infections (75-85 °F) the fruit will rot within 3 to 10 days. This disease is associated with poor insect control, harvesting during warm, rainy periods, and inadequate chlorination when washing fruit after harvest. In New Jersey, this problem occurs primarily during August harvests due to the favorable environmental conditions. Losses can be high since loads may be rejected due to high levels of rotted fruit.

### **Monitoring:**

Look for discolored areas or slimy rot on the stem or fruit. Avoid harvesting when plants are wet, and do not plant peppers after potatoes or cabbage.

### **Chemical Controls:**

There are no chemical controls to prevent bacterial soft rot (1).

### **Alternatives:**

No chemical alternatives are available.

### **Cultural Control Practices:**

Careful handling of fruit during harvesting and packing, and controlling insects, is necessary to reduce losses from this disease. When environmental conditions are favorable for soft rot, avoid picking fruit when fields are wet, and do not pick in the heat of the day. Practice good sanitation like removing infected fruit from the field. If weather conditions are favorable and soft rot begins to appear on the stem ends of harvested peppers, pack peppers dry without washing to minimize the disease.

### **Biological Controls:**

No biological controls are available.

### **Post Harvest Control Practices:**

During packing, maintain chlorine concentration at 75–150 ppm and pH between 6.5-7.5. Avoid wash water temperature differences of more than 10 °F from field temperatures, since cold water on hot fruit will increase the movement of bacteria into the fruit. Maintain storage temperatures at 45–50 °F. Disinfect picking containers.

## **Anthracnose Fruit Rot, *Colletotrichum* spp.**

### **Description and Damage:**

Anthracnose is a potential problem primarily for mature pepper fruit left on the plant for long periods, particularly colored peppers. Infected fruit develop sunken lesions that become brown and then black, and the center of the lesion may develop pustules of salmon-colored spores. Small necrotic spots may develop on the leaves as well.

Anthracnose fungi have been identified in pepper seed, and sclerotia may persist in plant debris from infected crops and in other solanaceous and cucurbit plant species. Infection and spread of the disease is moisture dependent. The longer the period of leaf wetness, high relative humidity, and/or rain, the greater the potential for a disease outbreak. Germination of the spores can occur over a wide range of temperatures, but the optimal temperature is 78 °F. Diseased fruit, foliage, and stems are sources of secondary inoculum, and the disease spreads to other plants via splashing rain and overhead irrigation. Severe losses may occur when environmental conditions are favorable and the disease is left untreated (19).

### **Monitoring:**

Scout fields and apply fungicides at the first sign of anthracnose. For late-maturing peppers (particularly colored peppers) in fields where there is a history of disease, apply fungicide preventatively beginning at flowering.

### **Chemical Controls:**

- azoxystrobin (Amistar, Quadris)
  - Percent acres treated: Newer material, data not available
  - Typical rates and frequency of application: 2.0-5.0 oz 80WDG/A or other labeled formulation, 4-5 applications

- Method of application: foliar application with ground equipment
- REI: 4 hours            PHI: 0 days
- Efficacy: Poor when used in alternation with Manex 37F (13).
- Use in IPM and resistance management: Alternate azoxystrobin with maneb every 7-10 days beginning at flowering for anthracnose prevention, apply prior to disease development.
  
- maneb (Manex)
  - Percent acres treated: 53.7% (18)
  - Typical rates and frequency of application: 1.5-3.0 lb 75DF/A or other labeled formulation; 4-5 applications
  - Method of application: foliar application with ground equipment.
  - REI: 24 hours            PHI: 7 days
  - Efficacy: Good
  - Use in IPM and resistance management: Use maneb (Manex) alternated with Cabrio, Amistar or Flint (suppression only) beginning at flowering every 7-10 days for resistance management
  
- pyraclostrobin (Cabrio)
  - Percent acres treated: Newer material, data not available
  - Typical rates and frequency of application: 8.0-12.0 oz 20EG/A, 4-5 applications
  - Method of application: foliar application with ground equipment
  - REI: 12 hours            PHI: 0 days
  - Efficacy: Good

- Use in IPM and resistance management: Alternate with maneb (Manex) on a 7-10 day schedule beginning at flowering for prevention of anthracnose.
  
