2008 New England Pepper Pest Management Strategic Plan

Compiled for the PRONewEngland Pest Management Network
by Ann Hazelrigg and Sarah L. Kingsley-Richards
University of Vermont
105 Carrigan Drive, Burlington, VT 05405
Telephone: (802) 656-0493
Email: ann.hazelrigg@uvm.edu

Completed: February 16, 2009

Table of Contents

Key Pest Name Abbreviations

Insects

ECB = European Corn Borer
Aph = Aphids
PM = Pepper Maggot

Diseases

BLS = Bacterial Leaf Spot
Phyt = *Phytophthora*

Weeds

PP = Pre-plant
Pre = Pre-emergent
Post = Post-emergent

Executive Summary

The list of key pests for pepper in New England consists of three insects, two diseases, and the weeds and vertebrates common to agricultural settings. These key pests are persistent problems that need to be managed every year when and where they occur.

Pepper growers in New England are aware of the need to protect food sources and provide for food security in the region today. Overlying specific pest management needs are concerns about climate change and its impacts on pest behavior and expanding geographical range of pests. In addition, increasing vertebrate wildlife management issues are a growing concern.

The distribution and numbers of farms in New England, in combination with a limited number of available extension agents and private consultants, make it difficult for growers to receive on-site pest management support. This is especially true among smaller and diversified farms that grow peppers and other vegetables. Research and extension being done at universities is helpful but more pest management research is needed and the information flow to growers can be expanded.

The following outlines the most critical research, regulatory, and educational issues as determined by a review group of pepper growers, researchers, and industry stakeholders during the Pest Management Strategic Plan process.

Research Needs

- Develop more *Phytophthora* resistant varieties.
- Explore the uses of grafting in achieving *Phytophthora* resistance.
- Explore methods of notifying and alerting growers of new information.
- Determine thresholds for nematode damage.

Regulatory Needs

- Loss of carbamate pesticides (carbaryl, methomyl, etc.) would impact management of many other crops found on a diversified farm.
- Direct funds towards development and continuation of models, forecasts, & newsletters that are useful to growers.
- Provide incentives to increase the research and extension that is beneficial to commercial growers.
- Create grant funding opportunities for newer researchers who may not yet have the background to as effectively compete for other funding.
- Encourage the infrastructure (fertilizers, suppliers, consultants) to support small farms.

Education Needs

- Provide information on pest lifecycles, pest movement and dispersal, and variations, such as race, that are critical to management.
- Promote awareness of critical periods when crop must be kept weed-free.
- Encourage proper identification of European Corn Borer and Pepper Maggot injury in comparison to diseases.
- Clarify the differences between systemic and topical material efficacy.
- Notify growers of models that are available for predicting and tracking pest activity.
- Spread awareness of pests that are likely to spread into and within New England due to climate change.
- Clarify chemical families of materials to avoid confusion when combining and to discourage development of resistance.

I. Introduction

Background of Pepper in New England

The six New England states combine to comprise a total of 1404 acres of peppers according to the 2002 Census of Agriculture. (NASS 2002) A recent survey (ProNewEngland 2006) indicated that the crop is split between 90% sweet and 9% hot peppers. Most (99%) of these peppers are grown for the fresh market with the remainder sent for processing. 64% of the fresh market peppers are sold to wholesale distributors and 35% for retail markets. While only contributing 0.0019% to the national production of peppers (NASS 2002), the pepper field is an integral part of the New England economy both in direct value and in its attraction and appeal as part of the New England landscape.

Peppers are susceptible to many pests including insects, diseases, weeds, and vertebrates. It is critical that these pests be effectively managed to maintain adequate yields of quality fruit that is acceptable to consumers. New England pepper growers have adopted innovative integrated pest management (IPM) and other cultural practices designed to manage these pests while reducing pesticide use, improving worker and food safety, and protecting environmental quality. While these methods do allow pesticides to be used more efficiently, they neither eliminate the need for pesticides nor reduce the critical importance of pesticides in pepper production. The loss of important pesticide tools due to pest resistance, regulatory, and consumer-driven pressures is a concern for the entire pepper industry.

How this plan was created

A review group of Pepper growers, researchers, and industry stakeholders throughout New England met for two days in March of 2008 to develop this Strategic Plan based on the 2008 New England Pepper Crop Profile. Key pests driving pesticide use were suggested by the 2006 New England Pepper Survey which was used to generate the Crop Profile. The survey was sent to 456 growers throughout New England and had a 52% return rate. The list of key pests was edited/approved by the review group.

The review group discussed the efficacy and practicality of current pesticides and pest management methods, identified acceptable alternative pest management methods, and listed the necessary research, regulatory and education needed to transition toward the use of these new methods. The pros and cons of each available option, along with opportunities for new technologies, were considered and contingency plans were discussed to prepare for possible future regulatory changes.

Benefits to the New England Pepper Industry

The New England Pepper Pest Management Strategic Plan will identify at-risk pesticides and propose future research, regulatory, and education priorities necessary to establish alternative pest management methods in the event of loss. These priorities will be used to inform EPA and state agency decisions and outline a development path for pest management researchers and educators. This information will be of great value in the pursuit of funding to address research and education needs identified through the Strategic Plan. The research and education necessary to establish effective alternative pest management methods requires this funding to account for the diversity of pests and the variety of habitats in pepper fields. The current pest management programs will be made more effective through implementation of actions proposed in this plan.

II. Summary

Key Pepper Pest Strategic Issues

Summaries adapted from the *2008 New England Pepper Crop Profile*.
http://PRONewEngland.org

Insects

European Corn Borer (*Ostrinia nubilalis* (Hubner))
This is an annual pest that attacks more than 200 host plants, including many common weeds and crops. It over-winters in New England and may have up to two generations in a season. Young larvae feed for a brief period on foliage then migrate to fruit where they feed on the flesh and seed head. Larval entry holes become the entry site for infection with the soft rot bacteria. A single larva may spread the soft rot disease to several fruit. Management with protective sprays targeted at larvae based on adult pheromone trap thresholds usually occurs in mid-late summer. Destruction of alternate hosts, especially corn stubble, is also common practice.

Aphids (Numerous species)
These are annual pests that have many generations per year. Aphids cause damage by sucking the sap from plants, making leaves appear stippled, chlorotic, distorted, and may reduce photosynthetic capacity. Additionally, aphids exude a clear sweet liquid on which a fungus called 'sooty mold' may grow. Peppers with sooty mold fungus are unmarketable. Aphids also spread viral diseases such as cucumber mosaic virus. Growers may preserve aphid parasites and predators by using selective insecticides against other pests, limiting applications to perimeter trap crops when possible, and by eliminating the use of broad-spectrum materials on resistant plants. Management with protective sprays based on monitoring thresholds may occur. Destruction of alternate hosts is also common practice.

Pepper Maggot (*Zonosemata electa* (Say))
This is an annual pest where established. Infestations can be complete or sporadic even within a single field. Adults emerge in July and eggs are deposited under the skin of the fruit. Often, the egg laying site heals over completely and is not noticeable. The maggots hatch a month later and migrate to the seed head to feed. Occasionally, maggots tunnel in the flesh, leaving an opaque scar which is visible from the exterior of the fruit. Larval exit wounds become the entry site for infection with the soft rot bacteria. Maggots in green peppers may be visually unappealing in fresh fruit or may contaminate processed products. Management with protective sprays targeted at adults based on baited trap thresholds usually occurs in mid-late summer. Perimeter trap cropping is also common practice.

Diseases

Bacterial Leaf Spot (*Xanthomonas campestris* pv. *Vesicatoria*)
This is the most common disease of peppers in New England. When introduced into a field it will spread under warm humid conditions aided by rain and wind. Leaf spots are water-soaked initially, then turn brown and become irregularly shaped. Affected leaves tend to crinkle, turn yellow and drop. Defoliation reduces plant productivity and fruit becomes vulnerable to sunscald. Fruit may also develop raised, scab-like spots. Management with protective sprays may occur following detection. However, use of resistant varieties and certified disease-free seed or transplants, sanitation, and crop rotation are common practices. In the absence of host crops, the disease is presumed destroyed by normal soil flora and fauna after two years.

Phytophthora (Numerous species)
The genus contains many destructive species, including *P. capsici* and *P. parasitica*, and is nearly ubiquitous in New England soils. The disease often starts following heavy rain or in low areas that remain flooded. Prolonged soil saturation causes release of swimming spores (zoospores) that travel to nearby hosts. Stem or branch lesions appear water-soaked then rapidly girdle and kill the plant beyond the wound. Infected fruit produce a white fungal growth on the skin. Successive heavy rainfalls can spread secondary spores throughout a field and to nearby sites. Management with protective sprays may occur following detection. However, use of resistant varieties, crop rotation, and proper water management are most effective in management of this disease.

Weeds

Weeds reduce yields by competing with the crop for water, light, and nutrients. Weeds serve as habitat and alternate hosts for insects, diseases, nematodes, and small vertebrate pests. They can inhibit spray penetration, air circulation, and drying conditions. Fields must be kept weed-free to maintain yields only during weeks 2-10 after transplanting into bare-ground or during weeks 4-10 when using plasticulture.

Weed infestations occur in mixed populations including annual grasses, annual broadleaf, perennial grasses, perennial broadleaf, woody perennial and vine weeds. Hairy galinsoga may build up in fields over time because this weed is not controlled by most herbicides registered for use in pepper and because it resists cultivation. Management with cultivation, crop rotation, and herbicides is common from pre-plant through post-plant pre-emergence and post-emergence applications.

Vertebrates

Whitetail Deer (*Odocoileus virginianus*)
Deer may occasionally trample crops, but the primary form of damage consists of feeding on plants. Damage levels may severely reduce crop yields on many sites especially those near woods. Management with various cultural control practices is common.

