Pest Management Strategic Plan for Strawberry in New England 2007

Compiled for the New England Pest Management Network
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Key Pest Name Abbreviations

Insects
SBW = Strawberry Bud Weevil
PLH = Potato Leaf Hopper
TPB = Tarnished Plant Bug

Diseases
Bot **=** Botrytis
LSp = Leaf Spot
PM = Powdery Mildew

Weeds
PP = Pre-plant (Weeds)
Pre = Pre-emergent Weeds
Post = Post-emergent Weeds

Executive Summary

The list of key pests for strawberry consists of three insects, three diseases, and the weeds and vertebrates common to agricultural settings. These key pests are persistent problems that need to be managed every year.

Of special note, there are other current and emerging pests that affect the crop to lesser degrees annually but can be extremely devastating when outbreaks occur. Root Weevils and Black Root Rot are two such pest complexes that are capable of putting a grower out of business when outbreaks occur. Contributing to these emerging pest problems is a shift to production using day-neutral varieties grown in plasticulture.

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

Weed management is the most critical component in the management of nearly all pests, making weed research, regulation and education the highest priority.

Research

- There is a great need to develop management options for pests other than the annual key pests. Many potentially devastating pests have limited options available when they occur.
- Greater understanding of root and weed complexes are needed to extend production of individual plantings beyond two seasons.
    - The root weevil complex (Black Root Rot, Root Weevils, White Grubs) has been traditionally overlooked and there is a lack of effective techniques to manage root weevils. Management options need to be developed.
    - Weed management options are strongly desired, particularly as alternatives to fumigation.
    - As an example, the loss of chloroxuron (Tenoran) for weed management, compounded by the loss of carbofuran (Furadan) for grub management, has led to a perceived overuse of terbacil (Sinbar) that is suspected in increased incidence of Black Root Rot. An effective alternative to chloroxuron (Tenoran) is needed to offset this development.

- Renewed emphasis on breeding for resistance to diseases and insects is important to New England. Such research needs to reflect several seasons of data collection to be of use to growers.
- Investigate the influence of day-neutral varieties and plasticulture on pest activity and management.
- Sustainable systems data (ecosystems, inputs, economics) are desired for strawberry production.
- Continue to identify and develop materials that are friendly to IPM and organic systems. Organic options are still needed for annual pests such as Tarnished Plant Bug and Botrytis.
- Develop effective weather models that encompass all of the major pests with a systems approach.
- Develop effective options to manage cedar waxwing and other birds.

Regulatory

- There is a strong desire for systems that encourage registration of new and existing weed management materials for use in New England and to reduce liability complications for small growers.
- Consider New England as a single unit, instead of six individual states, when pursuing registrations.
- The labor pool qualified to manage pests, maintain, and harvest fields is tenuous. Take steps to alleviate impediments to hiring foreign laborers, offset health insurance costs, and relieve labor issues that create obstacles for small farm operations.

Education

- Encourage organization and coordination of small fruit growers within and among the six New England states to present a strong voice.
- Regionally applicable research, coordination, meetings, educational events, and collaborative publications specific to strawberry production are also desired by growers. Funding for the pursuit of this objective is vital.
- More weed scientists, plant pathologists, entomologists, and small fruit production specialists with an understanding of applied practice are essential to pest management. These vocations need to be encouraged and supported to maintain and improve upon the number and quality of professionals in applied research and extension. Researchers focusing on weeds, slugs, and vertebrates are especially needed.
- Identify and train personnel in private enterprise to disseminate information about pests and management from research to growers.
- Increase perception of importance of crops produced at the local level to increase food safety, security, quality, nutrition, freshness, and the health of the local economy.

I. Introduction

Background of Strawberry in New England

The six New England states combine to rank eighth in national production of strawberries. A total of 1,191 acres produce 5,215 tons of harvested fruit that contribute $4 million dollars to the New England economy. Over half of the fruit is sold through pick-your-own or U-pick operations to the public, while the rest is sold wholesale and retail. Very little is processed. While contributing 18% to the national production of strawberries, the strawberry 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.

Strawberries are susceptible to many types of pests, including insects, diseases, weeds, nematodes, and vertebrates. It is critical that these pests be effectively managed to maintain adequate yields of quality fruit that is acceptable to consumers. The high percentage of pick-your-own or U-pick operations in New England also necessitate that pest management methods allow for customers in the fields during or immediately following management activities.

New England strawberry growers have adopted innovative integrated pest management (IPM) and other practices designed to manage these pests while reducing pesticide use, improving worker and food safety, and protecting environmental quality. While these methods allow pesticides to be used more efficiently, they neither eliminate the need for pesticides nor reduce the critical importance of pesticides in strawberry production. The loss of important pesticide tools due to pest resistance, regulatory, and consumer-driven pressures is a concern for the entire strawberry industry.

How this Plan was Created

A review group of strawberry growers, researchers, and industry stakeholders from New England met for two days in December of 2006 to develop this Strategic Plan.

Key pests driving pesticide use were identified from the New England Strawberry Pest Management Tactic Survey conducted in 2004. Current use patterns for pesticides and alternative methods of strawberry pest management were described in the New England Strawberry Crop Profile.

The review group discussed the efficacy, practicality, advantages, and disadvantages of current pest management methods; identified at-risk pesticides for key pests; identified acceptable alternative pest management methods; and created lists of research, regulatory and education priorities needed to improve pest management outcomes while minimizing reliance on pesticides.

Points made in this discussion were recorded as table and list entries to create the draft Pest Management Strategic Plan document. The draft document was reviewed by meeting participants and by other New England University and private sector experts for accuracy and completeness. At least one person in each New England state reviewed the draft PMSP and approved it as representative of that state.

Benefits to the New England Strawberry Industry

This strategic plan identifies regional needs for consideration in EPA regulatory decisions. The collective judgments recorded in this document provide a basis for contingency plans should EPA decisions result in the loss of key pesticide registrations.

The priority lists provide guidance for research, Extension, and regulatory efforts to improve strawberry pest management in New England. By documenting stakeholder-identified priorities and participation, the strategic plan brings attention to immediate needs and promising opportunities, and provides justification for funding proposals designed to address those priorities.

Current pest management programs will also benefit from the review of advantages and constraints of current practices contained within this strategic plan.

II. Summary

Key Pest Strategic Issues

Summaries adapted from the 2005 *New England Strawberry Crop Profile*. http://PRONewEngland.org/

Insects and Mites

Tarnished Plant Bug (*Lygus lineolaris)*
This is an annual pest beginning in late April and continuing until heavy frost. The nymphs feed on developing seed during and after bloom or from the receptacle of developing fruit. Their feeding kills surrounding tissue and renders fruits unmarketable. Management with protective sprays prior to bloom and during early fruit development, as well as reduction of nearby weeds is common.

Strawberry Bud Weevil (*Anthonomus signatus*)
This is an annual pest on early budding spring plants such as strawberries. The adults feed on the immature pollen, girdle the bud, and clip the stem. Fruit fails to develop from buds in which eggs are deposited. Management with protective sprays prior to bloom and early renovation of fields is common.

Potato Leaf hopper (*Empoasca fabae*)
This is the most common leafhopper on strawberries. Most serious damage is done in the late spring and early summer when nymph feeding injury on leaves causes distorted growth. Overall plant health can be affected, especially new plantings. Management commonly occurs in late summer following harvest.

Diseases

Gray Mold (*Botrytis cinerea*)
Blossom infections in the spring lead to fruit rot as the berries ripen. Other parts infected by the fungus include leaves, crown, petals, flower stalks, and fruit caps. Management with protective sprays during bloom and maintaining good air circulation between plants by keeping rows narrow and well spaced is common.

Leaf spot (*Mycosphaerella fragariae*)
Symptoms first appear as spots on leaves in May and can develop into severe lesions on susceptible varieties in some years. Sometimes fruit

infections also occur but this is rare. Protective sprays in early spring, maintaining air circulation between plants, and mowing at renovation are common management techniques.

Powdery Mildew (*Sphaerotheca macularis*)
Late season infections cause leaf edges to roll upward. Infected flowers and fruit may fail to ripen. Management with protective sprays following harvest or renovation and maintaining good air circulation between plants by keeping rows narrow and well spaced is common.

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 such as voles and mice. They can inhibit spray penetration, air circulation, and drying conditions.

Weed infestations occur in mixed populations including annual grasses, annual broadleaf, perennial grasses, perennial broadleaf, woody perennial and vine weeds. Management with herbicides is common from pre-plant through post-plant pre-emergence and post-emergence applications.

Vertebrates and other pests

Whitetail Deer (*Odocoileus virginianus*)
Deer may occasionally trample crops, but the primary form of damage consists of feeding on selected plant parts in early spring when few alternative foods are available. Damage levels may severely reduce crop yields on many sites, especially those near woods. Management with various cultural control practices is common.

Mice and Voles *(Peromyscus sp, Microtus pennsylvanicus, Microtus pinetorum)*
Mice and voles directly feed on underground plant parts and can introduce weed seeds to fields; their tunnel systems interfere with crop irrigation. Management with various cultural control practices is common.

Birds *(various species)*
Birds (especially Cedar Waxwings, *Bombycilla cedrorum*) feed on ripe fruit, rendering the fruit unmarketable. Feeding damage varies widely by location and year. Management with various cultural control practices is common.