- trifloxystrobin (Flint)
  - Percent acres treated: Newer material, data not available
  - Typical rates and frequency of application: 3.0-4.0 oz 50WDG/A, 4-5 applications.
  - Method of application: foliar application with ground equipment
  - REI: 12 hours            PHI: 3 days
  - Efficacy: For suppression only, use in alternation with maneb (Manex). Control with a similar chemistry azoxystrobin (Amistar,Quadris) rotated with Manex 37F was shown to be poor in field trials (13).
  - Use in IPM and resistance management: Alternate with maneb on a 7-10 day schedule beginning at flowering for prevention of anthracnose.

### **Alternatives:**

There are no alternatives for maneb, since maneb is needed for resistance management of the strobilurins. Use resistance management guidelines set by fungicide labels.

### **Cultural Control Practices:**

Using pathogen-free seed and crop rotation (away from solanaceous and cucurbit species for at least 2 to 3 years) are the most effective anthracnose management strategies (19). Sanitation, including deep plowing of crop residues and removal of plant material from the field, is important. Choose fields with good drainage and maintain weed control. Some tolerant cultivars are available. Research from field trials in the Mid-west (13) showed that the cultivars ‘Paladin’, ‘Colossal’ and ‘Brigadier’ were among the least susceptible. Harvest peppers as soon as possible, and/or plant varieties with shorter ripening periods.

## **Biological Controls:**

No biological controls are available.

## **Verticillium Wilt, *Verticillium albo-atrum* and *V. dahliae***

### **Description and Damage:**

Verticillium wilt (*Verticillium* spp.) is a soil-borne fungal disease that attacks a wide range of crops including eggplant, tomatoes, potatoes, peppers, strawberries, okra, and brambles. When temperatures are favorable and moisture is present, the pathogen penetrates the roots and grows through to the xylem. The fungus plugs the vascular system, disrupting water transport and nutrient uptake. The older leaves begin to yellow and the leaf margins and tips become dry, turn brown, and may drop prematurely. Varying degrees of leaf and stem discoloration may occur as the disease progresses, and in late stages the plant will be permanently wilted and stunted due to water stress. Verticillium typically only occurs sporadically as long as fields are rotated from host plants, however the pathogen may persist in a field indefinitely. This disease is not typically a problem in peppers in New Jersey.

### **Monitoring:**

Routine monitoring for this disease is not recommended since it is rarely present in peppers.

### **Chemical Controls:**

There are no chemicals available for control of verticillium wilt in peppers.

### **Alternatives:**

There are no alternatives available.

## **Cultural Control Practices:**

Proper crop rotation is the best method to use to avoid losses due to verticillium wilt. Avoid planting in contaminated fields, and observe a 4-5 year rotation with crops other than tomato, potato, eggplant, strawberry, or any of the brambles.

## **Biological Controls:**

No biological controls are available.

## **Southern Blight, *Sclerotium rolfsii***

### **Description and Damage:**

Southern blight is a soil-borne fungus that is common in warm, humid regions. The fungus attacks the crown of the plant, and within days the stem turns brown and decays at the soil line. A fluffy white mass may grow on the stem and adjoining soil surface near infected plants. Light tan to dark brown sclerotia about the size of cabbage seed may appear on infected areas. Pepper fruit may become infected by contact with infested soil. The fungus overwinters as sclerotia in the soil and survives on plant debris, volunteers, and weeds. High soil moisture, high temperatures, and acid soils favor disease development when the fungus is present. In New Jersey, this disease is associated with southern transplants and is rarely seen.

### **Monitoring:**

Routine monitoring for this disease is not recommended unless southern produced transplants are used.

### **Chemical Controls:**

- PCNB (Terraclor)

- Percent acres treated: 0% (18)
- Typical rates and frequency of application: 3.0 lb 75 WP/100 gal water or other labelled formation, apply 0.5 pints per plant; one application.
- Method of application: apply via the transplant solution at transplanting
- REI: 12                      PHI: not applicable; applied at transplanting only
- Efficacy: Unknown.
- Use in IPM and resistance management: This material is not typically used in New Jersey.

### **Alternatives:**

No alternatives are available.

### **Cultural Control Practices:**

Use disease-free transplants and avoid southern produced transplants. Rotate fields with corn and small grains to reduce disease incidence. Bury infected plant debris by deep plowing.

### **Biological Controls:**

Several commercially available antagonistic fungi have been shown to reduce damage (19).

### **Other Issues:**

Although PCNB is not used in New Jersey, if it is used, workers must wear the recommended personal protective equipment when transplanting.