Strategic Issues of Specific Pest Management Tactics

Insecticides

acephate (Orthene) - Aph, ECB

- Inexpensive
- Less detrimental to beneficials (than synthetic pyrethroids)
- Longer residual effect
- Systemic (Aph only)
- Broad spectrum - harmful to beneficials
- Long PHI (7 days)
- Resistance developing
- More useful for late-harvest peppers that have longer time in field
- Only useful early in season for early-harvest peppers due to Long PHI
- Used to be standard use material

azadirachtin (Aza-Direct) - ECB

- Immediate plus residual effects in combination with Pyganic
- OMRI listed
- Expensive
- Becoming common to combine with Pyganic

***Bacillus thuringiensis kurstaki* (Dipel) - ECB**

- Not detrimental to beneficials
- Not toxic to mammals
- OMRI listed
- Easily washed off by rain and photodegrades
- Narrow window of efficacy (only newly-hatched larvae susceptible)
- Requires frequent application
- Can be effective if applied properly and repeatedly
- More effective when applied with certain “stickers”
- Used in rotation with spinosad in organic program
- Very important for organic growers

***Beauvaria bassiana* (BotaniGard, Mycotrol) - Aph**

- OMRI listed (Mycotrol only)
- Efficacy drops with age of material
- Foliage damage (phytotoxicity) possible with liquid formulation

borax (Prev-Am) - Aph

- Only registered for use in CT
- Should not apply during mid-day sun
- New material

carbaryl (Sevin) - ECB

- Labeled for multiple crops
- Low toxicity to mammals
- Relatively inexpensive
- Broad spectrum - harmful to beneficials - leads to increased aphid population
- Especially harmful to pollinators of other crops
- Long PHI (5-7 days)
- Poor efficacy
- Should not be applied to wet plants
- Material more effective against beetles

chlorpyrifos (Warrior) – Aph, ECB

- Labeled for multiple crops
- Relatively inexpensive
- Harmful to beneficials
- Long PHI (5 days)
- Severe dermal reactions possible
- *The* material against ECB in sweet corn

cyflurin (Baythroid) – Aph, ECB

- Labeled for multiple crops
- Relatively inexpensive
- Harmful to beneficials
- Long PHI (5 days)
- Part of rotational insecticide arsenal

dimethoate (Dimethoate) – Aph, PM

- Systemic
- Very effective (PM only)
- Broad spectrum - harmful to beneficials (PM only)
- Harmful to beneficials - leads to increased aphid population (Aph only)

dimethyl phosphorothioate (MSR) - Aph

- Systemic
- Very toxic to mammals when compared to other materials
- Effective older material

endosulfan (Thiodan, Thiodex) - Aph, PM

- Highly toxic to mammals
- Poor efficacy
- Unpleasant to use
- Labeled for use on eggplant (PM only)

esfenvalerate (Asana) - ECB

- Labeled for multiple crops
- Relatively inexpensive
- Harmful to beneficials
- Long PHI (7 days)
- Severe dermal reactions possible
- No advantage over other pyrethroids

horticultural oil (Trilogy, JMS, Golden, etc.) - Aph

- OMRI listed
- Fungicidal properties
- Phytotoxicity possible
- Requires very good spray coverage

imidacloprid (Admire, Provado) - Aph

- Systemic
- Other neonicotinoids: Safari -Greenhouse use only, Venom -Field use

insecticidal soap (M-Pede) -Aph

- OMRI listed
- Phytotoxicity possible

malathion (Malathion) – Aph, PM

- Relatively inexpensive
- Short PHI (1 day)
- Not particularly effective against multiple insect pests
- Offensive odor
- Requires frequent application
- May be harmful to beneficials (no data, Aph, PM)

methomyl (Lannate) – Aph, ECM

- Broad spectrum
- Usually effective against melon aphid (but not always effective) (Aph only)
- Extreme protective equipment required (storage, loading, applying)
- Harmful to beneficials
- Highly toxic to mammals
- Phytotoxicity possible with certain varieties
- Requires frequent application (ECB only)
- Resistance developing (ECB and Green Peach Aphid)
- Old material
- Identification of pest important prior to use (Aph only)
- One of only a few materials available for aphids in corn
- Restricted use

methoxyfenozide (Intrepid) - ECB

- Labeled for multiple crops
- Longer residual effect
- Low toxicity to mammals
- Not detrimental to beneficials
- Short PHI (1 day)
- Difficult to validate effect - no immediate kill
- Only effective against Lepidoptera
- Relatively expensive
- Insect growth regulator
- Used in rotation with spinosad

oxamyl (Vydate) - Aph

- May cause blossom drop
- Harmful to beneficials
- Toxic to mammals
- Not recommended

permethrin (Ambush, Pounce) - ECB

- Labeled for multiple crops
- Relatively inexpensive
- Harmful to beneficials
- Long PHI (5 days)

pymetrozine (Fulfil) -Aph

- Best material available
- Labeled for multiple crops
- Not detrimental to beneficials
- Not systemic
- Only labeled for aphids
- EPA designated reduced risk material
- Unique chemistry

pyrethrins (Pyganic) - ECB

- No PHI
- OMRI listed
- Expensive
- Requires frequent application

Pyriproxyfen (Knack) - Aph

- Systemic
- Not effective against adult stages
- Insect growth regulator
- New material

spinosad (Entrust, SpinTor) - ECB

- Not detrimental to predators
- OMRI listed (Entrust only, ECB)
- Short PHI (1 day)
- Harmful to beneficial parasitic wasps
- Large volume packaging sometimes problematic for small acreage
- Used in rotation with Intrepid and B.t. materials

zeta-cypermethrin (Mustang) – Aph, ECB, PM

- Labeled for multiple crops
- Relatively inexpensive
- Short PHI (1 day)
- Harmful to beneficials

Fungicides, Bactericides

basic copper sufate (Basicop) - BLS

- Relatively inexpensive (compared to other copper materials)
- Probably not as effective as newer materials
- Older material
- The copper is the effective component

copper hydroxide (Champ, Kocide) - BLS

- New formulation (Kocide 3000) promising greater ease of use

cymoxanil + fumoxidone (Tanos) - Phyt

- One of the better materials available
- Poor efficacy
- Resistance development possible
- Foliar spray effective against secondary spread
- Must apply before symptoms appear

dimethomorph (Acrobat, Forum) - Phyt

- Some efficacy
- Systemic
- Resistance development possible
- Not as effective as Tanos
- Foliar spray effective against secondary spread
- Not widely used
- Different chemical family

fosetyl aluminum (Aliette) and others (Phostrol, PhosPhyte, ProPhyte) - Phyt

- Inexpensive
- Moderately effective
- Newer materials to market

hydrogen dioxide (Oxidate) – BLS, Phyt

- OMRI listed
- Expensive
- Requires frequent application
- Copper materials are more convenient to use (BLS only)
- Not widely used

maneb (Manex) - BLS, Phyt

- Some efficacy (Phyt only)
- Not as effective as Tanos (Phyt only)
- Not recommended (Phyt only)
- The old recommendation was to mix with copper –new copper materials work better alone (BLS only)
- Useful against downy mildew on cucurbits (Phyt only)

mefenoxam (Ridomil Gold) - Phyt

- Almost useless on newer mating types
- Expensive
- Apply prior to planting

mefenoxam + copper hydroxide (Ridomil Gold + copper) - Phyt

- Almost useless on newer mating types
- Expensive
- Added benefits of copper
- Foliar spray against secondary spread

sodium methyldithio-carbamate (Vapam) - Phyt

- Soil fumigant

streptomycin (Streptomycin) - BLS

- Must apply to transplants before planting
- Relatively expensive
- Keeps disease from entering field and spreading

Herbicides

bensulide (Prefar) - Pre

- Good activity against annual grasses only
- Safe on new growth
- Needs to be watered in to move to root zone
- Residual effects only good for 12 weeks
- Some important weeds not affected
- Rarely used

clethodim (Select) - Post

- Better activity against perennial grasses than Poast
- Best selective material for quackgrass
- New material

clomazone (Command) - Pre

- Some efficacy against galinsoga

glyphosate (Roundup) – Post*

- Activity against annuals and perennial weeds
- Easy to use
- Inexpensive
- Safe for applicator
- Crop injury potential
- No residual activity
- Timing is critical to efficacy
- Critical for spot treatment
- Very widely used
- *Not labeled for use when crop present

halosulfuron (Sandea, Permit) - Pre

- Poor efficacy against galinsoga

metolachlor (Dual) - Pre

- Very effective against galinsoga
- Special local needs use only in some states

napropamide (Devrinol) - Pre

- Good activity against annual grasses and small seeded broadleaf weeds
- Safe on new growth
- Needs to be watered in or incorporated to prevent photodegredation
- Residual effects only good for 12 weeks
- Some important weeds not affected
- Root growth inhibitor but used on new plantings
- Widely used

paraquat (Gramoxone) – Pre, Post*

- Effective burn-down
- Fast acting
- More effective against tree seedlings than other materials
- Applicator safety is an issue
- Crop injury potential
- Expensive
- Not effective against perennials
- Offensive odor
- Restricted use is an issue
- Important niche material for management of tree seedlings
- Must be used prior to crop emergence
- Nonionic surfactant recommended
- *Not labeled for use when crop present

pelargonic acid (Scythe) - Post

- Effective burn-down
- Fast acting
- No PHI
- Expensive
- Not effective against perennials
- Not very effective at killing growth point
- Very odorous

pendimethalin (Prowl) - Pre

- Good activity against annual grasses and many broadleaf weeds
- Effective with a surface application under plastic mulch
- Safe on new growth
- Poor efficacy against galinsoga
- Needs to be watered in or incorporated to move to root zone
- Residual effects only good for 6-8 weeks
- Recent registration
- Not commonly used

sethoxydim (Poast) - Post

- Good activity against annual grasses
- Safe on crop
- Crop injury potential due to required mix with crop oil
- Fair activity against perennial grasses with multiple applications
- Very long PHI (30 days)
- Generally used

trifluralin (Treflan, Trilin) - Pre

- Good activity against annual grasses and many broadleaf weeds
- Safe on new growth
- Poor efficacy against galinsoga, nightshade, and velvetleaf
- Must be incorporated so not effective with plastic mulch
- Can stunt crop if incorporated too deeply under plastic, especially in cold soils
- Residual effects only good for 8-10 weeks
- Commonly used for bare ground plantings or before laying plastic

Research priorities

New chemistries and options

- More organic management chemistries are needed that are safe to beneficial organisms. (PM)
- Develop more disease resistant varieties, particularly BLS resistant hot peppers and 'frying' peppers. (BLS, Phyt)
- Explore use of noncompetitive, fast-growing, permanent ground covers to reduce erosion during growing season. (Phyt)
- Explore the effects of groundcovers on soil drainage. (Phyt)
- Explore grass herbicide options (for between rows) that have shorter days to harvest and/or have a residual effect. (Weeds)

Specific materials and equipment

- More materials are needed that work against melon aphids. (Aphids)
- Determine the effects of fungicides, such as azadirachtin, on *Beauvaria bassiana* (Botanigard, Mycotrol) applications, particularly for any counterproductive activity. (Aphids)
- More information is needed on the use of harpin protein 'yield promoters' as relates to an increase of early blight in tomato in northern climates. (BLS)
- Alternatives to copper chemistries are needed to improve soil health and toxicity issues. (BLS)
- Explore the activity and application of other soil fungus to out-compete or consume Phytophthora. (Phyt)
- Explore the uses of grafting in achieving disease resistance. (Phyt)
- More materials are needed that work against galinsoga. (Weeds)
- Quantify the effect of flame weeding in galinsoga management. (Weeds)

Models

- Explore methods of notifying and alerting growers of new information.
- Develop monitoring models for coastal regions where seasonal development ranges ahead of other New England regions and insect population is heavier. (ECB)
- Clarify chemical families of materials to avoid confusion when combining and to discourage development of resistance. (ECB)
- Explore monitoring, mapping and trapping to determine current geographical ranges of pests. (PM, Phyt)
- Determine thresholds for nematode damage.
- A firm threshold model for Armyworms and Corn Earworms would be useful to growers, especially if developed for southern New England areas where the pest population is more consistent.
- Research is needed into effects of *Sclerotinia* infection on yield.

