

# **New England Tomato Pest Management Strategic Plan**

Compiled for the PRONewEngland Pest Management Network  
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# I. Introduction

## Tomato Production in New England

New England has less than 1% of the total acreage for the U.S. fresh market tomatoes, but is home to 8% of the total farms producing tomatoes in the U.S. In New England, tomatoes are produced by diversified fresh market vegetable producers. For field and greenhouse production combined, most (87%) of growers sold tomatoes as fresh market pre-picked retail, 45% sold fresh market wholesale, 5% sold for processing, and 7% for other markets. The estimated production by market destination for field grown (with greenhouse production in parentheses) in 2002 was: Fresh pre-picked retail, 47% (70%), Fresh wholesale, 43% (29%), Processing, 3% (<1%), and other sales, 7% (<1%). The average producer had 1.4 acres of field tomatoes and 5,400 square feet of greenhouse tomatoes.

Approximately 53% of New England farmers surveyed produce only field grown tomatoes; 10% grow only greenhouse tomatoes; and 37% of farmers surveyed produce both field and greenhouse tomatoes.

### **Field Grown, Cultural Information**

The tomato is a warm-season crop that grows best on well-drained soils high in organic matter. For earliest production, growers use transplants. Many growers use black polyethylene mulch because it conserves water, permits use of less nitrogen fertilizers (because leaching is reduced), and facilitates weed control. Greatest yields are achieved by irrigating with a complete nutrient solution supplemented with trace elements at weekly intervals. Tomatoes should be pruned 4-5 times. Pruning to one or two stems is common, with 2 stems yielding more fruit but requiring more time to prune. Tomatoes are generally topped after the fifth cluster.

Determinate tomatoes ("bush tomatoes") grown on the ground require no pruning. Seventy percent of the growers surveyed used staking, with the remainder using trellising, basket weave, cages, or no supports. Tomato plants are staked and tied 3-4 times each season. Tomatoes grown using the trellis system supported by twine are tied to a number 9 or 11 wire 5-6 feet above the ground. The trellis system is very time consuming as plants need to be trained ("twisted") around the string frequently and care must be taken to avoid breaking the stem.

Some growers are using a stake and weave system. Wooden stakes 4-5 feet long are driven into the ground and weather resistant twine is wrapped around the stakes and repeated on the opposite row. There are many variations of this method, which is also called the basket weave.

Spacing will vary according to cultivar and type of culture used. The growers surveyed use 4-6 square feet per plant.

Liming is done as directed by soil test results to maintain soil pH at 6.5-6.8. Many of the growers surveyed use composted manure as a nutrient. Drip irrigation is used on 75% of acres and overhead on approximately 25%. Only 8% of growers use tissue analysis for determining fertilizer needs and that group does so once a year.

### **Greenhouse, Cultural Information**

Greenhouse tomatoes are grown in glass-covered or plastic-covered houses. Most operations grow plants in either ground beds or in bags or pots of soil-free media. Greenhouse tomato varieties are indeterminate, and plants are pruned and tied to trellis systems. Multiple harvests are by hand, and harvesting typically lasts from April through the fall.

### **Worker Activities**

Worker activities that may occur during the growing season include production of transplants, laying black plastic, setting up trickle irrigation, staking, hand weeding, pruning, thinning, mowing, irrigation, scouting, pesticide application, and harvesting.

### **General Pesticide Information**

In the survey results, some growers reported at least one type of spray but did not provide a value for other types of sprays. We registered a zero for their other types of sprays. The average sprays per year with these assumptions were 5.8 for diseases, 2.8 for insects, 0.8 for weeds, and 0.4 for mites.

Most growers use IPM practices, such as insect trapping, degree-day accumulation data, and field sampling. Most of the sampling is informal rather than on scheduled intervals and several reported using the UMASS TomCast program for pest information. Of the growers surveyed, most classify their farm practices as conventional 38%, but an increasing number consider their practices as IPM (32%) or organic (23%).

Roughly 40% of the growers reported using no pesticides and are considered organic. Generally, where no pesticides were used, yields were reduced. Growers use the *New England Vegetable Management Guide*, off-season educational meetings, newsletters, other growers, and twilight meetings as the most important sources of pest management information.

## The Pest Management Strategic Plan Process and Benefits

A group of vegetable growers, researchers, and industry stakeholders from throughout New England met for two days in November 2003 at the Grappone Conference Center in Concord, New Hampshire to develop a pest management strategic plan (PMSP) for tomato production in New England. Working with the 2002 New England Tomato Crop Profile as a foundation, the group's task was to assess currently available pesticides and pest management recommendations and to identify research, regulatory, and education priorities to enhance pest management for tomato production in New England.