## **Mechanically Transmitted Virus:**

### **Tobacco Mosaic Virus (TMV)**

#### **Description and Damage:**

Tobacco mosaic virus (TMV) is one of the most stable plant viruses, capable of surviving on plant debris and roots for many years. Although the host range is wide, it is primarily a problem for solanaceous crops. Infected seed, fruit, leaves, stems, and root debris provide inoculum for infection. Plant to plant transmission occurs mechanically from contact with infected hands, tools, trays, pots, stakes, twine, clothing, and in pollination, pruning, and other hands-on cultural practices. Symptoms vary depending on the virus strain, cultivar, environmental conditions, and age of the plant. Plant symptoms typically include a dark green to yellow mosaic appearance on the leaves, leaf distortion, and stunting of transplants. Resistant cultivars may acquire necrotic lesions on the leaves. Fruit from infected plants are typically small, misshaped, mottled, and unmarketable. Losses can be significant (30-70%) when resistant cultivars are not used (19). TMV is not typically a problem in New Jersey.

#### **Monitoring:**

In the greenhouse and field, monitor plants for symptoms including stunting, leaf deformation, and/or leaf discoloration including mosaic or mottling patterns.

#### **Chemical Controls and Alternatives:**

No chemical controls are available.

#### **Cultural Control Practices:**

Sanitation is important for the control of TMV. In the greenhouse, sanitize all flats and bench surfaces before seeding. Keep the greenhouse and surrounding areas free of perennial weeds, especially marsh yellowcress, broadleaf plantain, horsenettle, and smooth and clammy groundcherry. Purchase disease-

free seed, and use resistant or tolerant varieties.

### **Biological Controls:**

None available.

### **Aphid-Transmitted Viruses:**

**Alfalfa Mosaic Virus (AMV), Cucumber Mosaic Virus (CMV),**

**Potato Virus Y (PVY), Tobacco Etch Virus (TEV)**

### **Description and Damage:**

Alfalfa Mosaic Virus (AMV) occurs sporadically in peppers, and is vectored by at least 14 aphid species, including the green peach aphid. The characteristic symptoms include a mosaic leaf pattern of bright yellow or white blotches. If infection occurs early in the plant development, plants will be stunted and will have distorted or misshaped fruit. This disease is not usually economically important in peppers, although yield losses can be as high as 65% in pepper fields near alfalfa fields (19).

Cucumber Mosaic Virus (CMV) affects over 1,000 plant species in 101 plant families, including tomatoes, cucurbits, and many weeds, and is vectored by over 75 aphid species. Due to the wide host range and the large number of vector species, CMV is a serious economic threat to pepper production worldwide. Symptom expression varies depending on the viral strain or isolate, environmental conditions, the pepper genotype, and the age of the plant at infection. Typically, symptoms appear on lower, mature leaves as ring-spot or oak-leaf necrotic patterns. Plants may be stunted, with a bushy appearance, and a mild to moderate mosaic pattern on the leaves. CMV is the most common and destructive virus disease in New Jersey. It has the potential to affect all pepper acreage. Losses depend on the plant age at the time of infection.

Potato Virus Y (PVY) affects solanaceous crops and weeds, and occurs rarely in peppers in New Jersey. Symptoms include a faint mosaic or mottling pattern and slight distortion of the foliage. A characteristic

symptom is a dark green banding pattern along the leaf veins ('veinbanding'). Infection results in reduced fruit set and size, and deformed fruit.

Tobacco Etch Virus (TEV) occurs rarely in New Jersey pepper production. Symptoms include stunted plants and intense mottling. Leaves may be distorted and wrinkled, and exhibit mosaic and veinbanding. The fruit from infected plants are misshaped and distorted. Symptoms on plants of the variety 'Tabasco' are particularly severe.

### **Monitoring:**

Yellow trap pans containing water, and yellow sticky cards, may be used to monitor mass flights of winged aphids.

### **Chemical Controls and Alternatives:**

No chemical controls are available.

### **Cultural Control Practices:**

For all of the aphid-transmitted viruses, maintain good weed control and isolate pepper plantings from weedy border areas. Tall border plantings like sweet corn can function as a nonsusceptible barrier crop. For AMV, avoid planting peppers next to susceptible hosts like alfalfa. No CMV or AMV resistant varieties are available, but resistant varieties are available to control PVY and TEV.

### **Biological Controls:**

No biological controls are available.