Regulatory priorities

Packaging and labels

- Loss of carbamate pesticides (carbaryl, methomyl, etc.) would impact management of many other crops found on a diversified farm.
- Create incentives for pesticide packaging that is practical for small-acreage growers. Smaller quantities are needed for small-acreage application. (ECB)

Specific materials

- Fast-track registration of new materials, especially organic materials. (PM)
- Standardize and limit the frequency at which the OMRI Products List and local organic certifying agency product lists change. The current rate of change is too frequent to maintain inventory of acceptable materials and is a hindrance to timely application of acceptable materials. (BLS)
- Expand Dual registration to other New England states. (Weeds)

Desired revisions

- Direct funds towards development and continuation of models, forecasts, newsletters that are useful to growers.
- Provide incentives to increase the research and extension that is beneficial to commercial growers.
- Create grant funding opportunities for newer researchers who may not yet have the background to as effectively compete for other funding.
- Encourage the infrastructure (fertilizers, suppliers, consultants) to support small farms.
- Direct funds towards publications and guides that may be useful to growers. (ECB)
- Provide incentives to increase the number of applied weed specialists in practice. (Weeds)
- Foster and enforce consistency among the varied international, federal, state, and county regulations, interpretation and enforcement. (Deer)
- Streamline and speed local permitting processes for deer control action. (Deer)

Education priorities

Scouting and identification

- Provide information on pest lifecycles, pest movement and dispersal, and variations, such as race, that are critical to management.
- Provide information on proper timing and placement of pest-monitoring traps. (ECB)
- Promote the efficacy of pest predator populations in aphid management strategies. (Aphids)
- Clarify the identification features of pest predators. (Aphids)
- Encourage proper identification of ECB and PM injury in comparison to diseases. (PM)

Timing

- Proper timing of sprays and alternating between materials (ECB)
- Promote awareness of critical periods when crop must be kept weed-free. (Weeds)

Methods

- Promote the uses and benefits of trap crops. (PM)
- Demonstrate the use of hot water seed treatment to illustrate the worth of the practice. (BLS)
- Encourage the separation of resistant and non-resistant varieties in the field to ease management and to minimize management to only non-resistant varieties. (BLS)
- Promote the management uses of a three-year crop rotation and removal of all pepper plant residues. (BLS)
- Continue to promote the criticalness of water management practices and the minimal efficacy of chemicals in disease management. (Phyt)
- Encourage checking irrigation sources for disease inoculum. (Phyt)
- Promote proper formation of beds to ease cultivation. (Weeds)
- Promote the management uses of crop rotation to reduce galinsoga. (Weeds)
- Encourage the cleaning of equipment to prevent the spread of weeds. (Weeds)

Awareness

- Clarify the differences between systemic and topical material efficacy.
- Notify growers of models that are available for predicting and tracking pest activity.
- Spread awareness of pests that are likely to spread into and within New England due to climate change.
- Clarify chemical families of materials to avoid confusion when combining and to discourage development of resistance. (ECB)
- Raise awareness that use of insecticides in addition to fungicides exacerbates aphid populations and such pest problems are avoidable. (Aphids)

- Spread awareness of the likely spread of Pepper Maggot into areas of northern New England. (PM)
- Notify growers of the changes in disease populations that are becoming more virulent, pervasive and destructive. (Phyt)
- Foster and enforce consistency among the varied international, federal, state, and county regulations, interpretation and enforcement. (Deer)
- Raise awareness that federal government assistance for deer fence installation is available. (Deer)

III. Key Pests

Key Insect pests

European Corn Borer (*Ostrinia nubilalis* (Hubner))

% Acres Affected: 81%

- Year to year problem but impact can be variable.
- A late winter temperature drop below freezing can reduce pest population when it happens.
- Monitoring and management is timed with adult flight periods but targeted at larvae which cause the damage.
- Stem boring activity early in the season is not as common as fruit damage later in season.
- The critical period for monitoring and management is when fruit is present in July and August.
- Traps to monitor for pest can be used in both corn and pepper, saving time and money when both crops are present.
- Management materials for corn and pepper are generally the same, saving time and money when both crops are present.
- The primary consideration when choosing applied materials is the pre-harvest interval (PHI).

Currently Registered Pesticides

Pesticide	Efficacy	Pros	Cons	Comments
acephate Orthene (5% growers)	60% excellent 40% good	• Inexpensive • Less detrimental to beneficials (than synthetic pyrethroids) • Longer residual effect	• Broad spectrum - harmful to beneficials • Long PHI (7 days) • Resistance developing	• More useful for late-harvest peppers that have longer time in field • Only useful early in season for early-harvest peppers due to Long PHI • Used to be standard use material
azadirachtin Aza-Direct		• Immediate plus residual effects in combination with Pyganic • OMRI listed	• Expensive	• Becoming common to combine with Pyganic
Bacillus thuringiensis kurstaki Dipel (11% growers)	30% excellent 70% good	• Not detrimental to beneficials • Not toxic to mammals • OMRI listed	• Easily washed off by rain and photodegrades • Narrow window of efficacy (only newly-hatched larvae susceptible)	• Can be effective if applied properly and repeatedly • More effective when applied with certain “stickers”

			• Requires frequent application	• Used in rotation with spinosad in organic program • Very important for organic growers
carbaryl Sevin (7% growers)	17% excellent 83% good	• Labeled for multiple crops • Low toxicity to mammals • Relatively inexpensive	• Broad spectrum - harmful to beneficials - leads to increased aphid population • Especially harmful to pollinators of other crops • Long PHI (5-7 days) • Poor efficacy	• Should not be applied to wet plants • Material more effective against beetles
chlorpyrifos Warrior (2% growers)	50% excellent 50% good	• Labeled for multiple crops • Relatively inexpensive	• Harmful to beneficials • Long PHI (5 days) • Severe dermal reactions possible	• *The* material against ECB in sweet corn
cyflurin Baythroid (2% growers)	100% good	• Labeled for multiple crops • Relatively inexpensive	• Harmful to beneficials • Long PHI (5 days)	• Part of rotational insecticide arsenal
esfenvalerate Asana (9% growers)	63% excellent 38% good	• Labeled for multiple crops • Relatively inexpensive	• Harmful to beneficials • Long PHI (7 days) • Severe dermal reactions possible	• No advantage over other pyrethroids
malathion Malathion (1% growers)		•	•	• Not labeled for ECB
methomyl Lannate (15% growers)	43% excellent 57% good	• Broad spectrum	• Extreme protective equipment required (storage, loading, applying) • Harmful to beneficials • Highly toxic to mammals • Phytotoxicity possible with certain varieties • Requires frequent application • Resistance developing	• Old material • One of only a few materials available for aphids in corn • Restricted use
methoxyfenozide Intrepid (IGR) (2% growers)	100% good	• Labeled for multiple crops • Longer residual effect • Low toxicity to mammals • Not detrimental to beneficials • Short PHI (1 day)	• Difficult to validate effect - no immediate kill • Only effective against Lepidoptera • Relatively expensive	• Insect growth regulator • Used in rotation with spinosad
permethrin Ambush, Pounce	66% excellent 33% good	• Labeled for multiple crops • Relatively inexpensive	• Harmful to beneficials • Long PHI (5 days)	•

(20% growers)				
pyrethrins Pyganic		• No PHI • OMRI listed	• Expensive • Requires frequent application	•
spinosad Entrust, SpinTor (22% growers)	75% excellent 25% good	• Not detrimental to predators • OMRI listed (Entrust only) • Short PHI (1 day)	• Harmful to beneficial parasitic wasps • Large volume packaging sometimes problematic for small acreage	• Used in rotation with Intrepid and B.t. materials
zeta-cypermethrin Mustang (1% growers)	100% excellent	• Labeled for multiple crops • Relatively inexpensive • Short PHI (1 day)	• Harmful to beneficials	•

Cultural and Biological Alternatives

Practices Reported	Efficacy	Pros	Cons	Comments
Row covers		• Effective barrier	• May cause blossom loss • Expensive • Must remove and cultivate (for weed control) after rain if organic	•
Remove nearby corn stubble		• Can affect pest population if done regionally	•	•
Eliminate alternative hosts (weeds, etc.)		•	• Difficult to remove all of the many alternative host plants	•
Traps to monitor		• Best way to time insecticide applications • No need to place specifically in pepper field	• Cloth traps don't last long	• Trap opening must be at weed height
Release predators /parasites		•	•	• Not common practice
Nitrogen application		•	•	• Balance between fruit production needs and vigorous growth
Perimeter trap crop		•	• Not effective	•

Research Needs:

- Develop monitoring models for coastal regions where seasonal development ranges ahead of other New England regions and insect population is heavier.
- Clarify chemical families of materials to avoid confusion when combining and to discourage development of resistance.

Regulatory Needs:

- Create incentives for pesticide packaging that is practical for small-acreage growers. Smaller quantities are needed for small-acreage application.
- Direct funds towards publications and guides that may be useful to growers.

Education Needs:

- Provide information on proper timing and placement of pest-monitoring traps.
- Proper timing of sprays and alternating between materials
- Clarify chemical families of materials to avoid confusion when combining and to discourage development of resistance.

Aphids (Numerous species including: Green Peach Aphid *Myzus persicae*, Melon Aphid *Aphis gossypii*, Potato Aphid *Macrosiphum euphorbiae*)

% Acres Affected: 64%

- Usually not a problem or not specifically managed.
- Growers may preserve aphid parasites and predators by using selective insecticides against other pests, limiting applications to perimeter trap crops when possible, and by eliminating the use of broad-spectrum materials on resistant plants.
- Predators will usually control aphid populations, especially on small farms with multiple crops, provided there is no disruption of the predator population.
- Incidence increases with use of broad-spectrum, weakly effective insecticides targeted at other insects because they affect the predator population.
- Use of fungicides targeted at other pests can destroy the entomopathic fungi that would kill aphids.
- Incidence more likely on plants that have come out of infested greenhouses, from under row covers in the early season, and during hot and dry weather.
- Green peach aphid is the predominant species. Melon aphid outbreaks are rare and very difficult to manage when they occur. Other species are minor pests.
- Aphid 'honey dew' waste can make fruit sticky.