Strategic Issues of Specific Pest Management Tactics

Insecticides

azadirachtin (Aza-Direct) - SBW, TPB

- Short REI
- Efficacy questionable
- OMRI listed

bifenthrin (Brigade WSB) – SBW, TPB

- Short REI convenient for use with day-neutral varieties
- Possible efficacy against other insects (especially Sap Beetles)
- Can trigger serious Two-Spotted Spider Mite problems
- Application rate recommendations are very confusing
- Harmful to beneficials
- Restricted use material
- Broad spectrum

carbaryl (Sevin 80S, 80WSB, XLR) - SBW, PLH, TPB

- Can be effective against other insects
- Toxic to pollinators
- Nighttime application necessary to avoid harming bees
- Phytotoxicity possible
- Long PHI
- Not restricted use
- Not first choice against TPB
- Efficacy may not be as excellent against SBW as growers reported in survey

chlorpyrifos (Lorsban 4E, Whirlwind, Warhead, Govern 4E) - SBW

- Also effective against grubs (when applied at different time of year)
- May only be applied pre-bloom to a maximum 2 applications
- Highly toxic to mammals
- Restricted use material

endosulfan (Phaser 3EC, Thiodan EC, Thionex) - PLH, TPB

- Also effective against some other insects
- Malodorous
- Long PHI
- Maximum 3 applications per year
- Labels are different between formulations
- Early application against TPB in spring after mulch removal

fenpropathrin (Danitol 2EC) - SBW, TPB

- Also effective against some other insects and mites
- Inexpensive
- Short PHI
- Moderately toxic to mammals
- Harmful to beneficials
- New material to market
- Restricted use material
- Broad spectrum
- 24 hr REI

imidacloprid (Provado, Admire Pro, Nuprid) - PLH

- Low toxicity to beneficials
- Long residual in some formulations
- Aphids and whiteflies management and ant bait
- Expensive
- Packaging not sized for small growers
- Label variable by state

malathion (Malathion 57EC) - SBW, PLH, TPB

- Useful to small grower on many crops and against many insects
- Inexpensive
- Timing important for effectiveness against TPB
- Malodorous
- Long PHI
- 12 hour REI
- Labeled use for genus (lygus bugs) not species
- Not restricted use
- Efficacy may not be as excellent against SBW as growers reported in survey

methomyl (Lannate SP) - TPB

- Very long PHI
- Can trigger serious Two-Spotted Spider Mite problems
- Toxic to beneficials
- Very highly toxic to mammals
- Packaging (water soluble bags) is inconvenient for use in small quantities

naled (Dibrom 8EC) - TPB

- Very effective when used in combination with malathion under conditions of high pest-pressure
- Short PHI
- Highly toxic to mammals
- Requires high gallonage
- Requires slow drying conditions after application

pyrethrins (Pyganic EC1.4) - SBW, PLH, TPB

- Repeat applications may be necessary
- Phytotoxicity possible
- Expensive
- OMRI listed
- Questionable efficacy

Fungicides, Bactericides

azoxystrobin (Quadris, Abound) - Bot, LSp, PM

- Effective
- Not recommended for use near apple orchards
- Cannot remove residue from spray tank
- Very expensive
- Number of applications limited
- Labeled for suppression only
- Should be rotated with materials with other chemistries to prevent resistance

captan (Captan 50W, Captec and others) - Bot, LSp, PM

- Long residual
- Broad spectrum fungicide
- Good alternate chemistry for use in resistance management
- Used as preventative and will only slow spread if disease already present
- No postinfection effect
- Persistent residue can be problem
- Do not apply with or after oils
- Highly recommended as a tank mix with other fungicides

captan + fenhexamid (Captivate 68WDG) - Bot

- May be less expensive to tank mix on site than to use premixed formulations

cyprodinil + fludioxinil (Switch 62.5WG) - Bot, LSp

- Residual effective into postharvest against Bot
- Expensive
- Number of applications limited
- Very new material to market
- Primary use against Botrytis

dodine (Syllit FL) - LSp

- Not very effective
- Permanent resistance probable
- Expensive
- Efficacy may not be as excellent as growers reported in survey

fenhexamid (Elevate 50WDG) - Bot

- Effective
- Reasonable price
- OK to apply during bloom
- Not broad spectrum
- Need to tank mix for resistance management
- Standard alternate chemistry with captan for use in resistance management

harpin protein (Messenger STS) - PM

- May take a long time to have an effect
- Not very effective by itself but works well as part of a management system
- New material to market

hydrogen dioxide (Oxidate) - Bot, PM

- Will work if in contact with fruit
- Zero PHI
- Can tank mix with almost anything
- Very broad spectrum (will disinfect field)
- No residual
- Must have clean spray tank
- Must have thorough coverage
- Infected areas of foliage with PM turn brown following application
- OMRI listed
- Rescue spray

myclobutanil (Nova 40W) - LSp, PM

- Moderately expensive
- Number of applications limited
- 30-day interval between last application and planting of new crop
- Primary use against Powdery Mildew
- Registration new for strawberries

paraffinic oil (JMS Stylet Oil) - Bot

- Organic
- Requires multiple applications
- Phytotoxicity possible on hot days
- Cannot be mixed with or applied near captan

pyraclostrobin (Cabrio EG) - Bot, LSp, PM

- Broad spectrum
- The preferred product for use near apple orchards
- Moderately effective against Bot
- Resistance development possible
- Number of applications limited
- Labeled for suppression only
- Quick development of resistance is known for cucurbit crops

pyraclostrobin + boscalid (Pristine) - Bot, PM

- Very effective
- Broad spectrum
- Okay for use near apple orchards
- Very expensive
- Number of applications limited
- Relatively new material to market

sulfur (Kumulus DF and other formulations) - PM

- Inexpensive
- No resistance development
- Possible acidification of soil with heavy use
- Deleterious effects on soil microbes with heavy use
- Can cause burns on skin during harvest
- Can not apply during high temp/humidity
- Most available formulations are organic
- Often recommended

thiophanate methyl (Topsin-M) - Bot, LSp, PM

- Inexpensive
- Broad spectrum
- Effective in tank mix with captan
- Good alternate chemistry with strobilurins for use in resistance management
- Resistance development possible if not alternated with other chemistries
- Not as effective as newer materials against Bot
- Not recommended for use when Bot disease pressure is high

thiram (Thiram 65WSB) - Bot

- Good rabbit and deer repellant
- Inexpensive
- Effective strictly as preventative
- Alternate chemistry with captan for use in resistance management
- Rarely used by itself but in combination with other chemistries

Herbicides

2,4-D (Formula 40, Amine 4) - Post

- Very effective against broadleaf and non-creeping perennial weeds
- Poor efficacy against chickweed
- Number of applications limited
- Must be applied when strawberry plants are not actively growing (e.g., just prior to renovation)
- Improper timing results in misshapen fruit
- Still very important material for most growers

clethodim (Select 2EC) - Post

- Effective against cool season and perennial grasses
- No residual activity
- Should not apply during hot, humid conditions
- Must use crop oil and be cautious of use with captan

dazomet (Basamid) - PP

- Pre-plant application only
- Easier for small grower to apply than other fumigants
- Suitable for use with plasticulture
- Broad spectrum affects more than weeds
- Poor efficacy against legumes
- Soil fumigant
- Restricted use material

DCPA (Dacthal F, W75) - Pre

- Limited spectrum of affected weeds
- Short residual activity
- Very expensive
- New label drastically reduced use due to expense

flumioxazin (Chateau) - Pre

- Effective against broadleaf weeds
- Residual activity only
- Timing important (dormant application)
- Supplemental label

glyphosate (Roundup Ultra 4S) - PP, Post

- Very effective against perennial grasses and broadleaf weeds
- No residual activity
- No applications after planting
- Many brands available
- Label confusing as to regulation

metam-sodium (Vapam HL) - PP

- Pre-plant application only
- Suitable for use with drip irrigation and plasticulture
- Broad spectrum affects more than weeds
- Poor efficacy against legumes
- Soil fumigant
- Restricted use material

methyl bromide + chloropicrin (Terr-O-Gas 33) - PP

- Pre-plant application only
- Suitable for use with plasticulture
- Broad spectrum affects more than weeds
- Extremely expensive due to ozone issues
- Expense makes use impractical in many instances
- Poor efficacy against legumes
- Soil fumigant
- Restricted use material

napropamide (Devrinol 50DF) - Pre

- Safe on most plantings
- Must have rainfall, irrigation, or cultivation to prevent volatizing material with sun exposure
- Primary herbicide for use against annual grass and chickweed

oxyfluorfen (Goal 2XL) - PP

- Good burn down of small weeds
- Disturbance of ground required
- Label not appropriate for New England soils (required disturbance)

paraquat (Gramoxone Max) - PP, Post

- Good burn down of broadleaf weeds
- Good burn down of weed runners
- No residual activity
- No systemic activity
- Does not affect small grasses
- Highly toxic
- Restricted use material

pelargonic acid (Scythe) - Post

- Good burn down of very small weeds
- Low toxicity risk to humans
- Malodorous
- Expensive
- Not effective against large weeds and grasses

- Organic listing unresolved
- Requires shielded application

sethoxydim (Poast) - Post

- Very effective against summer annual grasses
- No residual activity
- Should not apply during hot, humid conditions
- Not as effective as clethodim on cool season and perennial grasses
- Must use crop oil and be cautious of use with captan

terbacil (Sinbar) - Pre, Post

- Good to very effective against very small and broadleaf weeds
- Poor efficacy against grasses
- Use only when strawberry plants are dormant or just after mowing at renovation
- Varietal differences influence effectiveness
- Overuse can reduce vigor of crop, contribute to black root rot, etc.
- Long half-life

Vertebrate and other pests

thiram - Deer

- Inexpensive
- Taste repellent

zinc phosphide - Voles

- High potential for off-target kill
- Non harvest timing
- Use with bait stations recommended

Research, Education, and Regulatory Priorities

Research Needs:

New chemistries and options

- More chemistries are needed that are novel, safe to use, and well-suited to use in an integrated pest management system. (TPB, SBW, PLH, Bot)
- New chemistries are needed that discourage development of resistance. Current chemistries often foster development of resistance. (Bot)
- Develop and test new chemistries that can provide more management options. (Voles)
- Explore effective organic management tools. (Bot, LSp, PM)
- Explore options for management of problem weeds such as: chickweed, oxalis, field pansy, legumes, nutsedge, marestail. NOTE: Management materials for these weeds exist but are not labeled for use with strawberry crops in New England.
- Develop effective options for perennial broadleaf management.
- Discover an effective way to target management against egg-laying females before bloom period of crop. (TPB)
- Explore effects of nonchemical management options, including use of nematodes. (SBW)
- Study the ability of different cultivars to compensate for various levels of insect injury. (SBW)
- Develop disease-resistant varieties. (Bot, LSp)