### **Thrips-Transmitted Viruses:**

## **Tomato Spotted Wilt Virus (TSWV), Impatiens Necrotic Spot Virus (INSV)**

### **Description and Damage:**

Tomato spotted wilt (TSWV) occurs worldwide and infects peppers and a wide range of ornamental crops and vegetable crops including tomato, eggplant, melon, cucumber, bean, lettuce, and potato. Impatiens necrotic spot virus (INSV) is closely related to TSWV and causes similar symptoms but does not limit production like TSWV. TSWV can affect both greenhouse production of transplants and field production of peppers. The appearance and severity of symptoms varies and depends on the cultivar, virus isolate, stage of plant growth at the time of infection, and environmental conditions. Infections that occur during the transplant stage usually result in severely stunted plants that do not produce fruit. Later infections cause symptoms that may include chlorotic or necrotic flecking, or necrotic ring spots on the stems and leaves. Plants may be stunted, with systemic necrosis starting from the growing tips, which results in one-sided growth. Fruit from infected plants may exhibit undesirable fruit color, chlorotic or necrotic spots, and ring or mosaic patterns. Transmission of the virus occurs by several species of thrips. Only larval thrips can acquire TSWV, but larval and adult thrips can transmit the virus. The most common source of the virus and the vector is from ornamental and bedding plants that are brought into greenhouses from other production areas or grown in the same greenhouse as pepper transplants. TSWV occurs occasionally in New Jersey and is almost always associated with pepper transplants that are exposed to infected ornamental plants in the greenhouse.

### **Monitoring:**

Blue sticky cards can be used to monitor greenhouses for the presence of thrips.

### **Chemical Controls and Alternatives:**

The use of insecticides to control thrips reduces disease incidence.

### **Cultural Control Practices:**

Use virus-free transplants. Thrips-proof screens in greenhouses may help prevent or delay infection in greenhouse production. Do not grow any ornamental bedding plants in the same greenhouse as pepper transplants. Rogue out TSWV-infected plants. Maintain weed control around greenhouses and in the field

to reduce potential virus reservoirs.

### **Biological Controls:**

None available.

### **Blossom End Rot**

#### **Description and Damage:**

Blossom end rot is a physiological disorder caused by reduced calcium uptake. The symptoms include sunken black areas or lesions on the side and bottom half of the pepper fruit. The lesions darken and rapidly enlarge as the fruit grows, eventually turning brown to black in color. Secondary fungi may colonize the affected area. This disorder occurs particularly when the fruit are growing faster than the plant can supply calcium to it. High rates of blossom end rot are associated with growth fluctuations occurring from alternating wet and dry environmental conditions. This disorder can result in high yield loss when conditions are favorable, particularly for the first harvest.

#### **Monitoring:**

Monitor fruit for the presence of symptoms.

#### **Chemical Controls:**

No chemical controls are available.

#### **Alternatives:**

No alternatives are available.

### **Cultural Control Practices:**

Maintain proper soil calcium and nutrient balance. Avoid root pruning and damage. The most effective control is to maintain uniform, favorable soil moisture, especially on the raised beds needed for phytophthora control. Plant varieties that are less susceptible to blossom end rot.

### **Sunscald**

#### **Description and Damage:**

Sunscald is a physiological disorder that occurs when pepper fruit is exposed to intense direct sunlight. The damage appears as light colored, soft, and slightly wrinkled areas on the exposed side of the fruit. The lesions become dry, sunken, and turn white with a paper-thin appearance, and may turn black from secondary disease organisms. Conditions that reduce foliage cover, including lodging, breakage during harvesting, lack of proper fertility and water management, insect defoliation, and diseases like bacterial leaf spot, increase the potential for sunscald.

#### **Monitoring:**

Monitor fruit for the presence of symptoms.

#### **Chemical Controls:**

No chemical control is available.

#### **Alternatives:**

No alternatives are available.

### **Cultural Control Practices:**

Maintain vigorous vegetative growth, select varieties with good foliage cover, follow the recommended fertility program, maintain irrigation, and manage insects and diseases. Harvest carefully to avoid breaking foliage. Staking plants may help prevent sunscald.