Currently Registered Pesticides

Pesticide	Efficacy	Pros	Cons	Comments
acephate Orthene (8% growers)	29% excellent 71% good	• Inexpensive • Less detrimental to beneficials (than synthetic pyrethroids) • Longer residual effect • Systemic	• Broad spectrum - harmful to beneficials • Long PHI (7 days) • Resistance developing	• More useful for late-harvest peppers that have longer time in field • Only useful early in season for early-harvest peppers due to Long PHI • Used to be standard use material
Beauvaria bassiana BotaniGard, Mycotrol (1% growers)	100% good	• OMRI listed (Mycotrol only)	• Efficacy drops with age of material • Foliage damage (phytotoxicity) possible with liquid formulation	•
borax Prev-Am		•	• Only registered for use in CT • Should not apply during mid-day sun	• New material
chlorpyrifos		• Labeled for multiple	• Harmful to beneficials	• *The* material against

Warrior		crops • Relatively inexpensive	• Long PHI (5 days) • Severe dermal reactions possible	ECB in sweet corn
cyflurin Baythroid		• Labeled for multiple crops • Relatively inexpensive	• Harmful to beneficials • Long PHI (5 days)	• Part of rotational insecticide arsenal
dimethoate Dimethoate (1% growers)	100% good	• Systemic	• Harmful to beneficials - leads to increased aphid population	•
dimethyl phosphorothioate MSR		• Systemic	• Very toxic to mammals when compared to other materials	• Effective older material
endosulfan Thiodan, Thionex (8% growers)	29% excellent 57% good 14% poor	•	• Highly toxic to mammals • Unpleasant to use • Poor efficacy	•
horticultural oil Trilogy, JMS, Golden, etc. (1% growers)	100% poor	• OMRI listed	• Fungicidal properties • Phytotoxicity possible • Requires very good spray coverage	•
imidacloprid Admire, Provado (11% growers)	80% excellent 20% good	• Systemic	•	• Other neonicotinoids: Safari – Greenhouse use only, Venom –Fiel use
insecticidal soap M-Pede (1% growers)	100% good	• OMRI listed	• Phytotoxicity possible	•
malathion Malathion (3% growers)	100% excellent	• Relatively inexpensive • Short PHI (1 day)	• Not particularly effective against multiple insect pests • Offensive odor • Requires frequent application	• May be harmful to beneficials (no data)
methomyl Lannate (8% growers)	57% excellent 43% good	• Broad spectrum • Usually effective against melon aphid	• Extreme protective equipment required (storage, loading, applying) • Harmful to beneficials • Highly toxic to mammals • Phytotoxicity possible with certain varieties • Resistance developing (Green Peach Aphid)	• Old material • Identification of pest important prior to use • One of only a few materials available for aphids in corn • Restricted use
oxamyl Vydate		•	• May cause blossom drop • Harmful to beneficials	• Not recommended

(1% growers)			• Toxic to mammals	
pymetrozine Fulfil (2% growers)	50% excellent 50% good	• Best material available • Labeled for multiple crops • Not detrimental to beneficials	• Not systemic • Only labeled for aphids	• EPA designated reduced risk material • Unique chemistry
pyriproxyfen Knack (1% growers)	100% good	• Systemic	• Not effective against adult stages	• Insect growth regulator • New material
zeta-cypermethrin Mustang		• Labeled for multiple crops • Relatively inexpensive • Short PHI (1 day)	• Harmful to beneficials	•

Cultural and Biological Alternatives

Practices Reported*	Efficacy	Pros	Cons	Comments
Plastic mulches		• Reflective silver mulch repels insects • Black mulch reduces aphids and warms soil	• Reflective mulches do not allow soil to warm, stunts growth • Reflective mulches can oxidize and lose reflectivity later in season • Expensive	• May be more effective further south due to season/temp differences
Eliminate alternative hosts (weeds, etc)		•	• Difficult to remove all alternative hosts, particularly black cherry	• Especially critical in greenhouses
Scouting		• Identification of species present • Allows tracking of population growth • Can reduce frequency of management material application	•	•
Preserve/attract beneficials		• Cut flowers attract beneficials	• Seed is expensive for crops attractive to beneficials	• Not common practice in fields
Manage nitrogen		•	•	• High nitrogen levels encourage aphid populations

Research Needs:

- More materials are needed that work against melon aphids.
- Determine the effects of fungicides, such as azadirachtin, on *Beauvaria bassiana* (Botanigard, Mycotrol) applications, particularly for any counterproductive activity.

Regulatory Needs:

- None specified.

Education Needs:

- Promote the efficacy of pest predator populations in aphid management strategies.
- Clarify the identification features of pest predators.
- Raise awareness that use of insecticides in addition to fungicides exacerbates aphid populations and such pest problems are avoidable.

Pepper Maggot (*Zonosemata electa* (Say))

% Acres Affected: 63%

- This pest is currently present in Rhode Island and coastal New Hampshire but has not yet been identified as a pest in northern New Hampshire, Maine, or Vermont.
- Movement of population is likely to spread north along river valleys or through accidental transportation.
- Once present, the pest is endemic.
- Treatment is most effective when adults emerge in July although the maggots do not emerge until later in the summer.
- Systemic materials will be effective against maggots.
- Not all 'sting' damage done by adults result in eggs and/or maggots.
- There are no practical trapping methods but trap crops are very good to scout for first indication of pest presence.
- A perimeter trap crop of hot cherry peppers is very useful to attract pests away from other crops. Materials can sometimes be applied only to the trap crop to manage the pest population.

Currently Registered Pesticides

Pesticide	Efficacy	Pros	Cons	Comments
acephate Orthene (8% growers)	29% excellent 71% good	•	•	• Not labeled for PM
dimethoate Dimethoate (4% growers)	25% excellent 75% good	• Systemic • Very effective	• Broad spectrum - harmful to beneficials	•
endosulfan Thiodan, Thionex (11% growers)	30% excellent 70% good	•	• Highly toxic to mammals • Poor efficacy • Unpleasant to use	• Labeled for use on eggplant
esfenvalerate Asana (2% growers)	50% excellent 50% good	•	•	• Not labeled for PM
malathion Malathion (7% growers)	67% excellent 33% good	• Relatively inexpensive • Short PHI (1 day)	• Not particularly effective against multiple insect pests • Offensive odor • Requires frequent application	• May be harmful to beneficials (no data)
zeta-cypermethrin Mustang		• Labeled for multiple crops • Relatively inexpensive • Short PHI (1 day)	• Harmful to beneficials	•

Cultural and Biological Alternatives

Practices Reported*	Efficacy	Pros	Cons	Comments
Trap crop (1% growers)		• Increases ease of detecting damage • May only need to apply management material to trap crop	•	•

Research Needs:

- More organic management chemistries are needed that are safe to beneficial organisms.
- Explore monitoring, mapping and trapping to determine current geographical ranges of pests.

Regulatory Needs:

- Fast-track registration of new materials, especially organic materials.

Education Needs:

- Encourage proper identification of ECB and PM injury in comparison to diseases.
- Promote the uses and benefits of trap crops.
- Spread awareness of the likely spread of Pepper Maggot into areas of northern New England.

Comments on Other Insects and Slugs

These insects are not considered Key Pests but do warrant special note as emerging issues in New England.

Armyworms (Fall, Beet)

- Will infrequently affect peppers.
- Presence can be monitored.
- Spinosad (Entrust) is a better choice for management than acephate (Orthene) which will not affect armyworms.
- A firm threshold model would be useful to growers, especially if developed for southern New England areas where the pest population is more consistent.

Black Cutworms

- Migrate from the borders into every field in every year.
- The usual leaf damage is generally not a problem but sometimes stem damage occurs.
- Scout for leaf feeding.
- Can hand-dig out of soil.

Colorado Potato Beetle

- Can be a problem when eggplants are planted nearby or in rotation.
- Effective materials are available.

Corn Earworms

- Large populations occur along coastal New England.
- Spinosad (Entrust) is a better choice for management than acephate (Orthene) which will not affect armyworms.
- A firm threshold model would be useful to growers, especially if developed for southern New England areas where the pest population is more consistent.

Mites

- Broad mite outbreaks have been seen in New Hampshire and originating in greenhouses in Vermont.
- Relatively easy to manage.

Pepper Weevil

- Not present in New England.
- Could be imported on transplants grown outside New England.
- Avoid accidental introduction by growing or purchasing transplants locally.

Tarnished Plant Bugs

- Severe infestations can cause blossom drop.

Thrips

- Incidence more likely on plants that have come out of infested greenhouses
- Predators will usually control pest populations.
- Fruit damage is possible.

Slugs

- Usually not a significant problem on pepper.

Other Insects not considered Key Pests

Common stalk borer
Caterpillars (general)**, Hornworms**
Flea beetles
Grasshoppers
Japanese/Asiatic Beetles
Leafminers
Stinkbugs
Whiteflies
Wireworms

Key Diseases

Bacterial Leaf Spot (*Xanthomonas campestris* pv. *Vesicatoria*)

% Acres Affected: 61%

- Incidence is higher during periods of high humidity and warm nighttime temperatures. These conditions are less likely to be found in more northern areas of New England.
- Incidence is more likely where higher acreage of the crop is grown.
- Water management and crop rotation are critical to management.
- A three year crop rotation allows time for any infected pepper residue to decompose, reducing inoculum.
- Many resistant varieties are available to different races of disease.
- Seed may be infected prior purchase.
- Tomato plants are also susceptible.

Currently Registered Pesticides

Pesticide	Efficacy	Pros	Cons	Comments
basic copper sufate Basicop (3% growers)	100% excellent	• Relatively inexpensive (compared to other copper materials)	• Probably not as effective as newer materials	• Older material • The copper is the effective component
copper hydroxide Champ, Kocide (21% growers)	43% excellent 38% good 5% poor	•	•	• New formulation (Kocide 3000) promising greater ease of use
hydrogen dioxide Oxidate		• OMRI listed	• Expensive • Requires frequent application	• Copper materials are more convenient to use • Not widely used
maneb Manex (8% growers)	57% excellent 29% good 14% poor	•	•	• Not labeled for BLS • Old recommendation was to mix with copper –new copper materials work better alone
streptomycin Streptomycin		• Must apply to transplants before planting	• Relatively expensive	• Keeps disease from entering field and spreading

Cultural and Biological Alternatives

Practices Reported*	Efficacy	Pros	Cons	Comments
Resistant varieties (19% growers)	29% excellent 65% good	• Common practice	• Not completely effective • No variety is resistant to every strain of pathogen • Not every strain of pathogen has a resistant variety available	• Infection still occurs in resistant varieties but is prevented from spreading within the plant. Initial infection can look alarming.
Hot water treat seeds (2% growers)	100% good	• Effective • Some seed companies will treat prior to sale	• Can overheat/boil and destroy seed • Equipment necessary	• Seed companies discourage it –can destroy seed • Follow with fungicide to prevent damping off (normal procedure)
Bleach treat seeds		•	• Only removes pathogens on seed surface	•
Rotate crops/ Remove <u>all</u> plant residue		•	• Takes time to execute	• A three year rotation is preferred
Eliminate alternate hosts		•	•	• *Solonaceous* weeds such as nightshade, horsenettle, and jimsonweed
Inspect transplants and scout		•	•	• No comments
Maintain fertility, pH		•	•	• Drop in fertility or pH, especially nitrogen, encourages disease • High magnesium predisposes to bacterial diseases
Avoid planting in foggy areas		•	•	• Do not work field when plants wet

Research Needs:

- Develop more disease resistant varieties, particularly BLS resistant hot peppers and ‘frying’ peppers.
- More information is needed on the use of harpin protein ‘yield promoters’ as relates to an increase of early blight in tomato in northern climates.
- Alternatives to copper chemistries are needed to improve soil health and toxicity issues.