Specific materials and equipment

- Explore effects of the insecticide Warrior against TPB on strawberries. This insecticide is currently registered for TPB on other crops. (TPB)
- Develop an alternative to methoxychlor as a management tool. This is currently the material of choice however, there is no suitable substitute available. (SBW)
- Determine efficacy of Aza-Direct and other materials of questionable management value. (SBW)
- Determine efficacy of imidacloprid as a management tool. (PLH)
- Examine the efficacy of lime sulfur as a fungicide on strawberries. (PM)
- Extend research on effects of harpin protein as a fungicide. (PM)
- Determine the uses and efficacy of molasses in fungicide protocols. (PM)

Research, Education, and Regulatory Priorities (continued)

- Study the use of living mulches that can stabilize applied mulch between rows. Data are needed on timing, varieties, kill methods (winter, chemical), and yield into successive growing seasons.
- Examine the efficacy and economics of different applied mulch materials.
- Develop new or improved cultivation equipment for in-row weed management.
- Explore efficacy of electronic recordings of dog barking. (Deer)
- Explore the efficacy of placement of perches and houses to encourage predators to nest and hunt near strawberry fields. (Birds)
- Expand studies of sound devices that attract predators and the timing of their use as management options. (Birds)

Models

- Develop degree-day models predicting hatch or egg-laying for better management timing. (TPB)
- Develop phenology models for better management timing. (SBW)
- Develop and retain effective weather predicting tools that can integrate with management planning. (Bot)
- Adapt existing models (degree day, leaf wetness, etc.) for Powdery Mildew from other crops for use with strawberry crops. (PM)

Economic studies

- Study the economics for application of parasites as a management tool. (TPB)
- Determine the economic thresholds for Leaf Spot on strawberry crops. (LSp)
- Determine the dollar value of yield loss due to damage from deer and other vertebrate feeding. (Deer, Voles)
- Measure the cost of using bird netting in relation to income from increased quality and/or volume of the crop and in relation to field size. (Birds)

Research, Education, and Regulatory Priorities (continued)

Regulatory Needs:

Packaging and labels

- Create incentives for pesticide packaging that is practical for small growers. Certain packaging, such as water soluble bags, is inconvenient for use in small quantities. (TPB, PLH, PM)
- Include storage information and shelf life on packaging. (TPB)
- Encourage labels in specialty crops by setting up systems to offset liability complications.
- Streamline methods for acquiring Section 24(c) Special Local Need labels for Section 3 materials. An online form that allows users to register by reading agreement and clicking an "I Accept" button to print label is desired.

Specific materials

- Clarify labeled application rate recommendations for bifenthrin. (TPB)
- Re-registration of methoxychlor for use against SBW is desired. (SBW)
- Labeling of imidacloprid and endosulfan for use against PLH is desired. (PLH)
- Maintain availability of captan as management material. (Bot)
- Maintain all currently available chemical management materials. (LSp)

Desired revisions

- Registration for use in New England of management materials for problem weeds is the most important need. NOTE: Management materials for weeds such as: chickweed, oxalis, field pansy, legumes, nutsedge, and marestail exist but are not labeled for use with strawberry crops in New England.
- Re-examine current limits on Section 24(c) to allow broader use.
- Foster and enforce consistency among the varied international, federal, state, and county regulations, interpretation and enforcement in regards to use of firearms in agricultural situations. (Deer, Birds)
- Explore removing voles, particularly Pine voles and Meadow voles, from existing regulation. (Voles)
- Change falconry regulations to allow exercise of captive predators in strawberry fields. (Birds)

Research, Education, and Regulatory Priorities (continued)

Education Needs:

Scouting and identification

- Promote monitoring for movement of pest into field, and border application to reduce chemical use. (SBW)
- Encourage consistent scouting methods. (PLH)
- Raise awareness of the sporadic timing of the population influx due to migration process. (PLH)
- Advertise predictive models that are available. (Bot)
- Clarify the identification features of pest. (PLH)
- Clarify the identification features and differences between fungal and bacterial Leaf Spot, and Leaf Scorch and Powdery Mildew. Include differences in management options. (LSp, PM)
- Clarify the identification features and activity differences between vole species. (Voles)

Timing

- Encourage night-time application to protect pollinators. (TPB)
- Provide information for growers about proper timing for application of materials i.e. do not apply prior rain that will wash off material. (Bot)
- Promote the importance of bloom-time application of materials, weather permitting. (Bot)
- Encourage the importance of management following renovation to prevent disease carry-over into spring. (LSp)
- Raise awareness that growers must manage for disease in the spring if disease was present in the prior season. (LSp)
- Promote the necessity of pre-plant perennial weed management.

Methods

- Promote the necessity for acidified water in spray tank through filling sequence (add adjuvant first), combination with fertilizers, etc. (Bot)
- Clarify that water soluble bags do not dissolve in spray tank with Boron. (PM)
- Promote the practice of reserving one strobilurin application allotment for treatment of a summer disease such as Leaf Spot. (LSp)
- Provide information for growers about chickweed management.
- Develop detailed vole management plans. (Voles)
- Encourage placement of perches and houses to encourage predators to nest and hunt near strawberry fields. (Birds)

Research, Education, and Regulatory Priorities (continued)

Awareness

- Raise awareness of the need to protect pollinators in contrast with the need to apply management materials as determined by scouting. (TPB)
- Clarify that the use of floating row covers and high tunnel systems hasten disease onset and there is need to check under covers to monitor plants. (Bot, PM)
- Provide information on new varieties that may be more susceptible to disease. (LSp)
- Raise awareness that PM affects the flavor of day-neutral fruit. (PM)
- Provide information on the effect of preventative sprays over time in contrast to emergency use, "clean-up" sprays. (PM)
- Clarify for growers the use of different materials during pre-plant and against pre-emergent or post-emergent weeds. Different materials are appropriate to the different situations.
- Raise awareness that vertebrate wastes create possible routes for fecal contamination of crop. (Deer, Voles, Birds)
- Create awareness among growers of availability of captive predators that may be exercised in strawberry fields. (Birds)
- Growers need to report damage to wildlife services to document the effect of pests. This may influence further funding towards management issues for these pests. (Birds)
- Develop information to assist growers to answer questions from customers about residue. (Bot)

III. Strategic Issues for Key Strawberry Pests

Key Insects and Mite pests

Tarnished Plant Bug *(Lygus lineolaris)*

% Acres Affected: 87% of strawberry acres affected annually.
Yield Losses: 100% without management, 5% with management.

Currently Registered Pesticides

Pesticide (listed alphabetically)	**Efficacy**	**Pros**	**Cons**	**Comments**
azadirachtin (Aza-Direct)		• Short REI	• Efficacy questionable	• OMRI listed
bifenthrin* (Brigade WSB)	37% excellent 63% good	• Short REI convenient for use with day-neutral varieties • Possible efficacy against other insects (especially Sap Beetles)	• Can trigger serious Two-Spotted Spider Mite problems • Application rate recommendations are very confusing • Harmful to beneficials	• Restricted use material • Broad spectrum
carbaryl* (Sevin 80S, 80WSB, XLR)	20% excellent 60% good 20% poor	• Can be effective against other insects	• Toxic to pollinators • Nighttime application necessary to avoid harming bees • Phytotoxicity possible • Long PHI	• Not restricted use • Not first choice against Tarnished Plant Bug
endosulfan* (Phaser 3EC, Thiodan EC, Thionex)	54% excellent 33% good 13% poor	• Also effective against some other insects	• Malodorous • Long PHI	• Maximum 3 applications per year • Labels are different between formulations • Early application in spring after mulch removal

fenpropathrin* (Danitol 2EC)	56% excellent 44% good	• Also effective against some other insects and mites • Inexpensive • Short PHI	• Harmful to beneficials	• New material to market • Restricted use material • Broad spectrum • 24 hr REI
malathion* (Malathion 57EC)	17% excellent 33% good 50% poor	• Useful to small grower on many crops and against many insects • Inexpensive	• Timing important for effectiveness • Malodorous • Long PHI	• 12 hour REI • Labeled use for genus (lygus bugs) not species • Not restricted use
methomyl (Lannate SP)			• Very long PHI • Can trigger serious Two-Spotted Spider Mite problems • Toxic to beneficials • Very highly toxic to mammals	• Packaging (water soluble bags) is inconvenient for use in small quantities
naled* (Dibrom 8EC)	63% excellent 37% good	• Very effective when used in combination with malathion under conditions of high pest-pressure • Short PHI	• Highly toxic to mammals	• Requires high gallonage • Requires slow drying conditions after application
pyrethrins (Pyganic EC1.4)			• Repeat applications may be necessary • Phytotoxicity possible • Expensive	• OMRI listed • Questionable efficacy

*Materials specified in Crop Profile. Other materials are additional and efficacy data are based on limited input where available.

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Plant resistant cultivars			
Reduce proximity to alfalfa and other forage legumes or weeds	• Discourages migrating pests such as TPB and PLH		
Encourage proximity to woods	• Reduced early succession herbaceous growth that may harbor pests		
Avoid mowing during bloom			
Avoid use of broad spectrum insecticides on strawberries and surrounding crops	• Encourages predators (esp. spiders) and parasites	• Difficult to do under other pest pressure	• Introduce parasites following applications
Encourage or introduce parasites		• Difficult to do under other pest pressure • Native parasites seem to be more effective at parasitizing on weeds than on crops • No native parasites are commercially available at this time • Expensive	
Beauveria bassiana (BotaniGard ES) is a fungal pathogen of *Lygus* bugs	• Available commercially	• Expensive	
Use row covers to accelerate plant development	• Plant development outpaces effect of pest	• Potential for frost damage • Will not prevent SBW damage • Some weeds thrive under row covers	

Research Needs:

- More chemistries are needed that are novel, safe to use, and well-suited to an integrated pest management system.
- Explore effects of the insecticide Warrior against TPB on strawberries. This insecticide is currently registered for TPB on other crops.
- Develop degree day models predicting hatch or egg-laying for better management timing.
- Discover an effective way to target management against egg-laying females before bloom period of crop.
- Study the economics for application of parasites as a management tool.

Regulatory Needs:

- Create incentives for product packaging that is practical for small growers. Certain packaging, such as water soluble bags, is inconvenient for use in small quantities.
- Clarify labeled application rate recommendations for bifenthrin.
- Include storage information and shelf life on packaging.

Education Needs:

- Raise awareness of the need to protect pollinators in contrast with the need to apply management materials as determined by scouting.
- Encourage night-time application to protect pollinators.