### PMSP Meeting participants

John Ayers	Facilitator	University of Pennsylvania
Margaret Siligato	Coordinator	University of Rhode Island
Natalia Clifton	Coordinator	University of Massachusetts
Amanda Duphily	Extension	University of Massachusetts
Richard Bonanno	Extension	University of Massachusetts
George Hamilton	Extension	University of New Jersey
Dave Wallace	Extension	University of Rhode Island
Ann Hazelrigg	Extension	University of Vermont
Mark Hutton	Extension	University of Maine
Ruth Hazzard	Extension	University of Massachusetts
Edith Lurvey	IR-4	Cornell University
Richard Cole	Distributor	Helena Chemical Co
Frank Whittemore	Producer	Brookdale Farm - New Hampshire
Keith Marshall	Producer	Wilson Farm – New Hampshire
Mario Marini	Producer	Marini Farm - Massachusetts
Tom Baggott	Producer	Baggott Farms – Connecticut
Bill Jordan	Producer	Jordan Farm- Maine
Hank Bissell	Producer	Lewis Creek Farm - Vermont

This document provides context to help EPA and state agency regulatory staff consider the needs of New England tomato growers in regulatory decisions and to outline a development path for pest management researchers and educators. This information can also be useful as stakeholder input and justification in proposals pursuing funds to address pest management needs. Current pest management programs will be made more effective through implementation of actions proposed in this plan.

## **II. Summary of Research, Regulatory, and Education Priorities**

### **Research Priorities**

- Seed treatment for disease control.
- Possibility of using Platinum as a soil drench and efficacy trials.
- Traps for stink bugs.
- Stink bugs, because populations are on the rise.
- New chemicals and efficacy trials.
- Efficacy of Admire-Provado for control of flea beetles.
- Spinosad efficacy against flea beetles.
- Deer repellents.
- Disease-tolerant tomato varieties for organic growers.
- Bacterial canker (new pest problem that has no viable controls).
- Efficacy of Oxidate® for diseases and integration with cultural practices.
- Effect of decomposing rye on weeds.
- Sencor replacement if product is not re-registered.

### **Regulatory Priorities**

- Actiguard needs registration in New England for speck disease.
- Bravo re-registration.
- Early use of mancozeb/maneb days-to-harvest issues.
- Retaining the use of Thiodan for insect control.
- Financial assistance for electric and deer fencing.

### **Education Priorities**

- ID manual for insect and disease pests.
- Education about the timing of pesticide treatments for greatest efficacy, insect pest emergence, and treatment timing based on growing degree days.
- List of resistant varieties for blossom end rot and other diseases.
- Training on the proper use of new chemicals.
- Education on the use of Roundup appears to be overused.
- Dependence on Sencor.
- Whitefly and aphid management needs to be explained.
- Lepidoptera ID manual is needed.
- Rodent control systems for fields.

### III. Strategic Issues for Key Pests

Efficacy abbreviations: E=excellent; G=good; F=fair; P=poor

#### Key Insects and Mite pests

##### 1. Colorado Potato Beetle Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Bacillus thuringiensis tenebrionis (BT)	F	Effective against first and second instar larvae	Applications must coincide with first egg hatch  Several applications are needed.	Biological Insecticide  <b>Caution</b> signal word
endosulfan (Thionex)	F	Manages over 60 listed insects on vegetables, fruits and ornamentals	Central nervous system stimulant, may cause convulsions if inhaled, swallowed or contact with skin.  Restricted use	<b>Danger</b> signal word
imidacloprid (Admire)	E	Effective against vegetable and cotton pests	Highly toxic to bees	Flowable insecticide  Transplant drench  <b>Caution</b> signal word
lambda-cyhalothrin (Warrior)	G	May be used to control a wide variety of crop pests	Restricted use	<b>Warning</b> signal word
permethrin (Ambush)	F	Can be used on a wide range of crops	Restricted use	<b>Warning</b> signal word
spinosad (SpinTor)	E	Suppression of many foliage feeding insects	Toxic to bees exposed to treatment 3 hours after application	Used by organic growers

#### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Hand Picking	Non chemical	Time consuming	Important
Trap Crops (Eggplant)	Beetles attracted to, and feed on eggplant	Additional expense	Effective in control
Raised Beds with plastic	Improved drainage, no soil compaction, increased yields	Require more watering	Important
Scouting	Able to target treatment to problem areas.	Time consuming	Important

Research Needs: Seed treatment options need to be explored. Explore possible use of Platinum (thiamethoxam) insecticide as a soil drench.  
Regulatory Needs: None Identified.  
Education Needs: None Identified