Regulatory Needs:

- Standardize and limit the frequency with which the OMRI Products List and local organic certifying agency product lists change. The current rate of change is too frequent to maintain inventory of acceptable materials and is a hindrance to timely application of acceptable materials.

Education Needs:

- Demonstrate the use of hot water seed treatment to illustrate the worth of the practice.
- Encourage the separation of resistant and non-resistant varieties in the field to ease management and to minimize management to only non-resistant varieties.
- Promote the management uses of a three-year crop rotation and removal of all pepper plant residues.

Phytophthora (Numerous species including: *P. capsici* and *P. parasitica*)

% Acres Affected: 50%

- Sudden and dramatic losses are possible, particularly post-harvest, when conditions favor disease development.
- Inoculum can never be eliminated from soils and will accumulate in the soil if crop is not rotated.
- Causal organism is an aggressive colonizer of soil, especially following fumigation.
- Water management, proper drainage, and crop rotation are ***absolutely critical*** to management.
- Cultural methods that avoid standing water and prevent movement of water between beds are advantageous.
- Washing soil from equipment between fields will reduce the spread of inoculum.
- A three year crop rotation allows time for any infected pepper residue to decompose, reducing inoculum.
- Rotation is difficult on small acreage farms because many crops (*Solonaceous*, cucurbits, beans) are susceptible to the same species of *Phytopthora*.
- Mapping of field locations where and when there is disease present is a valuable tool for planning management.

Currently Registered Pesticides

Pesticide	Efficacy	Pros	Cons	Comments
cymoxanil + fumoxidone Tanos (2% growers)	50% good 50% poor	• One of the better materials available	• Poor efficacy • Resistance development possible	• Foliar spray effective against secondary spread • Must apply before symptoms appear
dimethomorph Acrobat, Forum (1% growers)	100% good	• Some efficacy • Systemic	• Resistance development possible • Not as effective as Tanos	• Different chemical family • Foliar spray effective against secondary spread • Not widely used
fosetyl aluminum Aliette and others (Phostrol, PhosPhyte, ProPhyte) (1% growers)		• Inexpensive • Moderately effective	•	• Newer materials to market
hydrogen dioxide Oxidate (1% growers)	100% good	• OMRI listed	• Expensive • Requires frequent application	• Not widely used

maneb Manex (7% growers)	17% excellent 33% good 50% poor	• Some efficacy	• Not as effective as Tanos	• Not recommended • Useful against downy mildew on cucurbits
mefenoxam Ridomil Gold (10% growers)	22% excellent 67% good 11% poor	•	• Almost useless on newer mating types • Expensive	• Apply prior to planting
mefenoxam + copper hydroxide Ridomil Gold +Copper (8% growers)	14% excellent 43% good 43% poor	•	• Almost useless on newer mating types • Expensive	• Added benefits of copper • Foliar spray against secondary spread
sodium methyldithio-carbamate Vapam (1% growers)	100% good	•	•	• Soil fumigant

Cultural and Biological Alternatives

Practices Reported*	Efficacy	Pros	Cons	Comments
Resistant varieties (4% growers)	50% excellent 25% good 25% poor	• The resistant variety 'Palidin' provides good yield and fruit is marketable	• Only one variety available with strong resistance • Others varieties less resistant but have more marketable fruit	•
Raised Bed (1% growers)	100% good	•	•	• Shaping beds into domes to prevent runoff into planting holes
Rotate crops		•	• Takes time to execute	• A three year rotation is preferred

Research Needs:

- Develop more disease resistant varieties.
- Explore use of noncompetitive, fast-growing, permanent ground covers to reduce erosion during growing season.
- Explore the effects of groundcovers on soil drainage.
- Explore the activity and application of other soil fungus to out-compete or consume Phytophthora.
- Explore the uses of grafting in achieving disease resistance.
- Explore monitoring, mapping and trapping to determine current geographical ranges of pests.

Regulatory Needs:

- None specified.

Education Needs:

- Continue to promote the criticalness of water management practices and the minimal efficacy of chemicals in disease management.
- Encourage testing irrigation sources for disease inoculum.
- Notify growers of the changes in disease populations that are becoming more virulent, pervasive and destructive.

Comments on Other Diseases and Nematodes

These diseases are not considered Key Pests but do warrant special note as emerging issues in New England.

Anthracnose

- Incidence is increasing in New England.

Bacterial Soft Rot (*Erwinia carotovora*)

- Secondary infection to ECB or Pepper Maggot damage.

Blossom End Rot

- This physiological damage can be mistaken for a disease.
- Low pH exacerbates the condition.
- Regular watering allows a constant flow of calcium to reduce the manifestation of the condition.

Pythium

- Pepper seedlings are particularly susceptible.
- Cold, wet soil during germination favors infection.
- Infection in a greenhouse can affect large numbers of seedlings.
- Older plants are a bit more resistant to effects of infection.
- Presence in all soils is managed through sanitation practices and moisture management.
- Fungicidal root and soil treatments can protect from infection.

Sclerotinia

- Inoculum presence is random in fields.
- Knowing presence is important to rotation with other crops because peppers tolerate presence better than other crops.
- Research is needed into effects of infection on yield.

Sun Scald

- This physiological damage can increase risk of *Alternaria* infection.
- Some varieties are more susceptible.

Viruses (Alfalfa, Cucumber, Potato, Tobacco, Tomato)

- Not usually persistent in the field from year to year.
- Some strains of virus are less damaging than others.
- Applied sprays are **not** a direct management option.
- Insecticides that induce increased aphid activity exacerbate the spread of virus.
- Resistant varieties are available.
- Avoid accidental introduction by growing or purchasing transplants locally.
- Avoid contact with thrips on ornamentals that may transmit the tomato spotted wilt virus.

Nematodes (Northern Root-knot, Lesion, Stubby Root)

- Growers tend to ignore this pest in New England.
- Research would be useful to determine and map presence to determine thresholds for damage.

Other Diseases not considered Key Pests

Alternaria
***Cercospora* leaf spot**
Rhizoctonia

Weeds

- Galinsoga and nightshade are the most problematic weeds.
- Presence between rows, under plants, and in holes in plastic can be problematic.
- Critical periods for weed control are different for mulched and bare ground.
- Days to harvest of applied materials are a limiting consideration during late season.

Currently Registered Pesticides for Pre-emergent Weeds

Pesticide	Efficacy	Pros	Cons	Comments
bensulide Prefar (2% growers)	50% good 50% poor	• Good activity against annual grasses only • Safe on new growth	• Needs to be watered in to move to root zone • Residual effects only good for 12 weeks • Some important weeds not affected	• Rarely used
clomazone Command (3% growers)	100% good	• Some efficacy against galinsoga	•	•
halosulfuron Sandea, Permit (3% growers)	67% excellent 33% good	•	• Poor efficacy against galinsoga	•
metolachlor Dual (1% growers)	100% excellent	• Very effective against galinsoga	•	• Special local needs use only in some states
napropamide: Devrinol (18% growers)	29% excellent 65% good 6% poor	• Good activity against annual grasses and small seeded broadleaf weeds • Safe on new growth	• Needs to be watered in or incorporated to prevent photodegredation • Residual effects only good for 12 weeks • Some important weeds not affected	• Root growth inhibitor but used on new plantings • Widely used
paraquat Gramoxone (2% growers)	50% excellent 50% good	•	•	• Not labeled for pre-emergent use
pendimethalin Prowl		• Good activity against annual grasses and many broadleaf weeds • Effective with a surface application under plastic mulch • Safe on new growth	• Poor efficacy against galinsoga • Needs to be watered in or incorporated to move to root zone • Residual effects only good for 6-8 weeks	• Recent registration • Not commonly used
trifluralin Treflan, Trilin (11% growers)	10% excellent 80% good 10% poor	• Good activity against annual grasses and many broadleaf weeds • Safe on new growth	• Poor efficacy against galinsoga, nightshade, and velvetleaf • Must be incorporated so not effective with plastic	• Commonly used for bare ground plantings or before laying plastic

			mulch • Can stunt crop if incorporated too deeply under plastic, especially in cold soils • Residual effects only good for 8-10 weeks	

Currently Registered Pesticides for Post-emergent Weeds

Pesticide	Efficacy	Pros	Cons	Comments
clethodim Select (1% growers)	100% good	• Better activity against perennial grasses than Poast	•	• Best selective material for quackgrass • New material
glyphosate Roundup (4% growers)	75% excellent 25% good	• Activity against annuals and perennial weeds • Easy to use • Inexpensive • Safe for applicator	• Crop injury potential • No residual activity • Timing is critical to efficacy	• Critical for spot treatment • Not labeled for use when crop present • Very widely used
metolachlor Dual (5% growers)	100% good	•	•	• Not labeled for post-emergent use
napropamide: Devrinol (1% growers)	100% good	•	•	• Not labeled for post-emergent use
paraquat Gramoxone (1% growers)	100% excellent	• Effective burn-down • Fast acting • More effective against tree seedlings than other materials	• Applicator safety is an issue • Crop injury potential • Expensive • Not effective against perennials • Offensive odor • Restricted use is an issue	• Important niche material for management of tree seedlings • Must be used prior to crop emergence • Nonionic surfactant recommended • Not labeled for use when crop present
pelargonic acid: Scythe (1% growers)	100% excellent	• Effective burn-down • Fast acting • No PHI	• Expensive • Not effective against perennials • Not very effective at killing growth point • Very odorous	•
sethoxydim: Poast (1% growers)	100% excellent	• Good activity against annual grasses • Safe on crop	• Crop injury potential due to required mix with crop oil • Fair activity against perennial grasses with multiple applications • Very long PHI (30 days)	• Generally used