## **Nematodes**

### **Description and Damage:**

Plant parasitic nematodes are non-segmented roundworms that live in the soil and feed on plant roots. Symptoms include a general lack of plant vigor, chlorosis of the foliage, stunting, and progressive dying of the older leaves. Infestations are typically clumped in a field, resulting in patches of affected plants, although tillage will widen the areas of infestations over time. Root knot (*Meloidogyne hapla*) and lesion (*Pratylenchus penetrans*) nematodes are the two species prevalent in New Jersey in bell pepper production. Both are widespread in agricultural areas and have a wide host plant range that includes many vegetable crops. Root knot nematodes are about 1/20 inch in length. Root knot juveniles attack the roots, penetrating as far as the vascular system. Secretions at the feeding sites cause cells to enlarge and multiply, resulting in characteristic root galls. Lesion nematodes are smaller, at 1/50 inch in length. They enter the root and damage the surface of the root. Infected roots may not develop properly and small lesions will be present. In the major production areas, nematodes are a minor pest.

### **Monitoring:**

Soil samples can be taken in the fall to assess nematode populations for fields to be planted the following spring. To determine if nematodes are present in a current production field, growers take soil samples within the suspected infested area.

## Chemical Controls:

- metam-sodium (Vapam), metam-potassium (K-PAM)
  - Percent acres treated: 14.3% (18)
  - Typical rates and frequency of application:
    - § Vapam: 56–75 gal HL/A, once
    - § K-PAM: 30–60 gal HL/A, once
  - Method of application: At least 2-3 weeks prior to planting, inject fumigant 6 – 8 inches into the soil and work the soil immediately after application to reduce fumigant loss; OR apply via irrigation systems (solid set sprinkler or drip/trickle), injecting fumigant with one inch of water per acre.
  - REI: 48 hours          PHI: not applicable
  - Efficacy: Good.
  - Use in IPM and resistance management: Growers do not typically treat for nematodes, however fumigation used for other diseases may control nematode population as well.
  
- Methyl bromide (Terr-O-Gas 67, MC-33)
  - Percent acres treated: 0% (18)
  - Typical rates and frequency of application: 225 – 350 lbs/A, once
  - Method of application: At least 2 to 3 weeks prior to planting, inject into the soil and seal with a plastic film.
  - REI: 48 hours          PHI: not applicable
  - Efficacy: Good.
  - Use in IPM and resistance management: Growers do not use this material in New Jersey.

- Chloropicrin, dichloropropene + chloropicrin (Telone C-17, Telone C-35)
  - Percent acres treated: 0% (18)
  - Typical rates and frequency of application:
    - § Chloropicrin: 50 gal/A, once
    - § Telone C-17: 11-17 gal/A, once
    - § Telone C-35: 13-20.5 gal/A, once
  - Method of application: At least 2-3 weeks prior to planting, inject fumigant 6 – 8 inches into the soil and work the soil immediately after application to reduce fumigant loss;
  - REI: 72 hours            PHI: not applicable
  - Efficacy: Good
  - Use in IPM and resistance management: Growers do not use this material in New Jersey.
  
- oxamyl (Vydate L)
  - Percent acres treated: Unknown
  - Typical rates and frequency of application: 2.0 pt 2L/A in 200 gal water, 1 application applied in the transplant solution, followed by 2.0-4.0 pts in 40-200 gal water applied in trickle irrigation or 2.0-4.0 pts 2L/A as a foliar treatment on a 14-day schedule.

Do not apply more than 24 pt per acre per season.

- Method of application: Treatment at transplanting followed by a treatment through trickle irrigation or by foliar application with ground or aerial equipment.
- REI: 48 hrs            PHI: 7 day

- Efficacy: Unknown.
- Use in IPM and resistance management: Growers do not typically use this material for nematode control in New Jersey.

### **Alternatives:**

There are no alternative materials for nematodes.

### **Cultural Control Practices:**

Some cover crop plants are suppressive to nematode populations. Some antagonistic crops like marigold and asparagus produce chemicals that are toxic to nematodes. The incorporation of large amounts of organic matter (i.e., municipal leaves, composts) may help reduce population levels. The decomposition products of some plants kill nematodes, such as butyric acid from ryegrass and timothy and isothiocyanates from rapeseed and other plants in the genus *Brassica*. The maximum benefit of these ‘natural nematicides’ is obtained when plant material is incorporated into the soil as green manure (8). Tarping areas where green manure is incorporated is likely to enhance efficacy.

### **Biological Controls:**

Biological control of nematodes is an active area of research, but at this time there are no commercially available products that are consistently effective (1).

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