Strawberry Bud Weevil, a.k.a. Clipper *(Anthonomus signatus)*

% Acres Affected: 64% of strawberry acres affected annually.
Yield Losses: 40% without management, <2% with management.

Currently Registered Pesticides

Pesticide (listed alphabetically)	**Efficacy**	**Pros**	**Cons**	**Comments**
azadirachtin (Aza-Direct)		•Short REI	•Efficacy questionable	•OMRI listed
bifenthrin* (Brigade WSB)	56% excellent 44% good	•Short REI convenient for use with day-neutral varieties •Possible efficacy against other insects (especially Sap Beetles)	•Can trigger serious Two-Spotted Spider Mite problems •Application rate recommendations are very confusing •Harmful to beneficials	•Restricted use material •Broad spectrum
carbaryl* (Sevin 80S, 80WSB, XLR)	75% excellent 25% good	•Can be effective against other insects	•Toxic to pollinators •Nighttime application necessary to avoid harming bees •Phytotoxicity possible •Long PHI	•Not restricted use •Efficacy may not be as excellent as growers reported in survey
chlorpyrifos (Lorsban 4E, Whirlwind, Warhead, Govern 4E)	67% excellent 33% good	•Also effective against grubs (when applied at different time of year)	•May only be applied pre-bloom to a maximum 2 applications •Highly toxic to mammals	•Restricted use material
fenpropathrin (Danitol2EC)		•Also effective against some other insects and mites •Inexpensive •Moderately toxic to mammals	•Harmful to beneficials	•New material to market •Restricted use material •Broad spectrum •24 hr REI

malathion (Malathion 57EC)	100% excellent	•Useful to small grower on many crops and against many insects •Inexpensive	•Malodorous •Long PHI	•12 hour REI •Not restricted use •Efficacy may not be as excellent as growers reported in survey
pyrethrins (Pyganic EC1.4)			•Repeat applications may be necessary •Phytotoxicity possible •Expensive	•OMRI listed •Questionable efficacy

*Materials specified in Crop Profile. Other materials are additional and efficacy data are based on limited input where available.

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Reduce proximity to unmanaged hosts and weeds (especially brambles)	•Discourages migrating pests		
Keep field in production for no more than three years	•Reduces the chances of injury		
Plow under old beds immediately after the final harvest	•Reduces the chances of injury		
Early renovation of established beds	•Reduces the chances of injury		
Some cultivars, e.g., 'Seneca' and 'Jewel' have been shown to strongly compensate for injury	•Increased size of secondary and tertiary fruit when primary buds are compromised by oviposition		•Ability to compensate is unknown for many varieties

Research Needs:

- More chemistries are needed that are novel, safe to use, and well-suited to an integrated pest management system.
- Develop an alternative to methoxychlor as a management tool. This is currently the material of choice; there is no suitable substitute available.
- Determine efficacy of Aza-Direct and other materials of questionable management value.
- Develop phenology models for better management timing.
- Study ability of different cultivars to compensate for various levels of insect injury.
- Explore effects of nonchemical management options, including use of nematodes.

Regulatory Needs:

- Re-registration of methoxychlor for use against SBW is desired.

Education Needs:

- Promote monitoring for movement of pest into field and border application to reduce chemical use.

Potato Leafhopper *(Empoasca fabae)*

% Acres Affected: 30% of strawberry acres affected annually.
Yield Losses: Indirect impact on yield. Damage occurs during establishment.

Currently Registered Pesticides

Pesticide (listed alphabetically)		**Pros**	**Cons**	**Comments**
carbaryl (Sevin 80S, 80WSB, XLR)	57% excellent 43% good	•Can be effective against other insects	•Toxic to pollinators •Nighttime application necessary to avoid harming bees •Phytotoxicity possible •Long PHI	•Not restricted use
endosulfan (Phaser 3EC, Thiodan EC, Thionex)	25% excellent 75% good	•Also effective against some other insects	•Malodorous •Long PHI	•Maximum 3 applications per year •Labels are different between formulations
imidacloprid (Provado, Admire Pro, Nuprid)		•Low toxicity to beneficials •Long residual in some formulations •Aphids and whiteflies management and ant bait	•Expensive •Packaging not sized for small growers	•Label variable by state
malathion* (Malathion 57EC, Cythion)	27% excellent 73% good	•Useful to small grower on many crops and against many insects •Inexpensive	•Malodorous •Long PHI	•12 hour REI •Not restricted use

pyrethrins (Pyganic EC1.4)	63% excellent 37% good		•Repeat applications may be necessary •Phytotoxicity possible •Expensive	•OMRI listed

*Materials specified in Crop Profile. Other materials are additional and efficacy data is based on limited input where available.

Nonchemical (Cultural and Biological) Alternatives

None identified

Research Needs:

- More chemistries are needed that are novel, safe to use, and well-suited to an integrated pest management system.
- Determine efficacy of imidacloprid as a management tool.

Regulatory Needs:

- Create incentives for product packaging that is practical for small growers. Certain packaging, such as water soluble bags, is inconvenient for use in small quantities.
- Labeling of imidacloprid and endosulfan for use against PLH is desired.

Education Needs:

- Encourage consistent scouting methods.
- Clarify the identification features of pest.
- Raise awareness of the sporadic timing of the population influx due to migration process.

Selected Comments on Other Insects and Slugs

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

Meadow Spittlebug

- Presence is highly visible and unappealing to PYO customers.
- Management thresholds exist.
- Chemical management occurs prior to periods when PYO customers are in field.
- Short PHI has a minimal effect on PYO operation.
- Weed management will minimize pest population.
- Raise awareness among customers of harmlessness of pest.

Root weevils (*Otiorhynchus* spp., *Polydrusus* spp.)

- Extremely devastating when outbreak occurs, even in planting year. Capable of putting a grower out of business.
- Very difficult to remove from field, even with rotation.
- Must continuously rotate, fallow and turn field to reduce populations.
- Large host range, including weeds.
- Populations will build up over time.
- Mild winters or row covers can encourage longer lifespan and more eggs.
- Adults feed at night, hide during the day.
- Adults migrate by walking or transport, do not fly.
- Only one chemical management material currently available (Brigade), which requires high rates and is effective only against adults.
- Parasitic nematodes are an available management option but are difficult to use.
- Develop materials that are effective against root weevil grubs.
- Reregistration of Furadan is desired.

Strawberry sap beetle (*Stelidota geminata*)

- Emerging problem in New England.
- Produce aggregation pheromones that attract population into field.
- Higher numbers are found in renovated fields.
- Hides in and under berries, making it difficult to target with pesticides.
- Only four chemical management materials currently available (Brigade, Danitol, PyGanic, malathion).
- Efficacy of PyGanic is questionable.
- Brigade is useful because of short PHI.
- Encourage field sanitation and removal of ripe fruit as management practice.
- Study the efficacy of perimeter baiting as a management tool.
- Evaluate crop mixes that encourage or discourage pest population.
- Research nematodes as a management tool.
- Research synthetic aggregation pheromone to use in trapping.
- Research role of alternate food sources (e.g., raspberry, peach, melon, corn) in building up populations in diversified farms.

Two-spotted spider mite (*Tetranychus urticae*)

- Emerging problem among day-neutral, row cover, and plasticulture crops.
- Predacious mites manage to hold in check unless disrupted in conventional cropping systems.
- At least eight currently registered materials and new management materials are coming onto market.
- Organic options are available and are viable alternatives.
- Examine potential of synthetic pyrethroids to have significant disruption of beneficials.
- Examine materials registered in greenhouse systems that might be effective if labeled for strawberry.

White grubs of various beetles (*Maladera castanea, Rhizotrogus majalis, Popillia japonica, Exomala orientalis*)

- Emerging problems with exotic species, resistance among current species, and in plasticulture systems.
- Somewhat managed through grassy weed management.

Strawberry rootworm (*Paria canella*)

- Can kill crop when outbreak occurs.

Thrips (*Thysanoptera*)

- Difficult to identify.
- Frequently undiagnosed or misdiagnosed

Slugs

- At least a half dozen species affect strawberries.
- Pest is prevalent in wet years.
- Mulches encourage slug problems by providing moist, dark environment.
- Feeding on fruit affects appearance and creates disease infection sites.
- Iron phosphide and metaldehyde baits are expensive.
- Metaldehyde is available in several formulations and care is needed to apply the one for strawberries
- Metaldehyde needs to be applied proactively prior to harvest to allow for delayed effect.
- Metaldehyde formulations are becoming unavailable as re-registration is in jeopardy.
- Raise awareness that application of baits is necessary in fall to target species that overwinter as eggs.
- Encourage research on pest and management options.

Key Diseases

Gray Mold (*Botrytis cinerea*)

% Acres Affected: 87% of strawberry acres affected annually.
Yield Losses: >50% without management, <10% with management.

Currently Registered Pesticides

Pesticide (listed alphabetically)		**Pros**	**Cons**	**Comments**
azoxystrobin* (Quadris, Abound)	55% excellent 45% good	•Effective	•Not recommended for use near apple orchards •Cannot remove residue from spray tank •Very expensive •Number of applications limited	•Labeled for suppression only •Should be rotated with materials with other chemistries to prevent resistance
captan* (Captan 50W, Captec and others)	54% excellent 43% good 3% poor	•Long residual •Broad spectrum fungicide •Good alternate chemistry for use in resistance management	•Used as preventative and will only slow spread if disease already present •No postinfection effect •Persistent residue can be problem •Do not apply with or after oils	•Highly recommended as a tank mix with other fungicides
captan + fenhexamid (Captivate 68WDG)	100% good			•May be less expensive to tank mix on site than to use premixed formulations
cyprodinil + fludioxinil* (Switch 62.5WG)	76% excellent 24% good	•Residual effective into postharvest	•Expensive •Number of applications limited	•Very new material to market

fenhexamid* (Elevate 50WDG)	69% excellent 31% good	• Effective • Reasonable price • OK to apply during bloom	• Not broad spectrum • Need to tank mix for resistance management	• Standard alternate chemistry with captan for use in resistance management
hydrogen dioxide (Oxidate)	100% excellent	• Will work if in contact with fruit • Zero PHI • Can tank mix with almost anything • Very broad spectrum (will disinfect field)	• No residual • Must have clean spray tank • Must have thorough coverage	• OMRI listed • Rescue spray
paraffinic oil (JMS Stylet Oil)		• Organic	• Requires multiple applications • Phytotoxicity possible on hot days • Cannot be mixed with or near captan	
pyraclostrobin* (Cabrio EG)	75% excellent 25% good	• Broad spectrum • The preferred product for use near apple orchards	• Moderately effective • Resistance development possible • Number of applications limited	• Labeled for suppression only • Quick development of resistance is known for cucurbit crops
pyraclostrobin + boscalid (Pristine)	100% excellent	• Very effective • Broad spectrum • OK for use near apple orchards	• Very expensive • Number of applications limited	• Relatively new material to market

thiophanate methyl* (Topsin-M)	50% excellent 50% good	• Inexpensive • Broad spectrum • Effective in tank mix with captan • Good alternate chemistry with strobilurins for use in resistance management	• Resistance development possible if not alternated with other chemistries • Not as effective as newer materials • Not recommended for use when disease pressure is high	
thiram* (Thiram 65WSB)	50% excellent 33% good 17% poor	• Good rabbit and deer repellant • Inexpensive	• Effective strictly as preventative	• Alternate chemistry with captan for use in resistance management • Rarely used by itself but in combination with other chemistries

*Materials specified in Crop Profile. Other materials are additional and efficacy data are based on limited input where available.