## 2. Tomato Hornworm Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Bacillus thuringiensis kurstaki (BT)	E	Effective against Lepidoptera larvae	Expense	Biological Insecticide  <b>Caution</b> signal word
Endosulfan (Thionex)	E	Manages over 60 listed insects on vegetables, fruits and ornamentals	Central nervous system stimulant, may cause convulsions if inhaled, swallowed or contact with skin.  Restricted use	Insect Spray  <b>Danger</b> signal word
Esfenvalerate (Asana)	?	Many be used on a large variety of crops	Restricted Use	Insecticide <b>Warning</b> signal word
Lambda-cyhalothrin (Warrior)	E	May be used to control a wide variety of crop pests	Restricted use	Insecticide <b>Warning</b> signal word
Methomyl (Lannate)	E	Can be used on a wide range of crops	Not for use in home plantings Restricted use	Insecticide <b>Danger</b> signal word

## Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Parasitic Wasps	Decreased use of pesticides, safe	Expense	Important in Hoop houses
Scouting	Inexpensive	Time consuming	Important
Handpicking	Inexpensive	Time consuming	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Identification of Lepidoptera species appears to be a priority.

### 3. Two Spotted Spider Mite Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Abamectin (Agri-Mek)	E	Compatible with many other pesticides	Expensive  Thorough coverage essential  Restricted Use	Miticide/ Insecticide  <b>Warning</b> signal word
Ultra fine oil	E	Safe	Temperature sensitive	Zero reentry interval

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Predatory mites	Decreased use of pesticides, safe	Timing, expense	In greenhouses
Scouting	Inexpensive	Time consuming	Important especially on black plastic

Research Needs: None Identified  
 Regulatory Needs: None Identified  
 Education Needs: None Identified

### 4. Aphid Currently Registered Pesticides

Pesticide	Effi- cac y	Pros	Cons	Comments
Abamectin (Agri-Mek)	E	Compatible with many other pesticides	Expensive  Thorough coverage essential  Restricted Use	Miticide/ Insecticide  <b>Warning</b> signal word
Ultra fine oil	E	Safe	Temperature sensitive	Zero reentry interval

## Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Predators: ladybird beetle, aphid midge	Effective, safe	Timing, expense	In greenhouses
Reflective Mulch	Decreases incidence of virus diseases and insects	Initial expense, maintenance	Excellent
Conservation Enhancement	Decreased use of pesticides	Time consuming	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: More information on aphid management was the highest educational priority for all pests.

## 5. Stink Bug Currently Registered Pesticides

Pesticide	Efficacy	Pros	Cons	Comments
Bacillus thuringiensis kurstaki (BT)	E	Effective against Lepidoptera larvae	Expense	Biological Insecticide  <b>Caution</b> signal word
Carbaryl (Sevin)	G	Compatible with large range of pesticides  Effective on many crops	Highly toxic to bees	Carbamate Insecticide  <b>Caution</b> signal word
Lambda- cyhalothrin (Warrior)	E	May be used to control a wide variety of crop pests	Restricted use	Insecticide  <b>Warning</b> signal word

## Cultural and Biological Alternatives – None reported

Research Needs: Traps for stinkbugs need to be developed.

Regulatory Needs: None Identified

Education Needs: Identification of stink bugs, IPM prevention, lifecycle and cultural controls for stink bug are needed.

## 6. Cutworms

### Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Carbaryl (Sevin)	F	Compatible with large range of pesticides  Effective on many crops	Highly toxic to bees	Carbamate Insecticide  <b>Caution</b> signal word
Endosulfan (Thionex)	E	Manages over 60 listed insects on vegetables, fruits and ornamentals	Central nervous system stimulant, may cause convulsions if inhaled, swallowed or contact with skin.  Restricted use	Insect Spray  <b>Danger</b> signal word
lambda-cyhalothrin (Warrior)	E	May be used to control a wide variety of crop pests	Restricted use	Insecticide  <b>Warning</b> signal word

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Scouting	Allows for targeted treatment areas.	Time consuming	Important
Sanitation	Inexpensive, decrease incidence of virus diseases and insects	Time consuming	Important
Weed Management	Decreased incidence of insects, increased resources available for crop	Can be expensive depending on approach	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Lepidoptera identification is needed.

## 7. Flea Beetles

### Currently Registered Pesticides

Pesticide	Effi-cacy	Pros	Cons	Comments
carbaryl (Sevin)	E	Compatible with large range of pesticides  Effective on many crops	Highly toxic to bees	Carbaryl Insecticide  <b>Caution</b> signal word
endosulfan (Thionex)	E	Manages over 60 listed insects on vegetables, fruits and ornamentals	Central nervous system stimulant, may cause convulsions if inhaled, swallowed or contact with skin.  Restricted use	Insect Spray  <b>Danger</b> signal word
imidacloprid (Admire)	G	Effective against vegetable and cotton pests	Highly toxic to bees	Flowable Insecticide  Transplant drench  <b>Caution</b> signal word
lambda-cyhalothrin (Warrior)	G	May be used to control a wide variety of crop pests	Restricted use	Insecticide  <b>Warning</b> signal word

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Scouting	Able to target treatments to time needed.	Time consuming	Important
Exclusion using floating row cover	Effective	Must rotate crops for it to be effective Expensive	

Research Needs: There were questions on the efficacy of Admire-Provado for control of flea beetles. Spinosad research is needed for efficacy with flea beetles.