Cultural and Biological Alternatives

Practices Reported	Efficacy	Pros	Cons	Comments
Plastic mulching (72% growers)	79% excellent 20% good 2% poor	• The most effective option around plants • The first step in weed management • Can be supplemented with chemical options • Very effective • Organically acceptable if plastic not left on ground over winter	• Holes can allow weed growth • Application costs can be high • Can provide pine vole habitat when plastic left on ground over winter	• A standard practice • Provides other benefits (soil moisture retention, etc) • Use in combination with bed shaping into domes to prevent runoff into planting holes • Must fertilize through drip irrigation
Other mulching (straw, hay, or other organic material) (10% growers)	56% excellent 33% good 11% poor	• The most effective option around plants • The first step in weed management • Can be supplemented with chemical options • Very effective • Organically acceptable	• Can provide slug habitat • Can prevent warming of soil • Application costs can be high	• Provides other benefits (soil moisture retention, etc)
Mechanical cultivation (79% growers)	44% excellent 52% good 3% poor	• Fairly effective on emerged annual weeds	• Can be challenging when mulch present • Perennial weed growth quick to recover • Not effective on wet soil • Can damage crop roots	• Galinsoga is resistant to cultivation • Cultivation generally occurs between crop rows • More effective in sandier soils
Hoeing (66% growers) & Hand pulling (78% growers)	61% excellent 38% good	• The best mechanical option for persistent and noxious weeds	• Very labor intensive	•
No-till or zone-till (3% growers)	33% excellent 67% poor	• Provides benefits towards improving soils • Zone-till allows soil to warm in narrow bands	• Lowers overall soil temp	•
Mowing between rows (1% growers)	100% good	• The most effective option for between crop rows	• Requires multiple treatments • Can encourage weed seed dispersal	• Standard practice

Late season cover crop overseeding (1% growers)	100% good	• Useful for between crop rows	• Living mulches can compete with crop for nutrients and resources	• Dutch white clover and rye are commonly used
Crop rotation (1% growers)	100% good	•	•	• Standard practice

Research Needs:

- Explore grass herbicide options (for between rows) that have fewer days to harvest and/or have a residual effect.
- More materials that work against galinsoga are needed.
- Quantify the effect of flame weeding in galinsoga management.

Regulatory Needs:

- Expand Dual registration to other New England states.
- Provide incentives to increase the number of applied weed specialists in practice.

Education Needs:

- Promote awareness of critical periods when crop must be kept weed-free.
- Promote proper formation of beds to ease cultivation.
- Promote the management uses of crop rotation to reduce galinsoga.
- Encourage the cleaning of equipment to prevent the spread of weeds.

Key Vertebrates

Whitetail Deer (*Odocoileus virginianus*)

- Damage can be variable but dramatic
- There are wide variations in international, federal, state, and county regulations, interpretation and enforcement.
- Fencing is the most effective management tool when pest populations are high.

Currently Registered Pesticides – None specified

Cultural and Biological Alternatives

Practices Reported	Efficacy	Pros	Cons	Comments
Fence	50% excellent 50% good	• The most effective barrier	• Expensive to install	• Deer like to go under fences as well as over
Electric fence	17% excellent 83% good	• Effective temporarily • Double layer more confusing to deer	• Must be on all the time • No longer effective once deer learn to go over	• May need to bait fence to educate deer
Shooting	50% excellent 50% good	• Very effective on individuals	• Not as effective when pest pressure is high • Can be unsafe if neighbors are nearby • Noise can be irritating to neighbors • Deer are active at night	• Bow hunting is less disruptive to neighbors
Dogs	50% good	•	• Temporary effectiveness • Require upkeep • Fencing necessary to contain dogs	•
Reflectors	100% good	•	• Must move or change regularly • Limited range	•
Odors, etc		• Temporary effectiveness	• Cannot spray directly on crops	•

Research Needs:

- None specified.

Regulatory Needs:

- Foster and enforce consistency among the varied international, federal, state, and county regulations, interpretation and enforcement.
- Streamline and speed local permitting processes for deer control action.

Education Needs:

- Foster and enforce consistency among the varied international, federal, state, and county regulations, interpretation and enforcement.
- Raise awareness that federal government assistance for deer fence installation is available.

Comments on Other Vertebrates

These vertebrates are not considered Key Pests but do warrant special note as emerging issues in New England.

Woodchuck/Groundhog

- Not widespread
- Scattered occurrence is easy to manage

Turkeys

- Pull fruit off plants, peck fruit
- Pull transplants
- Eat beneficials
- Remove straw mulch

Other Vertebrates not considered Key Pests

Birds
Coyote
Porcupine
Rabbit
Raccoons
Skunks
Voles, Chipmunks, Squirrels, Mice

IV. Appendices

Pepper Crop, Worker, Pest and Pesticide Timing

	Apr.				May				June				July				Aug.				Sep.				Oct.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Crop Stage																												
Greenhouse		X	X	X	X	X																						
Pre-Harvest							X	X	X	X	X																	
Green fruit Harvest												X	X	X	X	X	X	X										
Green & Mature fruit Harvest																			X	X	X	X	X	X	X	X	X	X
Worker activities																												
Land preparation and cultivation	X	X	X	X	X																							
Planting					X	X	X	X	X																			
Harvest												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fertilization							X	X	X	X	X	X	X	X	X	X	X	X										
Irrigation							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Field Scouting for Integrated Pest Management (IPM)							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

ECB = European Corn Borer
Aph = Aphids
PM = Pepper Maggot
BLS = Bacterial Leaf Spot
Phyt = Phytophthora

	Apr.				May				June				July				Aug.				Sep.				Oct.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Insect & Disease Pest Key Activity & Monitoring Periods																												
ECB									X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X
Aph		X	X	X	X	X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
PM											X	X	X	X	X	X	X	X										
BLS											X	X	X	X	X	X	X	X	X	X	X	X						
Phyt							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Insecticide & Disease Application Timing																												
ECB									X	X	X	X	X	X	X	X	X	X	X	X								
Aph												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
PM											X	X	X	X	X	X	X	X										
BLS					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Phyt							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Nonchemical Insect & Disease Pest Control Timing																												
ECB							X	X	X	X	X	X	X	X	X	X	X	X	X	X								
Aph												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PM							X	X	X	X	X	X	X	X	X	X	X	X										
BLS	X	X	X	X	X	X																	X	X	X	X	X	X
Phyt	X	X	X	X	X																							

	Apr.				May				June				July				Aug.				Sep.				Oct.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Weed Key Activity & Monitoring Periods																												
Preplant	X	X	X	X	X	X	X																					
Pre-emergent weeds								X	X	X	X	X	X	X	X	X	X	X										
Post-emergent weeds								X	X	X	X	X	X	X	X	X	X	X										
Herbicide Application Timing																												
Preplant	X	X	X	X	X	X	X																					
Pre-emergent weeds								X	X	X	X	X	X	X	X	X	X	X										
Post-emergent weeds								X	X	X	X	X	X	X	X	X	X	X										
Nonchemical Weed Control Timing																												
Preplant	X	X	X	X	X	X	X																					
Pre-emergent weeds								X	X	X	X	X																
Post-emergent weeds								X	X	X	X	X	X	X	X	X	X	X										

	Apr.				May				June				July				Aug.				Sep.				Oct.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Vertebrate Pest Control Timing																												
Deer*							X	X	X	X	X	X																

* Deer browsing can happen anytime, but may be more prevalent and damaging in the spring.

New Pest Management Technologies for Insect and Mite Pests of Pepper Tables adapted from *http://www.pestmanagement.info/NPMT/*

Method	Source	Status	Pests Affected
Abamectin	Pipeline	Registration Approved (Insecticide) (Miticide) Tolerance Accepted (Insecticide) (Miticide)	MITES, LEAFMINERS, THRIPS
Abamectin	IR4	Registered (Insecticide)	Broad spectrum acaricide with activity on leafminers, Colorado potato beetle, and pear psylla. Weak against sucking insects and thrips. Good IPM tool with short re-entry interval. Translaminar activity providing long residual activity.
Acetamiprid	IR4	Registered (Insecticide)	Broad spectrum control with contact and systemic activity via foliar applications. Excellent on sucking pests like aphids and whitefly.
Azadirachtin	IR4	Registered (Insecticide)	Disrupts insect molting. Target pests include whitefly, leafminer, and Lepidoptera.
Bacillus thuringensis	IR4	Registered (Insecticide)	New strains of Bt are being discovered that have activity against numerous pests.
Beauvaria bassiana	Pipeline	Biopesticide (Insecticide) (Miticide) Registration Approved (Miticide) (Insecticide) Tolerance Accepted (Miticide) (Insecticide)	SOWBUGS, MILIPEDES, MITES, LEAFROLLERS, THRIPS, BEETLES, WEEVILS, BILLBUGS, WHITE GRUBS, FLEAHOPPERS, WHITEFLIES, APHIDS, LEAFHOPPERS, MEALYBUGS, PEAR PSYLLA, ANTS, CORN BORERS, LOOPERS
Bifenazate	IR4	Pending (Insecticide)	Controls spider and European red mites, including eggs and motiles. Provides quick knockdown. Safe on predator mites.
Bifenthrin	IR4	Registered (Insecticide)	Broad spectrum activity on aphids, armyworms, cutworms, flea beetles, mites, and corn borers.
Bistrifluron	IR4	Potential (Insecticide)	Active against lepidopteran pests, whitefly. It acts by inhibiting chitin synthesis (Insect Growth Regulator).
Canola oil	Pipeline	Biopesticide (Insecticide) Registration Approved (Insecticide) Tolerance Accepted (Insecticide)	MITES, LEAFROLLERS, LEAFMINERS, BEETLES, PLANT BUGS, WHITEFLIES, APHIDS, LEAFHOPPERS, SOFT SCALES, ARMORED SCALES, MEALYBUGS, PSYLLIDS, ADELGIDS, CATERPILLARS, WEBWORMS, CANKERWORMS
Chromafenozide	IR4	Potential (Insecticide)	Specific to lepidopteran pests, novel ecodyosone agonist.
Chrysoperla	IR4	Potential (Insecticide)	Controls aphids.