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Remove all fruit from field	Decreases inoculum	• Labor intensive • Awkward to time around customers in field	
Keep rows narrow and well spaced and/or use raised beds. Orient rows in direction of prevailing winds.	• Improves air circulation		• Mechanical thinner
Proper nitrogen and weed management to avoid excessive canopy growth	• Improves air circulation		
Allow drying time prior to evening following overhead irrigation. Use drip irrigation during harvest.	• Can apply pesticides through irrigation system		• Optimizes drying conditions
Plant resistant cultivars			
Molasses	• Functions as sticker • Stimulates microflora		• Need more information on activity

Research Needs:

- Develop disease-resistant varieties.
- Explore effective organic management tools.
- More chemistries are needed that are novel, safe to use, and well-suited to an integrated pest management system.
- New chemistries are needed that discourage development of resistance. Current chemistries often foster development of resistance.
- Develop and retain effective weather predicting tools that can integrate with management planning.

Regulatory Needs:

- Maintain availability of captan as management material.

Education Needs:

- Promote the necessity for acidified water in spray tank through filling sequence (add adjuvant first), combination with fertilizers, etc.
- Develop information to assist growers to answer questions from customers about residue.
- Promote the importance of bloom-time application of materials, weather permitting.
- Provide information for growers about proper timing for application of materials i.e. do not apply prior rain that will wash off material.
- Advertise predictive models that are available.
- Clarify that the use of floating row covers hastens disease onset and there is need to check under covers to monitor plants.

Leaf Spot (*Mycosphaerella fragariae*)

% Acres Affected: 44% of strawberry acres affected annually.
Yield Losses: No documented direct yield impact, but may weaken plants and reduce yield indirectly.

Currently Registered Pesticides

Pesticide (listed alphabetically)		**Pros**	**Cons**	**Comments**
azoxystrobin* (Quadris Abound)	25% excellent 75% good	•Effective	•Not recommended for use near apple orchards •Cannot remove residue from spray tank •Very expensive •Number of applications limited	•Labeled for suppression only •Should be rotated with materials with other chemistries to prevent resistance
captan* (Captan 50W, Captec and others)	40% excellent 60% good	•Long residual •Broad spectrum fungicide •Good alternate chemistry for use in resistance management	•Used as preventative and will only slow spread if disease already present •No postinfection effect •Persistent residue can be problem •Do not apply with or after oils	•Highly recommended as a tank mix with other fungicides
cyprodinil + fludioxinil (Switch 62.5WG)	no rating		•Expensive •Number of applications limited	•Very new material to market •Primary use against Botrytis
dodine* (Syllit FL)	100% excellent		•Not very effective •Permanent resistance probable •Expensive	•Efficacy may not be as excellent as growers reported in survey

myclobutanil (Nova 40W)	100% excellent	• Moderately expensive	• Number of applications limited • 30 day interval between last application and planting of new crop	• Primary use against Powdery Mildew • Registration new for strawberries
pyraclostrobin* (Cabrio EG)	54% excellent 46% good	• Broad spectrum • The preferred product for use near apple orchards	• Resistance development possible • Number of applications limited	• Labeled for suppression only • Quick development of resistance is known for cucurbit crops
thiophanate methyl* (Topsin-M)	33% excellent 58% good 9% poor	• Inexpensive • Broad spectrum • Effective in tank mix with captan • Good alternate chemistry with strobilurins for use in resistance management	• Resistance development possible if not alternated with other chemistries	

*Materials specified in Crop Profile. Other materials are additional and efficacy data are based on limited input where available.

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Keep rows narrow and well spaced and/or use raised beds. Orient rows in direction of prevailing winds.	• Improves air circulation		• Mechanical thinner
Proper nitrogen and weed management to avoid excessive canopy growth	• Improves air circulation		
Plant resistant cultivars		• Difficult to find	
Mowing at renovation	• Helps suppress disease	• Must incorporate or remove leaves to be effective	

Research Needs:

- Develop disease-resistant varieties.
- Explore effective organic management tools.
- Determine the economic thresholds for Leaf Spot on strawberry crops.

Regulatory Needs:

- Maintain all currently available chemical management materials.

Education Needs:

- Clarify the identification features and differences between fungal and bacterial Leaf Spot, and Leaf Scorch and Powdery Mildew. Include differences in management options.
- Encourage the importance of management following renovation to prevent disease carry-over into spring.
- Raise awareness that growers must manage for disease in the spring if disease was present in the prior season.
- Provide information on new varieties that may be more susceptible to disease.
- Promote the practice of reserving one strobilurin application allotment for treatment of a summer disease such as this.

Powdery Mildew (*Sphaerotheca macularis*)

% Acres Affected: 52% of strawberry acres affected annually.
Yield Losses: No documented direct yield impact, but may weaken plants and reduce yield indirectly.

Currently Registered Pesticides

Pesticide (listed alphabetically)		**Pros**	**Cons**	**Comments**
azoxystrobin* (Quadris, Abound)	56% excellent 44% good	• Effective	• Not recommended for use near apple orchards • Cannot remove residue from spray tank • Very expensive • Number of applications limited	• Should be rotated with materials with other chemistries to prevent resistance
captan (Captan 50W, Captec and others)	100% good	• Long residual • Broad spectrum fungicide • Good alternate chemistry for use in resistance management	• Used as preventative and will only slow spread if disease already present • No postinfection effect • Persistent residue can be problem • Do not apply with or after oils	• Highly recommended as a tank mix with other fungicides
harpin protein (Messenger STS)	no rating		• May take a long time to have an effect	• Not very effective by itself but works well as part of a management system • New material to market

hydrogen dioxide (Oxidate)	100% good	• Will work if in contact with fruit • Zero PHI • Can tank mix with almost anything • Very broad spectrum (will disinfect field)	• No residual • Must have clean spray tank • Must have thorough coverage • Infected areas of foliage turn brown following application	• OMRI listed • Rescue spray
myclobutanil (Nova 40W)	100% good	• Moderately expensive	• Number of applications limited • 30 day interval between last application and planting of new crop	• Primary use against Powdery Mildew • Registration new for strawberries
pyraclostrobin* (Cabrio EG)	83% excellent 17% good	• Broad spectrum • The preferred product for use near apple orchards	• Resistance development possible • Number of applications limited	• Quick development of resistance is known for cucurbit crops
pyraclostrobin + boscalid (Pristine)	100% excellent	• Very effective • Broad spectrum • OK for use near apple orchards	• Very expensive • Number of applications limited	• Relatively new material to market
sulfur* (Kumulus DF and other formulations)	50% good 50% no rating	• Inexpensive • No resistance development	• Possible acidification of soil with heavy use • Deleterious effects on soil microbes with heavy use • Can cause burns on skin during harvest • Can not apply during high temp/humidity	• Most available formulations are organic • Often recommended

thiophanate methyl* (Topsin-M)	50% excellent 50% good	• Inexpensive • Broad spectrum • Effective in tank mix with captan • Good alternate chemistry with strobilurins for use in resistance management	• Resistance development possible if not alternated with other chemistries	

*Materials specified in Crop Profile. Other materials are additional and efficacy data are based on limited input where available.

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Keep rows narrow and well spaced and/or use raised beds. Orient rows in direction of prevailing winds.	• Improves air circulation		• Mechanical thinner
Plant resistant cultivars			
Molasses	• Functions as sticker • Stimulates microflora		• Need more information on activity

Research Needs:

- Explore effective organic management tools.
- Examine the efficacy of lime sulfur as a fungicide on strawberries.
- Extend research on effects of harpin protein as a fungicide.
- Determine the uses and efficacy of molasses in fungicide protocols.
- Adapt existing models (degree day, leaf wetness, etc.) for Powdery Mildew from other crops for use with strawberry crops.

Regulatory Needs:

- Create incentives for product packaging that is practical for small growers. Certain packaging, such as water soluble bags, is inconvenient for use in small quantities.

Education Needs:

- Clarify the identification features and differences between fungal and bacterial Leaf Spot, and Leaf Scorch and Powdery Mildew. Include differences in management options.
- Raise awareness that PM affects the flavor of day-neutral fruit.
- Clarify that water soluble bags do not dissolve in spray tank with Boron.
- Clarify that the use of high tunnel systems hastens disease onset and there is need to check under covers to monitor plants.
- Provide information on the effect of preventative sprays over time in contrast to emergency use, "clean-up" sprays.

Selected Comments on Other Diseases

These diseases are not considered Key Pests but do warrant special note as existing or emerging issues in New England. Although not annual problems, presence of these diseases can cause significant damage to crop. Some of these diseases can be of higher priority than a Key Pest. Many of these diseases have limited management options and development of more or better management options are highly desired.

Leaf Scorch (*Diplocarpon earliana*)

- No documented direct yield impact, but may weaken plants and reduce yield indirectly.
- Mowing at renovation helps suppress disease provided leaves are incorporated or removed.
- Crop rotation can eliminate susceptible plant tissue and break disease cycle but may be difficult with limited land area.
- Explore effective organic management tools.
- Clarify the identification features and differences between fungal and bacterial Leaf Spot, and Leaf Scorch and Powdery Mildew. Include differences in management options.