Regulatory Needs: None Identified

Education Needs: None Identified

## 8. Whiteflies

### Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Endosulfan (Thionex)	G	Manages over 60 listed insects on vegetables, fruits and ornamentals	Central nervous system stimulant, may cause convulsions if inhaled, swallowed or contact with skin.  Restricted use	Insect Spray  <b>Danger</b> signal word
Esfenvalerate (Asana)	G	May be used on a large variety of crops	Restricted Use	Insecticide <b>Warning</b> signal word
Imidacloprid (Admire)	E	Effective against vegetable and cotton pests	Highly toxic to bees	Flowable Insecticide Transplant drench <b>Caution</b> signal word
lambda-cyhalothrin (Warrior)	?	May be used to control a wide variety of crop pests	Restricted use	Insecticide  <b>Warning</b> signal word
methomyl (Lannate)	E	Can be used on a wide range of crops	Restricted use Not for use in home plantings	Insecticide <b>Danger</b> signal word
pymetrozine (Fulfill)	?	Low toxicity	Thorough coverage is essential for optimal control, long PHI	Insecticide 14 PHI <b>Caution</b> signal word

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Scouting	Inexpensive	Time consuming	Important
Sanitation	Decrease incidence of insects and disease, inexpensive	Time consuming	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Identification of best management practices for whitefly control.

## Key Diseases

Efficacy abbreviations: E=excellent; G=good; F=fair; P=poor

### 1. Early Blight: Currently Registered Pesticides

Pesticide	Efficacy	Pros	Cons	Comments
azoxystrobin (Quadris)	G/E	Available for use on a large number of vegetable crops	Harmful if absorbed through skin	Flowable Fungicide <b>Caution</b> signal word
chlorothalonil, (Bravo Ultrex 82 WDG)	G/E	Available for use a large number of crops	Not for use in greenhouses	Broad spectrum Fungicide <b>Danger</b> signal word
maneb (Pentathlon)	G/E	Can be used on a large number of ornamental crops and turf grass diseases		Flowable with Zinc <b>Caution</b> signal word
mefenoxam plus chlorothalonil, (Ridomil/Bravo)	G	Available for use on a large number of vegetable crops		<b>Danger</b> signal word
mancozeb (Dithane, Fore)	G/E	Use for outdoor or greenhouse crops  Compatible with most commonly used fungicides, insecticides, and growth regulators	Multiple applications	Specialty Fungicide <b>Caution</b> signal word
copper sulfate (Basicop 53%)	F/G	Available for use a large number of crops		Fungicide/Bactericide Warning signal word
cupric hydroxide (Kocide 4.5 LF)	F/G	May be used in greenhouses or shadehouses	Should not be applied in a spray solution having a pH of less than 6.5 to avoid phytotoxicity	Fungicide/Bactericide  Caution signal word
pyraclostrobin (Cabrio)	G			New Chemistry

trifloxystrobin (Flint)	G			New Chemistry
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## Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Crop Rotation	Reduce disease incidence by 12% Pesticide cost reduced, improved yields	Additional planning and management	Important
Insect Management	Increase yields	Can be expensive depending on approach	Important
Weed Management	Decreased incidence of insects, increased resources available for crop	Can be expensive depending on approach	Important
Tolerant varieties / Variety Selection	Reduce disease incidence by 2% Plant is not seriously affected by pest	Expense	Important
Staking System	Reduce disease incidence by 2% Keep plants and fruit off ground, easier to spray or dust	Time consuming	Important
Mulch/Plastic	Reduce disease incidence by 11% Increased soil temp, increased growth, less fertilizer leaching	Higher initial cost, increased management, costly to remove.	Important
Raised Beds	Improved drainage, no soil compaction, increased yields	Require more watering	Important
Multiple Plantings	Increased diversity	Expense	Important
Hay Mulch btw Plastic	Decreased runoff and erosion	Time consuming, expense	Important