carnea			
Cinnamaldehyde	IR4	Registered (Insecticide) (Fungicide)	Aphids, mites and the diseases downy mildew, powedery mildew, botrytis, and brown rots.
Clothianidin	IR4	Potential (Insecticide)	Contact and stomach activity. It controls plum curculio, aphids, leafhoppers, apple maggot, leafminers, leafrollers, codling moth, and pear psylla.
Cyfluthrin	IR4	Registered (Insecticide)	Manages cabbage looper, potato leafhopper, Colorado potato beetle, European corn borer, flea beetle, potato tuberworm, citrus thrips.
Cyromazine	IR4	Registered (Insecticide)	Leaf miners, maggots, fungal gnats.
Deltamethrin	IR4	Pending (Insecticide)	Beetles, bugs, Lepidoptera.
Diflubenzuron	IR4	Pending (Insecticide)	Wide range of leaf feeding insects.
Emamectin Benzoate	IR4	Pending (Insecticide)	Effective on larval Lepidoptera. (Beet/fall armyworms, cabbage webworms, corn earworms, imported cabbage worm, cabbage looper.) and leafminers
Esfenvalerate	IR4	Registered (Insecticide)	Broad-spectrum control on numerous insect pests.
Fenpropathrin	IR4	Pending (Insecticide)	Aphids, whitefly, various worms, mites, glassy winged sharpshooter, and stinkbugs.
Ferric phosphate	Pipeline	Registration Approved (mullusicide) Tolerance Accepted (mullusicide)	SLUGS AND SNAILS
Fipronil	IR4	Potential (Insecticide)	Controls Coleoptera, Lepidoptera, Diptera, Homoptera, Isoptera, and Thysanoptera. Systemic activity with long residual control.
Flonicamid	IR4	Pending (Insecticide)	Effective against aphids, thrips, leafhoppers, plant bug and other sucking pests. Provides rapid antifeeding activity. Non-toxic to beneficials.
Flufenzin	IR4	Potential (Insecticide)	Acaricide.
Imidacloprid	IR4	Registered (Insecticide)	Primarily effective against sucking insects (aphid, whitefly, scale, etc.) as well as beetles and grubs. Controls numerous pests which are resistant to insecticides.
Indoxacarb	Pipeline	Organophosphate (OP) Alternative (Insecticide) Reduced-Risk Pesticide (Insecticide) Registration Approved (Insecticide) Tolerance Accepted (Insecticide)	loopers, armyworms, fruitworms, pinworms
Indoxacarb	IR4	Registered (Insecticide)	Controls most major Lepidopteran pest species. Possibly controls plant bugs. Soft on beneficials so it is a good fit with IPM.

Iron phosphate	Pipeline	Biopesticide (mullusicide) Registration Approved (mullusicide) Tolerance Accepted (mullusicide)	SLUGS, SNAILS
Isomate BTW	IR4	Registered (Insecticide)	Mating disruption of Beet Armyworm.
Kaolin	Pipeline	Biopesticide (plant growth regulator) (Insecticide) (Miticide) Registration Approved (Miticide) (Insecticide) (plant growth regulator) Tolerance Accepted (Miticide) (plant growth regulator) (Insecticide)	mites, flea beetles, tarnished plant bugs, leafhoppers, Colorado potato beetle, lace bugs, stink bugs, tomato fruit worm, tomato pinworm
Kaolin	IR4	Registered (Insecticide)	Various insect and mite pests.
Lambda-Cyhalothrin	IR4	Pending (Insecticide)	Broad spectrum insect control.
Lufenuron	IR4	Potential (Insecticide)	Whitefly, thrips, Colorado potato beetle and lepidopterous insects.
Metarhizium anisopliae	IR4	Potential (Insecticide)	Controls whitefly, thrips, and mites.
Methoxyfenozide	IR4	Pending (Insecticide)	Similar to tebufenozide in that it only controls Lepidoptera larvae. Better on budworm/bollworm, leafminer and diamondback moth. Excellent fit with IPM programs.
Pymetrozine	IR4	Registered (Insecticide)	Controls sucking insects (aphids/whiteflies). The product has a rapid knockdown on aphids if they are contacted by direct sprays.
Pyridanil	IR4	Pending (Insecticide)	Good activity against lepidoptera. Effective against insecticide resistant insecticides. Safe on beneficials.
Pyriproxyfen	Pipeline	Reduced-Risk Pesticide (Insecticide) Registration Approved (Insecticide) Tolerance Accepted (Insecticide)	WHITEFLIES, APHIDS, CABBAGE LOOPER, TOBACCO HORNWORM
Pyriproxyfen	IR4	Registered (Insecticide)	Controls scales, whiteflies, thrips, pear psylla, codling moth, and ants. It is a juvenile hormone mimic that is slow acting with a long residual, safe to beneficial insects, non-toxic to man and wildlife. Effective on eggs and immature stages.
Spinosad	Pipeline	Reduced-Risk Pesticide (Insecticide) Registration Approved (Insecticide) Tolerance Accepted (Insecticide)	LEAFMINERS, THRIPS, ARMYWORMS, LOOPERS, EUROPEAN CORN BORER, HORNWORMS
Tebufenozide	Section 18	issued	beet armyworm
Tetradecadienyl acetate + tetradecenol	Pipeline	Biopesticide (Insecticide) Registration Approved (Insecticide)	BEET ARMYWORM
Thiacloprid	IR4	Potential (Insecticide)	Broad spectrum systemic control of sucking and chewing pests;

			specifically, aphids, whiteflies, leaf hoppers, plant bugs, pear psylla, weevils, fruit flies, oriental fruit moth, leafminers, and codling moth. Very safe to bees.
Thiamethoxam	IR4	Registered (Insecticide)	Broad-spectrum activity against soil dwelling pests, sucking pests, and some chewing pests. Effective against aphids, whitefly, thrips, leafhopper and certain beetles. Being marketed for seed, soil, and foliar treatments.
Thiamethoxam	Section 18	withdrawn	pepper weevils
Thiocyclam	IR4	Potential (Insecticide)	
Verticillium lecanii	IR4	Potential (Insecticide)	Effective against whitefly.
Zeta-cypermethrin	IR4	Registered (Insecticide)	Contols cutworms, thrips, armyworms, etc.

New Pest Management Technologies for Diseases of Pepper

Tables adapted from *http://www.pestmanagement.info/NPMT/*

Method	Source	Status	Pests Affected
Acibenzolar	IR4	Registered (Fungicide)	Induces resistance to Blue mold, bacterial diseases, Downy Mildew, and Sclerotinia.
AE C638206	IR4	Pending (Fungicide)	Active against Phytophthora, Pythium, Plasmopora, Peronospora, Bremia and Pseudoperonospora.
AKD-3088	IR4	Potential (Nematicide)	
Ampelomyces quisqualis isolate M-10	IR4	Pending (Fungicide)	Hyperparasite of Powdery mildew.
Azoxystrobin	Pipeline	Reduced-Risk Pesticide (Fungicide) Registration Approved (Fungicide) Tolerance Accepted (Fungicide) issued ()	powdery mildew, anthracnose
Azoxystrobin	IR4	Registered (Fungicide)	Broad spectrum of pathogens of fungi: Cladosporium, Venturia, Botryosphaeria, Mycosphaerella, Pyrenophora, Puccinia, Pyricularia, Plasmopara, Guignardis, Pseudopeziza, Alternaria, Sphaerotheca, Erysiphe, Leveillula, Septoria, Pythium, Uncinula, Didymella
Bacillus firmus	IR4	Potential (Bacterial Nematicide)	Controls root knot and other nematodes including Heterodera avenae.
Bacillus pumilus strain 2808	IR4	Pending (Fungicide)	Botrytis, downy and powdery mildews, rusts, Sclerotinia blight, and rots.
Bacillus subtilis	IR4	Potential (Fungicide)	Disease suppression.
Bacillus subtilis QST 713	Pipeline	Biopesticide (Fungicide) Registration Approved (Fungicide) Tolerance Accepted (Fungicide)	gray mold, powdery mildew
Bacillus subtilis strain QST 713	IR4	Registered (Fungicide)	Protectant fungicide/bactericide with SAR activity. Broad spectrum, controls Botrytis, powdery and downy mildews, early blight, and bacterial spot.
Bacteriophages	IR4	Pending (Fungicide)	Manages bacteria spot and bacteria speck.
Benthiavalicarb	IR4	Potential (Fungicide)	Controls downy mildew
Chitosan	IR4	Pending (Fungicide)	Downy and powdery mildew, gray mold and Botrytis.
Copper Octanoate	IR4	Registered (Fungicide)	Downy mildew, powdery mildew, blue mold, white rust, anthracnose.
Copper octanoate	Pipeline	Registration Approved (Bactericide) (Fungicide) Tolerance Accepted (Fungicide) (Bactericide)	ANTHRACNOSE, BACTERIAL BLIGHT, EARLY BLIGHT, LATE BLIGHT, GRAY MOLD, LEAF SPOTS, BACTERIAL SPOT
Cyazofamid	IR4	Pending (Fungicide)	Effective against Oomycete and

			Plasmodiophoromycetes, fungi, especially late blight and downy mildew.
Dimethomorph	IR4	Pending (Fungicide)	Downy mildew, late blight, Phytophthora, Plasmopara, Pseudoperonospora Bremia, and Peronospora. Should be mixed with other fungicides for resistance management.
Ethaboxam	IR4	Potential (Fungicide)	Useful for grape downy mildew, potato and tomato late blight, pepper blight and cucumber downy mildew. Preventive and curative activity.
Famoxadone	IR4	Pending (Fungicide)	Broad spectrum fungicide, including Early blight, downy mildews, and other ascomycetes. Can be combined with Cymoxanil (marketed as Tanos) to pick up Late blight.
Fenamidone	IR4	Potential (Fungicide)	Foliar protectant and curative activity against Oomycete fungi. Also effective against ascomycete and Alternaria. Inhibits electronic transport.
Fenbuconazole	IR4	Pending (Fungicide)	Powdery mildew, rusts, apple scab, brown rot, cotton ball, mummy berry (Monolinia spp.), smuts, bunts, Cladosporium, Myclosphaerella, Cercospora, Septoria, Rhizoctonia, Pyrenophora, Helminthosporium & related genera, and a Colletotrichum sp. - in turf.
Fenhexamid	IR4	Pending (Fungicide)	Non-systemic protectant fungicide that is effective against Botrytis cinerea, Monolinia, Sclerotina sclerotiorum of lettuce.
Gliocladium catenulatum J1446	Pipeline	Biopesticide (Fungicide) Registration Approved (Fungicide)	damping-off, seed rot, root and stem rot, wilt diseases caused by Rhizoctonia, Pythium, Phytophthora, Fusarium, Didymella, Botrytis, Verticillium, etc. in greenhouse or indoors
Gliocladium catenulatum Strain J1446	IR4	Registered (Fungicide)	Recommended for control of Pythium and Rhizoctonia.
Glutamic Acid	IR4	Pending (Fungicide)	Controls brown rot and supresses shot hole.
Harpin protein	Pipeline	Biopesticide (Fungicide) (Bactericide) (virus resistance) (plant growth regulator) (Insecticide) Registration Approved (plant growth regulator) (Insecticide) (virus resistance) (Fungicide) (Bactericide) Tolerance Accepted (Fungicide)	PLANT DISEASES, IMPROVEMENT IN GROWTH AND YIELD, SUPPRESSION OF INSECTS AND OTHER PESTS