Black Root Rot (*Rhizoctonia, Pythium, Pratylenchus*)

- Extremely devastating when outbreak occurs. Capable of putting a grower out of business.
- Emerging problem in New England.
- No management tools are available.

Research

- Research is needed into this complex and influences on development.
- Evaluate possible herbicide effects that trigger disease development.
- Examine soil insects and nematodes that may damage root systems and encourage disease.
- Develop models to address nematode assay results that relate to disease development.

Regulation

- Allow registration of materials that manage the pests as well as soil insects and nematodes.
- Create incentives to address the need for more affordable nematode specialists and assay labs in New England.

Education

- Clarify the identification features of the pests and the influence of the complex.

Red Stele (*Phytophthora fragariae*)

- Extremely devastating when an outbreak occurs. Capable of putting a grower out of business.
- Only three chemical management materials currently available.
- Develop new resistant varieties and screening practices.
- Clarify the identification features of the pest.
- Raise awareness that overdependence on Aliette as a management tool will develop resistance.

Leather Rot (*Phytophthora cactorum*)

- Emerging problem with day-neutral, plasticulture crops.
- Only two chemical management materials currently available.
- Raise awareness about benefits of minimizing water splashing on plants

Leaf Blight (*Phomopsis obscurans*)

- Typically managed by other broad spectrum materials, loss of which could result in increase of this disease.

Bacterial Angular Leaf spot (*Xanthomonas fragariae*)

- Management options are limited to clean nursery stock and long rotations.
- No chemical management tools are available.
- Clarify the identification features and differences between fungal and bacterial Leaf Spot, and Leaf Scorch and Powdery Mildew. Include differences in management options.

Verticillium Wilt (*Verticillium albo-atrum*)

- Extremely devastating when outbreak occurs. Capable of putting a grower out of business.
- Management options are limited to long term rotation and soil fumigation.
- Develop disease-resistant varieties.

Anthracnose (*Colletotrichum* spp.)

- Emerging problem in New England in many different crops.
- A problem on day-neutral, plasticulture strawberry crops.
- Irrigation practices are important to management.
- Register Procloraz for use in USA. Effective management tool in other countries.

Weeds

Annual Grass weeds
Annual Broadleaf weeds
Perennial Grass weeds.
Perennial Broadleaf weeds

% Acres Affected: 100%
Yield Losses: 10-90% depending on weed pressure. Directly compete with crop. Act as alternate host and harborage for other pests.

General description of herbicide practices: Weed infestations occur in mixed populations (i.e., annual and perennial grasses and broadleaf weeds). Herbicide applications are made often to control a range of weeds. Success in weed management can start with pre-plant site preparation practices including herbicide applications. Herbicide use is described below in table summarizing pre-plant applications and post plant pre-emergence and post-emergence herbicide applications.

Currently Registered Pesticides: Pre-plant

Pesticide (listed alphabetically)		**Pros**	**Cons**	**Comments**
dazomet (Basamid)		•Easier for small grower to apply than other fumigants •Suitable for use with plasticulture •Broad spectrum affects more than weeds	•Poor efficacy against legumes	•Soil fumigant •Restricted use material
glyphosate* (Roundup Ultra 4S)	65% excellent 30% good 5% poor	•Very effective against perennial grasses and broadleaf weeds	•No residual activity	•No applications after planting •Many brands available •Label confusing as to regulation
metam-sodium (Vapam HL)*	100% excellent	•Suitable for use with drip irrigation and plasticulture •Broad spectrum affects more than weeds	•Poor efficacy against legumes	•Soil fumigant •Restricted use material
methyl bromide + chloropicrin (Terr-O-Gas 33)	33% excellent 67% good	•Suitable for use with plasticulture •Broad spectrum affects more than weeds	•Extremely expensive due to ozone issues •Expense makes use impractical in many instances •Poor efficacy against legumes	•Soil fumigant •Restricted use material
oxyfluorfen (Goal 2XL)	100% excellent	•Good burn down of small weeds	•Disturbance of ground required	•Label not appropriate for New England soils (required disturbance)
paraquat* (Gramoxone Max)	50% excellent 50% no rating	•Good burn down of broadleaf weeds •Good burn down of weed runners	•No residual activity •No systemic activity •Does not affect small grasses •Highly toxic	•Restricted use material

Currently Registered Pesticides: Pre-emergence

Pesticide (listed alphabetically)		**Pros**	**Cons**	**Comments**
DCPA (Dacthal F, W75)	23% excellent 54% good 23% poor		• Limited spectrum of affected weeds • Short residual activity • Very expensive	• New label drastically reduced use due to expense
flumioxazin (Chateau)		• Effective against broadleaf weeds	• Residual activity only • Timing important (dormant application)	• Supplemental label
napropamide* (Devrinol 50DF)	19% excellent 73% good 8% poor	• Safe on most plantings	• Must have rainfall, irrigation or cultivation to prevent volatizing material with sun exposure	• Primary herbicide for use against annual grass and chickweed
terbacil* (Sinbar)	100% excellent	• Good to very effective against very small and broadleaf weeds	• Poor efficacy against grasses • Varietal differences influence effectiveness • Overuse can reduce vigor of crop, contribute to black root rot, etc.	• Long half-life

Currently Registered Pesticides: Post-emergence

Pesticide		Pros	Cons	Comments
2,4-D* (Formula 40, Amine 4)	28% excellent 65% good 7% poor	•Very effective against broadleaf and non-creeping perennial weeds	•Poor efficacy against chickweed •Number of applications limited •Strawberry plants must be dormant or at renovation •Improper timing results in misshapen fruit	•Still very important material for most growers
clethodim* (Select 2EC)	9% excellent 91% good	•Effective against cool season and perennial grasses	•No residual activity •Should not apply during hot, humid conditions	•Must use crop oil and be cautious of use with captan
glyphosate (Roundup Ultra 4S)	100% excellent	•Very effective against perennial grasses and broadleaf weeds	•No residual activity	•No applications after planting •Many brands available •Label confusing as to regulation
paraquat* (Gramoxone Max)	73% excellent 27% good	•Good burn down of broadleaf weeds •Good burn down of weed runners	•No residual activity •No systemic activity •Does not affect small grasses •Highly toxic	•Restricted use material
pelargonic acid* (Scythe)	50% excellent 50% no rating 4% poor	•Good burn down of very small weeds •Low toxicity risk to humans	•Malodorous •Expensive •Not effective against large weeds and grasses	•Organic listing unresolved •Requires shielded application
sethoxydim* (Poast)	24% excellent 72% good 4% poor	•Very effective against summer annual grasses	•No residual activity •Should not apply during hot, humid conditions •Not as effective as clethodim on cool season and perennial grasses	•Must use crop oil and be cautious of use with captan
terbacil (Sinbar)	100% good	•Good to very effective against very small and broadleaf weeds	•Poor efficacy against grasses •Varietal differences influence effectiveness •Overuse can reduce vigor of crop, contribute to black root rot, etc.	•Long half-life

*Materials specified in Crop Profile. Other materials are additional and efficacy data are based on limited input where available.

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Black plastic	•Very effective in row •Heavier plastic potentially effective up to 2 years	•Must be careful about banding herbicides between plastic •Can encourage voles •Encourages Leather Rot and Anthracnose	•Disposal issues •Requires drip irrigation •Complicates between-row weed management
Mowing	•Removes seed heads	•Encourages lateral development	•Perform at renovation
Mulching	•Effective between plants •Effective against weeds	•Expensive •Encourages slugs and other pests	
Cultivation	•Effective against small weeds	•Ineffective in wet seasons •Ineffective in row	•Timing is critical •Potential to cultivate too deep
Hand weeding	•Effective	•Labor intensive	
Hoeing	•Effective	•Labor intensive	
Living mulch in aisles	•Effective against broadleaf weeds	•Competes with crop	
Weeder geese	•Effective against grasses	•Food safety concerns from geese waste (*Salmonella, E. coli*) •Feeding patterns variable •Fencing necessary to protect geese and focus feeding	•Perform following renovation and mid-summer
Flaming	•Effective against small broadleaf weeds	•Can't use with plastic •Poor efficacy against grasses •No residual effects	
Repeat pre-plant disturbance	•Encourages germination •Effective against annual weeds	•Does not allow enough perennial weed development to justify chemical management	•Can be performed with or without cover crops

Research Needs:

- Study use of living mulches that can stabilize applied mulch between rows. Data are needed on timing, varieties, kill methods (winter, chemical), and yield into successive growing seasons.
- Examine the efficacy and economics of different applied mulch materials.
- Explore options for management of problem weeds such as: chickweed, oxalis, field pansy, legumes, nutsedge, marestail. NOTE: Management materials for these weeds exist but are not labeled for use with strawberry crops in New England.
- Develop effective options for perennial broadleaf management.
- Develop new or improved cultivation equipment for in-row weed management.

Regulatory Needs:

- Registration for use in New England of management materials for problem weeds is the most important need. NOTE: Management materials for weeds such as: chickweed, oxalis, field pansy, legumes, nutsedge, and marestail exist but are not labeled for use with strawberry crops in New England.
- Encourage labels in specialty crops by setting up systems to offset liability complications.
- Streamline methods for acquiring Section 24(c) Special Local Need labels for Section 3 materials. An online form that allows users to register by reading agreement and clicking an “I Accept” button to print label is desired.
- Re-examine current limits on Section 249(c) to allow broader use.

Education Needs:

- Promote the necessity of pre-plant perennial weed management.
- Provide information for growers about chickweed management.
- Clarify for growers the use of different materials during pre-plant and against pre-emergent or post-emergent weeds. Different materials are appropriate to the different situations.