Wider Spacing	Spot spraying easier, weeds/disease easier to ID	Fertilizer placement more difficult	Important
Drip Irrigation	Reduce disease incidence by 10% Efficient use of water, decreased onset of disease	Expense, increased management and upkeep	Important
Sanitation	Reduce disease incidence by 4% Inexpensive	Time consuming	Important
Air Circulation	Reduce disease incidence by 4%	Increased planning	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 2. Late Blight Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
azoxystrobin (Quadris)	G	Available for use on a large number of vegetable crops	Harmful if absorbed through skin	Flowable Fungicide <b>Caution</b> signal word
chlorothalonil, (Bravo Ultrex 82 WDG)	G	Available for use a large number of crops	Not for use in greenhouses	Broad spectrum Fungicide <b>Danger</b> signal word
mefenoxam plus manzate, (Ridomil Gold MZ)	G	For use on selected crops to control diseases caused by members of the Phycomycete family of fungi  Cost effective		Fungicide  <b>Caution</b> signal word
pyraclostrobin (Cabrio)	F			New Chemistry

trifloxystrobin (Flint)	F			New Chemistry
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### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Crop Rotation	Reduce disease incidence by 12% Pesticide cost reduced, improved yields	Additional planning and management	Important
Well drained soils	Decreased incidence of disease	Increased management	Important
Wider Spacing	Spot spraying easier, weeds/disease easier to ID	Fertilizer placement more difficult	Important
Staking system	Reduce disease incidence by 2% Keeps plants/fruits off ground, easier to spray/dust	Time consuming	Important
Drip Irrigation	Reduce disease incidence by 10% Efficient use of water, decreased onset of disease	Expense, increased management and upkeep	Important
Scouting	Inexpensive	Time consuming	Important
Sanitation	Reduce disease incidence by 4% Inexpensive	Time consuming	Important
Clean Transplants	Decreased incidence of disease/virus	Inspection, time consuming	Important
Air Circulation	Reduce disease incidence by 4% Inexpensive	Increased planning	Important

Variety Selection	Reduce disease incidence by 2%	Expense	Important
Moisture Control	Reduce disease incidence by 8%	Increased management	Important
Plastic Mulching	Reduce disease incidence by 11% Increased soil temp and growth, decreased fertilizer leaching	Increased initial cost, increased management, costly to remove	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

### 3. Anthracnose

#### Currently Registered Pesticides

Pesticide	Effi-cacy	Pros	Cons	Comments
azoxystrobin (Quadris)	G/E	Available for use on a large number of vegetable crops	Harmful if absorbed through skin	Flowable Fungicide <b>Caution</b> signal word
chlorothalonil, (Bravo Ultrex 82 WDG)	G/E	Available for use a large number of crops	Not for use in greenhouses	Broad spectrum Fungicide <b>Danger</b> signal word
cupric hydroxide (Kocide 4.5 LF)	F	May be used in greenhouses or shadehouses	Should not be applied in a spray solution having a pH of less than 6.5 to avoid phytotoxicity	Fungicide/Bactericide <b>Caution</b> signal word
mancozeb (Dithane, Fore)	F	Use for outdoor or greenhouse crops Compatible with most commonly	Multiple applications	Specialty Fungicide <b>Caution</b> signal word

		used fungicides, insecticides, and growth regulators		
maneb (Pentathlon)	F	Can be used on a large number of ornamental crops and turf grass diseases		Flowable with Zinc <b>Caution</b> signal word
pyraclostrobin (Cabrio)	G/E			New Chemistry
trifloxystrobin (Flint)	G/E			New Chemistry
copper sulfate (Basicop 53%)	F	Available for use a large number of crops		Fungicide/Bactericide <b>Warning</b> signal word

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Crop rotation	Reduce disease incidence by 12%. Pesticide cost reduced, higher yields	Additional planning and management	Important
Tolerant varieties / variety selection	Reduce disease incidence by 2%. Plant not seriously affected by pest	Expense	Important
Weed Management	Decreased incidence of insects, increased resources available for crop	Can be expensive depending on approach	Important
Drip irrigation	Reduce disease incidence by 10%. Efficient use of water, decrease incidence of disease	Expense, maintenance	Important
Wider spacing	Spot spraying easier, weeds/disease easier to ID	Fertilizer placement more difficult	Important
Staking systems	Reduce disease incidence by 2%. Keeps plants and fruits	Time consuming	Important

	off ground, easier to spray or dust		
Sanitation	Reduce disease incidence by 4%. Inexpensive	Time consuming	Important
Ventilation	Reduce disease incidence by 4%. Inexpensive	Increased planning	Important
Moisture Control	Reduce disease incidence by 8%.	Increased management	Important
Plastic mulching	Reduce disease incidence by 11%. Increased soil temp and growth, decreased fertilizer leaching	Increase initial cost, increased maintenance, costly to remove	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