		(Bactericide) (Insecticide) (plant growth regulator) (virus resistance)	
Harpin Protein	IR4	Registered (Fungicide)	Bacterial leaf spot wilt, blight and fungal diseases such as botrytis, brunch rot, and powdery mildew.
Hydrogen peroxide	Pipeline	Biopesticide (Bactericide) (Fungicide) Registration Approved (Fungicide) (Bactericide) Tolerance Accepted (Bactericide) (Fungicide)	ANTHRACNOSE, POWDERY MILDEW, PHYTOPHTHORA BLIGHT
Hydrogen peroxide	IR4	Pending (Fungicide)	Broad spectrum bactericide and fungicide.
Mefenoxam	IR4	Registered (Fungicide)	Same spectrum as metalaxyl.
Milsana Bioprotectant	IR4	Pending (Fungicide)	Induces phytoalexins which infer resistance to powdery mildew and other diseases such as Botrytis.
Muscodor albus	IR4	Potential (Fungicide)	Fungus produces volatile compounds that are effective against plant pathogenic and bacteria.
Myclobutanil	Section 18	crisis issued	powdery mildew
Myclobutanil	IR4	Pending (Fungicide)	Powdery mildews, rusts, apple scab, brown rot (Monilinia spp.), shothole (Stimina spp.), cherry leaf spot (Coccomyces spp.) grape black rot (Guignardia spp.).
Nocobifen-BAS 510	IR4	Pending (Fungicide)	Manages powdery mildew, Alternaria, Botrytis, Sclerotinia and Monillia
Oxolinic Acid	IR4	Potential (Fungicide)	Controls gram-negative bacteria including rice grain rot, potato black leg, soft rot, and fire blight.
Paecilomyces lilacinus	IR4	Potential (Nematicide)	Controls root knot and cyst nematodes.
Peroxyacetic Acid	IR4	Registered (Fungicide)	Post-harvest decay and rot.
Phosphorous acid and its sodium, potassium, and ammonium salts	Pipeline	Biopesticide (Fungicide) Tolerance Accepted (Fungicide)	Phytophthora and Pythium diseases, downy mildew
Potassium dihydrogen phosphate	Pipeline	Biopesticide (Fungicide) Registration Approved (Fungicide)	POWDERY MILDEW
Potassium Dihydrogen Phosphate	IR4	Registred (Fungicide)	Powdery mildew.
Prochloraz	IR4	Potential (Fungicide)	Powdery mildew, Fusarium spp., leafblotch, Botrytis, Alternaria and others.
Propamocarb Hydrochloride	IR4	Potential (Fungicide)	Downy mildew, late blight, damping-off, Pythium, Phytophthora, and Aphanomyces. Should be mixed with other fungicides for resistance management.
Pyraclostrobin	IR4	Pending (Fungicide)	Broad spectrum activity on

			Anthracnose, Alternaria, downy mildew, Cercospora leaf spot, rust, powdery mildew, Septoria, Phytophthora, Pythium, Rhizoctonia.
Pyrimethanil	IR4	Potential (Fungicide)	Active against Botrytis spp., Venturia spp., Alternaria solani, Alternaria mali , Sphaerotheca macularis and Monilinia spp.
Quinoxyfen/DE795	IR4	Pending (Fungicide)	Has shown activity against powdery mildew in a wide range of crops.
Streptomyces lydicus WYEC 108	IR4	Pending (Fungicide)	Controls soil borne plant root rots and damping off fungi.
TM 416	IR4	Potential (Fungicide)	Bacterial speck and spot.
Trifloxystrobin	IR4	Registered (Fungicide)	Active against powdery mildew and leaf spot diseases. Also provides significant control of scab, rusts, downy mildew and other diseases.
Zoxamide	IR4	Registered (Fungicide)	Control of foliar phycamycetes and albugo. Also protectant against Oomycete fungi. Will be mixed with mancozeb for broader activity.

Pesticide and Non-chemical Methods for Weeds

Tables adapted from *New England Vegetable Management Guide 2008-2009*. http://www.nevegetable.org/.

Weed Group Name Abbreviations
PER **=** Perennial
AG = Annual Grass
AB = Annual broadleaf

Ratings:
E = 90% control or better
G = 70-70% control
F = 50-70% control or better
P = 5-50% control
N = less than 5% control

Active ingredient or Method	Brand name(s)	AG	AB	PER
bensulide	Prefar	E	N-P	N-P
clethodim	Select	E	N	N-E
clomazone	Command	G	N-E	N-F
glyphosate	Roundup	E	E	G-E
halosulfuron	Sandea, Permit	P	F-E	P-G
metolachlor	Dual	G-E	P-E	P-G
napropamide	Devrinol	G-E	P-E	P
paraquat	Gramoxone	E	G-E	P-G
pelargonic acid	Scythe	E	G-E	P-G
sethoxydim	Poast	E	N	N-E
trifluralin	Treflan	G-E	P-E	P-G

New Pest Management Technologies for Weeds of Pepper

Tables adapted from *http://www.pestmanagement.info/NPMT/*

Method	Source	Status	Pests Affected
Alternaria destruens	IR4	Potential (Herbicide)	Controls dodder (swamp, largeseed, field, and smallseed).
Carfentrazone-ethyl	IR4	Pending (Herbicide)	Numerous broadleaf weeds, including cocklebur and water hemp.
Clethodim	IR4	Registered (Herbicide)	Strictly a grass herbicide.
Clomazone	IR4	Registered (Herbicide)	Material controls a broad spectrum of grasses and broadleaf weeds.
Colletotrichum gloeosporioides f. sp malvae	IR4	Pending (Herbicide)	It is pathogenic to round-leaved mallow, small flowered mallow, common mallow, and velvetleaf.
Flufenacet	IR4	Potential (Herbicide)	Soil applied for annual grasses and some broadleaf weeds.
Flumioxazin	IR4	Potential (Herbicide)	Low use rate pre-emergence broadleaf herbicide with contact activity and residual soil activity.
Glyphosate	IR4	Registered (Herbicide)	Controls most weeds.
Halosulfuron	IR4	Pending (Herbicide)	Nutsedge, velvetleaf, cocklebur, other broadleaf weeds.
Oxadiargyl	IR4	Potential (Herbicide)	Broad spectrum weed control, similar to oxidiazinon.
Pelargonic Acid	IR4	Registered (Herbicide)	Contact, non-selective broad spectrum foliar applied material
Pyrithiobac-sodium	IR4	Potential (Herbicide)	Controls a wide range of broadleaf weeds via pre- and post-emergence application.
S-metolachlor	IR4	Registered (Herbicide)	Same spectrum as metolachlor (Dual).
Sulfentrazone	IR4	Potential (Herbicide)	Controls broadleaf and grass species.
Trifloxysulfuron	IR4	Potential (Herbicide)	Broadleaf weeds.

V. Acknowledgements and Contacts

Strategic Plan Meeting Participants

Connecticut

Jude Boucher
University of Connecticut
Storrs, CT
(860) 875-3331
jude.boucher@uconn.edu

Maine

Rick Belanger
Lewiston, ME
(207) 576-5845
veggiefarmerinme@aol.com

Bill Spiller
85 Spiller Farm Lane
Wells, ME 04090
(207) 985-2575
spillerfarm@juno.com

Gordon True
True Farms
305 Ridge Road
Charleston, ME 04422
(207) 286-3604
truefarming1@netzero.com

Massachusetts

A. Richard Bonanno
University of Massachusetts
Cooperative Extension
255 Merrimack St.
Methuen, MA 01844
(978) 682-9563
rbonanno@umext.umass.edu

New Hampshire

George Hamilton
Hillsborough County
Cooperative Extension
329 Mast Road
Goffstown , NH 03045
(603) 641-6060
george.hamilton@unh.edu

William Lord
University of New Hampshire
Department of Biological Sciences
Spaulding Hall, G-28
38 Academic Way
Durham, NH 03824
(603) 738-3424
wlord@ceunh.unh.edu

Keith Marshal
Wilson Farm
144 Charles Bancroft Highway
Litchfield, NH 03051
(603) 882-9919

Rhode Island

Skip Paul
Wishing Stone Farm
25 Shaw Road
Little Compton, RI 02837
(401) 635-4274
skippaul@cox.net

Vermont

Ann Hazelrigg
University of Vermont
105 Carrigan Drive
Burlington, VT 05405
(802) 656-0493
ann.hazelrigg@uvm.edu

Sarah Kingsley-Richards
University of Vermont
106 Carrigan Drive
Burlington, VT 05406
(802) 656-0475
sarah.kingsley@uvm.edu

Pooh Sprague
Edgewater Farm
Plainfield, NH
(603) 298-8391
ps@edgewaterfarm.com

References

New England Pepper Pest Management Survey. Survey Conducted by Candace Bartholomew, University of Connecticut Cooperative Extension. Data management and report by Natalia P. Clifton, University of Massachusetts. 2006. PRONewEngland Pest Management Network, http://PRONewEngland.org/

New England Pepper Crop Profile. Candace Bartholomew, University of Connecticut Cooperative Extension. 2008. PRONewEngland Pest Management Network, http://PRONewEngland.org/

Northeast Pepper Integrated Pest Management (IPM) Manual. 2001. T. Jude Boucher and Richard A. Ashley, Eds. University of Connecticut, Cooperative Extension System.136pp.

New England Vegetable Management Guide: 2008-2009. Cooperative Project from University of Connecticut, University of New Hampshire, University of Maine, University of Rhode Island, University of Massachusetts and University of Vermont. http://www.nevegetable.org/

New Pest Management Technologies. 2008. http://www.pestmanagement.info/NPMT/

Reviewers

Connecticut:
Candace Bartholomew
University of Connecticut Cooperative Extension
1800 Asylum Avenue
West Hartford, CT 06117
(860) 570-9067
cbarthol@canr1.cag.uconn.edu

Maine
Glen Koehler
University of Maine Cooperative Extension
Pest Management Office
491 College Avenue
Orono, ME 04473
Phone: 207-581-3882
Fax: 207-581-3881
Email: gkoehler@umext.maine.edu

New Hampshire:
William Lord
University of New Hampshire
Department of Biological Sciences
Spaulding Hall, G-28
38 Academic Way
Durham, NH 03824
Phone: (603) 738-3424
Fax : (603) 862-1713
Email: wlord@ceunh.unh.edu

Rhode Island:
Peggy Siligato
University of Rhode Island Cooperative Extension
316 Woodward Hall
Kingston, RI 02881
(401) 874-5997
siligato@uriacc.uri.edu

Vermont:
Ann Hazelrigg
Plant & Soil Science Department
105 Carrigan Drive
University of Vermont
Burlington, VT 05405-0082
(802) 656-0493
ann.hazelrigg@uvm.edu

Vermont:
Sarah Kingsley-Richards
Plant & Soil Science Dept.
105 Carrigan Drive
University of Vermont
Burlington, VT 05405-0082
(802) 656-0475
sarah.kingsley@uvm.edu