Key Vertebrates and other pests

Whitetail Deer (*Odocoileus virginianus*)

Currently Registered Pesticides: Post-emergence

Pesticide (listed alphabetically)		**Pros**	**Cons**	**Comments**
thiram		• Inexpensive		• Taste repellent

Nonchemical (Cultural and Biological) Alternatives

Method	**Pros**	**Cons**	**Comments**
Taste and smell repellents (fish emulsion, capsaicin, predator urine, putrescent egg solids, soaps, garlic, etc.)	• Can be effective	• Short residual effect • Limited range	
Electric fence	• Effective when combined with peanut butter and foil bait • Many portable options are available	• More effective on smaller acreage • Not effective when pest pressure is high	• Wide ribbon fence is more effective than wire
Fence (non-electric)	• Can be effective (depends on type)	• Very expensive initial cost	
Noise devices		• Neighbor annoyance • Deer become accustomed to	
Shooting	• Very effective	• Can be difficult to justify • Safety issues inherent	• Local agencies may control access to lethal controls
Dogs		• Not as effective at night when deer are active • Food safety concerns from dog waste (*Salmonella, E. coli*) • Require food and water maintenance • Fencing necessary to contain dogs	• Can post in field overnight

Research Needs:

- Explore efficacy of electronic recordings of dog barking.
- Determine the dollar value of yield loss due to damage from deer and other vertebrate feeding.

Regulatory Needs:

- Foster and enforce consistency among the varied international, federal, state, and county regulations, interpretation and enforcement in regards to use of firearms in agricultural situations.

Education Needs:

- Raise awareness that vertebrate wastes create possible routes for fecal contamination of crop.
- Raise awareness of Chronic Wasting Disease (CWD), a prion that causes mad cow-like disease in deer.

Mice and Voles (*Peromyscus sp, Microtus pennsylvanicus, Microtus pinetorum*)

Currently Registered Pesticides: Post-emergence

Pesticide (listed alphabetically)		**Pros**	**Cons**	**Comments**
zinc phosphide			• High potential for off-target kill	• Non harvest timing • Use with bait stations recommended

Nonchemical (Cultural and Biological) Alternatives

Method	**Pros**	**Cons**	**Comments**
Encourage natural enemies (cats, dogs, raptors, etc.)	• Several predators exist		
Weed management	• Reduces habitat		• Meadow vole specific
Sonic irritant		• Must move regularly • Not efficient for large acreage	
Traps		• Labor intensive • Limited efficacy	

Research Needs:

- Develop and test new chemistries that can provide more management options.
- Determine the dollar value of yield loss due to damage from deer and other vertebrate feeding.

Regulatory Needs:

- Explore removing voles, particularly Pine voles and Meadow voles, from existing regulation.

Education Needs:

- Raise awareness that vertebrate wastes create possible routes for fecal contamination of crop.
- Clarify the identification features and activity differences between vole species.
- Develop detailed vole management plans.

Birds (*various species*)

- Cedar waxwing is the most troublesome species.
- Turkeys are an increasing problem (they disrupt the mulch). Select mulch that will prevent attraction. Avoid pre-grain stage mulches.

Currently Registered Pesticides: None identified.

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Row covers or bird netting	•Physical barrier	•Labor intensive	
Scare devices (Scare eye balloons, mylar tape, mirrors)		•Must move or change regularly •Limited range •Can interfere with picker access	
Noise devices (fire crackers, bird bangers, propane cannon)		•Temporary effects •Annoying to neighbors •Fire potential	•Work better on transient flocking species
Owls and other predators (natural and artificial)		•Difficult to manage •Must move or change artificial predators regularly	•Accurate placement of artificial predators is necessary
Dead crows	•Extremely effective on crows		
Human presence	•Effective if pickers present		
Dogs		•Temporary effectiveness •Food safety concerns from dog waste (*Salmonella, E. coli*) •Require food and water maintenance •Fencing necessary to contain dogs	
Shooting		•Can be difficult to justify •Safety issues inherent	•Local agencies may control access to lethal controls

Research Needs:

- Explore the efficacy of placement of perches and houses to encourage predators to nest and hunt near strawberry fields.
- Expand studies of sound devices that attract predators and the timing of their use as management options.
- Measure the cost of using bird netting in relation to income from increased quality and/or volume of the crop and in relation to field size.

Regulatory Needs:

- Foster and enforce consistency among the varied international, federal, state, and county regulations, interpretation, and enforcement.
- Change falconry regulations to allow exercise of captive predators in strawberry fields.

Education Needs:

- Raise awareness that vertebrate wastes create possible routes for fecal contamination of crop.
- Create awareness among growers of availability of captive predators that may be exercised in strawberry fields.
- Encourage placement of perches and houses to encourage predators to nest and hunt near strawberry fields.
- Growers need to report damage to wildlife services to document the effect of pests. This may influence further funding towards management issues for these pests.

IV. Appendices

Strawberry Crop, Worker, Pest, and Pesticide Timing

	Mar.				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	1	2	3	4
Crop Stage																																
Bloom										X	X	X	X																			
Renovation																		X	X	X	X											
Worker activities																																
Soil Fumigation																									X	X	X	X	X	X	X	X
Land preparation and cultivation			X	X	X	X	X	X																	X	X	X	X	X	X	X	X
Planting*					X	X	X	X	X	X	X	X																				
Blossom Removal (Establishment Year Only)													X	X	X	X																
Fertilization																	X	X	X	X					X	X	X	X				
Harvest**												X	X	X	X	X	X	X														
Mulch Removal (Application in Nov/Dec)	X	X	X	X																												
Row-cover Installation	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							
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						

* for traditional matted row system. Other systems planted at other times.

** for June-bearing varieties.

SBW = Strawberry Bud Weevil
PLH = Potato Leaf Hopper
TPB = Tarnished Plant Bug
TSSM = Two-spotted Spider Mite
RW = Root Weevils
MS = Meadow Spittlebug
SB = Strawberry Sap Beetle
WG = White Grubs
RW = Strawberry Rootworm
Th = Thrips

	Mar.				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	1	2	3	4
Insect & Mite Pest Key Activity & Monitoring Periods																																
TPB									X	X	X	X	X	X	X																	
SBW								X	X	X	X	X																				
PLH														X	X	X	x	x	X	X	X	X										
TSSM											X	X	X	X	X	X	X				X	X	X	X	X							
RW																	X	X			X	X	X	X								
MS											X	X	X																			
SB												X	X	X	X																	
WG									X	X	X	X									X	X	X	X								
RW								X	X	X	X								X	X	X	X										
Th										X	X	X	X	X																		
Insecticide and Miticide Application Timing																																
TPB								X	X	X			X	X																		
SBW							X	X	X																							
PLH															X	X	X	X	X	X	X	X	X	X								
TSSM													X	X	X	X	X															
RW																			X	X	X	X										
MS												X	X																			
SB												X	X																			
WG									X	X	X	X									X	X	X	X								
RW																	X	X	X	X												
Th								X	X				X	X																		

	Mar.				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	1	2	3	4
Nonchemical Insect and Mite Pest Control Timing																																
TPB	Keep weeds in control all season; don't mow around field during pre-bloom or bloom.																															
SBW																																
PLH (N/A)																																
TSSM										X	X	X	X	X	X	X					X	X	X	X								
RW	Prompt renovation.																	X	X	X	X											
MS																																
SB																																
WG									X	X	X	X									X	X	X	X								
RW																																
Th																																

	Mar.				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	1	2	3	4
Diseases Key Activity & Monitoring Periods																																
Botrytis									X	X	X	X	X	X	X	X																
Leaf Spot									X	X	X	X									X	X	X	X	X	X						
Powdery Mildew																					X	X	X	X	X	X	X	X				
Leaf Scorch									X	X	X	X									X	X	X	X	X	X						
Black Root Rot					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Red Stele					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Leather Rot									X	X	X	X	X	X	X																	
Leaf Blight									X	X	X	X									X	X	X	X	X	X						
Bacterial Angular Leaf Spot									X	X	X	X	X	X	X	X																
Verticillium Wilt					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Anthracnose									X	X	X	X	X	X	X																	
Fungicide - Bactericide Application Timing																																
Botrytis									X	X	X	X	X	X	X	X																
Leaf Spot									X	X	X	X	X	X	X	X							X	X	X	X						
Powdery Mildew																					X	X	X	X	X	X	X	X				
Leaf Scorch											X	X											X	X	X	X						
Black Root Rot																												X	X	X	X	
Red Stele					X	X	X	X																	X	X	X	X				
Leather Rot									X	X	X	X																				
Leaf Blight											X	X											X	X	X	X						
Bacterial Angular Leaf Spot																																
Verticillium Wilt																																
Anthracnose									X	X	X	X																				

	Mar.				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	1	2	3	4
Weed Key Activity & Monitoring Periods																																
Annual grasses											X	X	X	X											X	X	X	X				
Perennial grasses																							X	X	X	X	X	X	X	X	X	X
Annual broadleaf						X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X				
Perennial broadleaf																							X	X	X	X	X	X				
Preplant																					X	X	X	X	X	X	X	X	X	X	X	X
Pre-emergence						X	X	X	X	X	X	X	X	X	X	X	X	X														
Post-emergence						X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
Herbicide Application Timing																																
Annual grasses					X	X	X	X										X	X	X	X	X	X	X								
Perennial grasses																									X	X	X	X	X	X	X	X
Annual broadleaf	X	X	X	X	X	X	X	X										X	X	X	X	X	X	X	X	X	X	X				
Perennial broadleaf	X	X	X	X													X	X														
Preplant																	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pre-emergence	X	X	X	X																	X	X	X	X	X	X	X	X	X	X	X	X
Post-emergence	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Nonchemical Weed Control Timing																																
Annual grasses											X	X	X	X	X	X																
Perennial grasses	X	X	X	X	X	X	X	X																								
Annual broadleaf	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Perennial broadleaf	X	X	X	X	X	X	X	X															X	X	X	X	X	X	X	X	X	X
Preplant																	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pre-emergence	X	X	X	X	X	X	X	X											X	X	X	X	X	X	X	X	X	X	X	X	X	X
Post-emergence	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	Mar.				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	1	2	3	4
Vertebrate Pest Control Timing																																
Deer*	x	x	x	x	x																								x	x	x	x
Voles	X	X	X	X	X	X	X	X																								
Birds												X	X	X	X	X	X															

* Deer browsing on established or newly planted beds can happen anytime, but may be more prevalent and damaging in the spring as new growth begins.

Pesticide and Non-chemical Methods for Insect and Mite Pests

Tables adapted from *New England Small Fruit Pest Management Guide 2003/2004*. http://www.umass.edu/fruitadvisor/nesfpmg/index.htm.