#### 4. Septoria Leafspot Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
azoxystrobin (Quadris)	G/E	Available for use on a large number of vegetable crops	Harmful if absorbed through skin	Flowable Fungicide <b>Caution</b> signal word
chlorothalonil, (Bravo Ultrex 82 WDG)	G/E	Available for use a large number of crops	Not for use in greenhouses	Broad spectrum Fungicide <b>Danger</b> signal word
copper sulfate (Basicop 53%)	F	Available for use a large number of crops		Fungicide/Bactericide <b>Warning</b> signal word
cupric hydroxide (Kocide 4.5 LF)	F	May be used in greenhouses or shadehouses	Should not be applied in a spray solution having a pH of less than 6.5 to avoid phytotoxicity	Fungicide/Bactericide <b>Caution</b> signal word
maneb (Pentathlon)	P	Can be used on a large number of ornamental crops and turf grass diseases		Flowable with Zinc <b>Caution</b> signal word
mefenoxam plus chlorothalonil, (Ridomil/Bravo)	G	Available for use on a large number of vegetable crops		Fungicide <b>Danger</b> signal word
pyraclostrobin (Cabrio)	G/E			New Chemistry
trifloxystrobin (Flint)	G/E			New Chemistry

## Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Crop rotation	Pesticide cost reduced, improved yields	Additional planning and management	Important
Insect management	Lower incidence of disease, increased yield	May be expensive depending on approach	Important
Tolerant varieties	Plant not seriously affected by insect/disease	Expense	Important
Drip irrigation	Efficient use of water, decrease onset of disease	Expense, maintenance	Important
Wider Spacing	Spot spraying easier, weeds/disease easier to ID	Fertilizer placement more difficult	Important
Mulch/plastic	Increased soil temp and growth, decreased fertilizer leaching	Increased initial cost, increased management, costly to remove	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 5. Powdery Mildew Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Azoxystrobin (Quadris)	E	Available for use on a large number of vegetable crops	Harmful if absorbed through skin	Flowable Fungicide <b>Caution</b> signal word
Chlorothalonil, (Bravo Ultrex 82 WDG)	F	Available for use a large number of crops	Not for use in greenhouses	Broad spectrum Fungicide <b>Danger</b> signal word
Mefenoxam plus chlorothalonil, (Ridomil/Bravo)	F	Available for use on a large number of vegetable crops		Fungicide <b>Danger</b> signal word
Pyraclostrobin (Cabrio)	E			New Chemistry
Trifloxystrobin (Flint)	E			New Chemistry

## Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Wider Spacing	Spot spraying easier, weeds/disease easier to ID	Fertilizer placement more difficult	Important
Staking system	Keeps plants and fruits off ground, easier to spray or dust	Time consuming	Important
Crop rotation	Reduce disease incidence by 12% Pesticide cost reduced, improved yields	Additional planning and management	Important
Plastic mulching	Reduce disease incidence by 11% Increased soil temp and yields, decreased fertilizer leaching	Higher initial cost, increased management, costly to remove	Important
Drip irrigation	Reduce disease incidence by 10% Efficient use of water, decreased onset of disease	Expense, maintenance	Important



Keeping dry	Reduce disease incidence by 8%	Increased management	Important
Sanitation	Reduce disease incidence by 4% Inexpensive	Time consuming	Important
Variety selection	Reduce disease incidence by 2% Plant not seriously affected by pest/disease	Expense	Important
Ventilation	Reduce disease incidence by 4% Inexpensive	Increased planning	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 6. Damping Off / Seed Decay Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Water Management	Efficient use of water, decreased onset of disease	Increased management and planning	Important
Temperature Management	Decreased incidence	Increased management	Important
Seedling Growth Temperatures	Decreased incidence	Increased management	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 7. Wilt

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Resistant varieties	Plants not seriously affected by pest/disease	Expense	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 8. Blotchy Ripening

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Water, Fertility and Temperature Management	Increased yields, decreased incidence of disease	Time consuming, additional planning	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 9. Bacterial Speck Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Copper sulfate (Basicop 53%)	G	Available for use a large number of crops		Used in conjunction with maneb  Fungicide/Bacteri cide  <b>Warning</b> signal word
Cupric hydroxide (Kocide 4.5 LF)	G	May be used in greenhouses or shadehouses	Should not be applied in a spray solution having a pH of less than 6.5 to avoid phytotoxicity	Used in conjunction with maneb  Fungicide/Bacteri cide  <b>Caution</b> signal word
Maneb (Pentathlon)	G	Can be used on a large number of ornamental crops and turf grass diseases		Used in conjunction with copper sulfate or Kocide  Flowable with Zinc  <b>Caution</b> signal word

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 10. Bacterial Canker

### Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Copper sulfate (Basicop 53%)	E	Available for use a large number of crops		Fungicide/Bacteri- cide  <b>Warning</b> signal word
Streptomycin, (Agri-Mycin 17, Agri-Step)	E		Greenhouse grown tomatoes only	Agricultural Streptomycin  <b>Caution</b> signal word

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Sterilize pots and stakes	Inexpensive, decreased incidence of disease/virus	Time consuming	Important
Three-year crop rotation	Pesticide cost reduced, improved yields, adds diversity	Additional planning and management	May reduce incidence
Treated seed, hot water treatment of seed	Decreased incidence	Time consuming	May reduce incidence

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 11. Viruses (Tomato Spotted Wilt Virus, Tobacco Mosaic Virus, Cucumber Mosaic Virus)

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Weed Management	Decreased incidence of disease/virus Increased resources for plants	Virus can spread by contact with contaminated hands and tools	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 12. Sclerotinia Blight

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Weed Management	Decreased incidence of insects, increased resources available for crop	Can be expensive depending on approach	Important
Scouting	Inexpensive	Time consuming	Important
Rouging of infected plants before sclerotia are formed	Decreased incidence	Time consuming	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 13. Grey Mold

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Ventilation in greenhouse grown tomatoes	Inexpensive	Increased planning and management	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## 14. Leaf Mold

### Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
chlorothalonil, (Bravo Ultrex 82 WDG)	G	Available for use a large number of crops	Not for use in greenhouses	Broad spectrum Fungicide  <b>Danger</b> signal word
maneb (Pentathlon)	G	Can be used on a large number of ornamental crops and turf grass diseases		Flowable with Zinc  <b>Caution</b> signal word

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Water Management	Efficient use of water, decreased incidence of disease	Additional planning and management	Important
Variety Selection	Plants not seriously affected by pest/disease	Expense	Important

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Disease identification guides, diagnostic services definitely needed.

## Weed Management

Efficacy abbreviations: E=excellent; G=good; F=fair; P=poor

### 1. Stale Seed Bed Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
glyphosate (Roundup)		Broad spectrum control of annual and perennial weeds, woody brush, and trees	Not registered for multiple uses	Postemergence systemic herbicide
paraquat (Gramoxone Max 3S)		Can be used on a wide variety of crops. Less expensive than glyphosate.	Not effective against perennial weeds. High mammalian toxicity. Restricted use	Herbicide <b>Danger</b> signal word
pelargonic acid (Scythe 4.3)		Control or burndown of a broad spectrum of weeds on contact  Visible effects within hours. Was previously on OMRI list allowing use by organic growers.	Not effective against perennial weeds. No residual weed control. Very expensive. No longer on OMRI list? Smells terrible.	Foliar Applied Herbicide <b>Warning</b> signal word

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Flaming with propane	Fast activity	Safety issues using large gas tanks Expensive	

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: Overuse of Roundup is a key concern, education on labeled usage rates and frequency need to be covered.

## 2. Soil Applied - Transplants Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
metribuzin (Sencor 75 DF)	E	Available for use on a wide variety of crops. Controls established weeds.	Can leach and contaminate ground water	Dry Flowable Pre and post activity <b>Caution</b> signal word
napropamide (Devrinol 50 DF)	G	Controls many annual grasses and broadleaf weeds as they germinate.	Does not control established weeds. Needs irrigation to work.	<b>Caution</b> signal word
trifluralin (Treflan)	G	Controls many annual grasses and broadleaf weeds as they germinate	Does not control established weeds. Must be incorporated.	Preemergence Granular Herbicide <b>Caution</b> signal word

Research Needs: None Identified

Regulatory Needs: Sencor works well, there is concern that its registration may be lost for use on tomatoes.

Education Needs: None Identified

## 3. Postemergence - Transplants Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
paraquat (Gramoxone Max 3S)	G	Can be used on a wide variety of crops	Restricted use	<b>Danger</b> signal word
clethodim (Select 2EC)	G	Controls annual and perennial grasses  Available for use on a wide variety of crops	Not recommended for use on vegetable crops being grown for seed production No residual control Does not control sedges or broadleaf weeds	Selective Postemergence Herbicide  <b>Warning</b> signal word
sethoxydim (Poast 1.53EC)	G	Essentially all grass crops, such as corn, sorghum, small	Does not control sedges or broadleaf weeds. Weak on cool	<b>Warning</b> signal word



		grains and rice are susceptible	season and perennial grasses. No residual control.	
halosulfuron (Sanda)	G	Controls many broadleaf weeds both pre and post emergence.	Does not control common lambsquarters postemergence. Can cause crop injury.	Dry Flowable <b>Caution</b> signal word
metribuzin (Sencor 75 DF)	E	Available for use on a wide variety of crops	Can leach and contaminate ground water	Dry Flowable <b>Caution</b> signal word
Pelargonic acid	G	Reduced risk pesticide	Does not control grasses or large broadleaf weeds.	Safe to use.

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Hand weeding	Effective	Time consuming and expensive	Labor issues
Cultivation	Effective when weeds are small	Time consuming, expense. Not effective during wet seasons.	Need good operator on tractor
Black Plastic	Increased soil temp and growth	Expense, increased management	Still need control between the rows.
Hay between rows	Effective at controlling weeds and retaining soil moisture	Cooler soil temperature which may delay plant maturity.	Supply and expense issues.
Plant competition after initial cultivation	Can be effective , expensive	Potential for increased diseases	Most underutilized weed management tool.

Research Needs: None Identified

Regulatory Needs: Sencor works well, there is concern that its registration may be lost for use on tomatoes.

Education Needs: Overuse of Roundup is another concern here.

## Key Vertebrates and Other Pests

Efficacy abbreviations: E=excellent; G=good; F=fair; P=poor

### 1. Birds

#### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Scare eye balloons	Decreased bird activity	Expense	Used by 45% of growers surveyed
Noise cannons	Decreased bird activity	Noise	Used by 20% of growers surveyed
Poison Baits	Decreased bird activity	Expense	Used by 20% of growers surveyed
Netting	Decreased bird activity	Time consuming	Used by 10% of growers surveyed
Row covers	Decreased bird activity	Time consuming	Used by 10% of growers surveyed

Research Needs: None Identified

Regulatory Needs: None Identified

Education Needs: None Identified

### 2. Deer Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Fencing	Decreased deer activity	Time consuming, expense	Used by 60% of farmers surveyed
Electric Fencing	Effective	Expensive	
Predator Urine	Decreased deer activity	Expense	
Hunting / Shooting	Inexpensive	Time consuming	
Hair and Soap	Decreased deer activity	Expense	

Research Needs: New, effective, affordable deer repellents are needed.

Regulatory Needs: Growers are looking for government resources to subsidize cost of fencing.

Education Needs: None Identified

### 3. Mice/Voles Currently Registered Pesticides

Pesticide	Effi- cacy	Pros	Cons	Comments
Poison Baits		Decreased rodent activity	Expense	

### Cultural and Biological Alternatives

Method	Pros	Cons	Comments
Snap Traps	Decreased rodent activity, Inexpensive	Time consuming	
PVC piping for baiting	Decreased rodent activity, Inexpensive		Innovative design to bait for rodents in hoop houses.

Research Needs: None Identified  
 Regulatory Needs: None Identified  
 Education Needs: None Identified

## IV. Appendices

### Pesticide Efficacy for Insect and Mite Pests

Active ingredient	Brand name(s)	Col. Pot. beetle	Tom. Horn-worm	Two Spotted Spider mite	Aphids	Stink bugs	Cut worms	Flea beetles	White flies
azinphosmethyl	Guthion								
abamectin	Agri-Mek 0.15 EC			E					
azadirachtin	Neemix 4.5	P							F/GH
Bacillus thuringiensis kurstaki	Foray		E						
Bacillus thuringiensis tenebrionis	Novodor	F							
Bacillus thuringiensis israelensis	Gnatrol								
Beauveria bassiana	Botanigard 22WP								
carbaryl	Sevin XLR PLUS					G	E	E	
cyfluthrin	Baythroid 2								
cryolite	Kryocide								
diazinon	Diazinon 50W								
dicofol	Kelthane MF								
dimethoate	Dimethoate 4EC								
endosulfan	Thiodan 50 WP	F	E		E		E	E	G
esfenvalerate	Asana XL		G						G
imidacloprid	Admire 2F	E			E			G	G
indoxacarb	Avaunt								
insecticidal soap	M-Pede								
kaolin	Surround WP								
lambda-cyhalothrin	Warrior T	G	E			E	E	G	?
methomyl	Lannate LV		E		E				E
permethrin	Ambush	F							
pymetrozine	Fulfill								?
pyrethrum	Pyrenone Crop Spray	F							
spinosad	SpinTor 2 SC	E							
tebufenozide	Confirm 2F								

Efficacy abbreviations: E=excellent; G=good; F=fair; P=poor

## Pesticide Efficacy for Diseases

Active ingredient	Brand name(s)	Early blight	Late blight	Anthrax-nose	Septoria leaf-spot	Powdery mildew	Leaf Mold	Bacterial Speck	Bacterial Canker
azoxystrobin	Quadris	G/E	G/E	G/E	G/E	G/E			
chlorothalonil,	Bravo Ultrex 82 WDG	G/E	G	G/E	G/E	F	G		
copper sulfate	Basicop 53%	F		F	F			G	G
cupric hydroxide	Kocide 4.5 LF	F		F	F			G	
mancozeb	Dithane, Fore	G/E		F	P				
maneb	Pentathlon	G/E		F	P		F	G	
mefenoxam plus chlorothalonil,	Ridomil/Bravo	G/E		G	G	F			
mefenoxam plus manzate,	Ridomil Gold MZ		G						
mefenoxam,	Ridomil Gold EC								
pyraclostrobin	Cabrio		F	G/E	G/E	E			
streptomycin	Agri-Mycin 17, Agri-Step								G
trifloxystrobin	Flint		F	G/E	G/E	E			

Efficacy abbreviations: E=excellent; G=good; F=fair; P=poor

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