Pest Name Abbreviations
Aph = Aphids
SBW = Strawberry Bud Weevil
CM = Cyclamen Mite
PLH = Potato Leaf Hopper
SLR = Strawberry Leaf Roller
RWv = Root Weevils
SR = Strawberry Rootworm
SB = Strawberry Sap Beetle
MS = Meadow Spittlebug
Th = Thrips
TSSM = Two Spotted Spider Mite
TPB = Tarnished Plant Bug
WG = White Grubs
CW = Cutworms

Ratings:
3 = highly effective, 2 = moderately effective, 1 = slightly effective
* = labeled but insufficient data
- = not labeled
? = unknown
x = listed in 2005 *New England Strawberry Crop Profile* but not labeled in *New England Small Fruit Pest Management Guide 2003/2004*
1/- = 1 or - depending on brand
3/* = 3 or * depending on brand

Active ingredient or Method	Brand name(s)	Aph	SBW	CM	PLH	SLR	RWv	SR	SB	MS	Th	TSSM	TPB	WG	CW
abamectin	Agri-Mek 0.15 EC	-	-	1	-	-	-	-	-	-	-	3	-	-	
azinphos methyl	Guthion 2L, Solupak, Sniper WSP	*	-	-	-	3	-	-	-	2	-	-	-	-	?
bifenazate	Acramite 50WS											?			
bifenthrin	Brigade WSB	*	2	-	-	*	1	x	2	3	-	1	3	-	
carbaryl	Sevin 80S, 80WSB, XLR	-	*	-	x	2	x	x	-	2	x	-	*	*	?
chlorpyrifos	Lorsban 4E		?												
diazinon	Diazinon														?
dicofol	Kelthane	-	-	2	-	-	-	-	-	-	-	3		-	
endosulfan	Phaser 3EC or Thiodan EC	3/*	-	3	x	-	-	-	-	3/*	-	-	3/*	-	
esfenvalerate	Asana XL						?								
fenbutatin oxide	Vendex														
fenpropathrin	Danitol 2.4EC	-	-	-	-	-	x	x	-	3	-	1	3	-	?
hydrogen dioxide	OxiDate												?		
imidacloprid	Admire 2F						?	?						?	
malathion	Malathion 57EC, Cythion	*	x	-	*	*	*	x	1/-	-	*	*	2	-	
methoxychlor	Methoxychlor 50WP		?												
methyl bromide + chloropicrin	Terr-O-Gas 33						?								?
naled	Dibrom 8EC	*	-	-	-	*	-	-	-	*	*	*	3	-	
paraffinic oil	JMS Stylet oil											?			
permethrin	Ambush									?					
pyrethrins	Pyganic EC 5.0		r		?							x	r		

New Pest Management Technologies for Insect and Mite Pests

Method	Source	Status	Pests Affected
acequinocly/TM 413	IR4	Pending (Insecticide)	Broad spectrum mite control (no rust mite activity). Unique mode of action. Easy on beneficials with long residual activity.
Beauveria bassiana	Pipeline	Biopesticide (miticide) (insecticide); Registration Approved (miticide) (insecticide); Tolerance Accepted (insecticide) (miticide)	SOWBUGS, MILIPEDES, MITES, LEAFROLLERS, THRIPS, BEETLES, WEEVILS, BILLBUGS, WHITE GRUBS, FLEAHOPPERS, WHITEFLIES, APHIDS, LEAFHOPPERS, MEALYBUGS, PEAR PSYLLA, ANTS, CORN BORERS, LOOPERS
canola oil	Pipeline	Biopesticide (insecticide); Registration Approved (insecticide); Tolerance Accepted (insecticide)	MITES, PLANT BUGS, SCALES, WHITEFLIES, APHIDS, LEAFHOPPERS, PHYLLOXERANS, MEALYBUGS, PSYLLIDS, ADELGIDS, SAWFLIES
chlorfenapyr	IR4	Potential (Insecticide)	Controls selective lepidopteran larva, mites, some aphids, thrips, scale, leafminers.
Chrysoperla carnea	IR4	Potential (Insecticide)	Controls aphids.
etoxazole	IR4	Pending (Insecticide)	Insecticide/acaricide for control of Panonychus spp and Tetranychus spp., including hexythiazox resistant mite strains. Inhibition of molting, effective on eggs, larvae, & nymphs.
fenpyroximate	IR4	Potential (Insecticide)	Contols mites, including two-spotted, European red, and citrus rust mite and psylla.
imidacloprid	IR4	Pending (Insecticide)	Primarily effective against sucking insects (aphid, whitefly, scale, etc.) as well as beetles and grubs. Controls numerous pests which are resistant to insecticides.

imidacloprid	Section 18	crisis; issued	silverleaf whitefly
milbemectin	IR4	Pending (Insecticide)	Excellent miticide and also controls aphids, leafminers, thrips, leafhoppers.
pyridaben	IR4	Pending (Insecticide)	Activity on mite, whiteflies, aphids, mealybugs, leafhoppers, and thrips. A new class of insecticide offering long term residual control. Good for IPM/resistance management programs.
pyriproxyfen	IR4	Pending (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, not effective on adults
Telone	IR4	Potential (Nematicide)	Many soil insects, nematodes, and plant diseases.
tetradecadienyl acetate + tetradecenol	Pipeline	Biopesticide (insecticide); Registration Approved (insecticide)	BEET ARMYWORM
thiamethoxam	IR4	Pending (Insecticide); Potential (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.

Pesticide and Non-chemical Methods for Diseases

Tables adapted from *New England Small Fruit Pest Management Guide 2003/2004*. http://www.umass.edu/fruitadvisor/nesfpmg/index.htm.

Pest Name Abbreviations
Bot = Botrytis
LRt = Leather Rot
LSp = Leaf Spot
PM = Powdery Mildew
An = Anthracnose
RS = Red Stele
BRR = Black Root Rot
LB = Leaf Blight
LSh = Leaf Scorch
VW = Verticillium Wilt

Ratings:
4 = excellent, 3=good, 2=moderate, 2=poor
- =not effective or not labeled for this use
x = listed in 2005 *New England Strawberry Crop Profile* but not labeled in *New England Small Fruit Pest Management Guide 2003/2004*
* = See comments below table

Active ingredient or Method[a]	Brand name(s)	Bot	LRt	LSp	PM	An	RS	BRR	LB	LSh	VW
1,3 dichloropropene	Telone II*							?			
1,3 dichloropropene + chloropicrin	Telone C17, Telone C35							?			
azoxystrobin[d]	Quadris, Abound	1	1	3	3	4	-				
bifenthrin	Brigade WSB							?			
captan	Captan 50W, Captec and others	3	1	3	-	3	-		?	?	
captan + fenhexamid	Captivate 68WDG	?									
cyprodinil + fludioxinil[e]	Switch 62.5WG	4	-	-	-	2	-				
dodine	Syllit FL			?					?	?	
fenhexamid[c]	Elevate 50WDG	4	-	-	-	x	-				

fenhexamid + captan	various formulations	3	1	2	-	2	-				
fenhexamid + thiram	Elevate 50WDG + Thiram 65WSB	3	1	2	-	1	-				
fosetyl aluminum[b]	Aliette WDG	-	3	-	-	-	2				?
harpin protein	Messenger STS				?						
hydrogen dioxide	Oxidate	?	?		?						
imidacloprid	Admire 2F										
mefenoxam	Ridomil Gold EC	-	3	-	-	-	4				
metam-sodium	Vapam HL							?			
methyl bromide + chloropicrin	Terr-O-Gas 33						?	?			?
myclobutanil	Nova 40W			?	?				?	?	
nutraphos mg	Leffingwell		?				?				
pyraclostrobin	Cabrio EG	2	?	3	3	4	?				
pyraclostrobin + boscalid	Pristine	?			?					?	
sulfur	Kumulus DF and other formulations	-	-	-	3	-	-				
thiophanate methyl[c]	Topsin-M	3	-	3	2	1	-		?	?	
thiophanate methyl + captan	Topsin-M +captan	3	1	3	3	3	-				
thiophanate methyl + thiram	Topsin-M + thiram	3	1	3	3	2	-				
thiram	Thiram 65WSB	3	1	2	-	3	-		?		

a. This is not a complete listing of the fungicides used for strawberry disease management.
b. Limited efficacy data available for Aliette.
c. Fungicide that is prone to develop resistant strains of fungi for resistance management, Topsin-M, and Elevate are recommended only in combination with an unrelated fungicide such as; captan or thiram.
d. This material is extremely phytotoxic to McIntosh and some other apple varieties and should not be used near apples or in a sprayer also used on apples.
e. Note restrictive plant back regulations on this product.

New Pest Management Technologies for Diseases

Method	Source	Status	Pests Affected
azoxystrobin	Section 18	crisis; issued	anthracnose
Bacillus pumilus strain 2808	IR4	Pending (Fungicide)	Botrytis, downy and powdery mildews, rusts, Sclerotinia blight, and rots.
Bacillus subtilis strain GB03	IR4	Pending (Fungicide)	
BAS 516	IR4	Pending (Fungicide)	Broad spectrum activity on Anthracnose, Alternaria, downy mildew, powdery mildew, Botrytis, Sclerotinia, and Monilinia.
cinnamaldehyde	Pipeline	Biopesticide (miticide) (insecticide) (fungicide); Registration Approved (insecticide) (fungicide) (miticide)	DOWNY MILDEW, POWERY MILDEW, BOTRYTIS, MITES, THRIPS, BLUEBERRY MAGGOT, LYGUS BUGS, WHITEFLIES, APHIDS, LEAFHOPPERS
cyprodinil	Section 18	crisis; issued; withdrawn	gray mold
cyprodinil/fludioxonil	IR4	Pending (Fungicide)	Controls Botrytis, Alternaria, and Brown Rot.
famoxadone	IR4	Potential (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.
fluazinam	IR4	Potential (Fungicide)	Broad spectrum disease control: Alternaria, Botrytis, Cladosporium, Colletotrichum, Phytophthora, Plasmopara, Rhizoctonia, Sclerotinia, Venturia, Streptomyces, and some mites.
fludioxonil	Section 18	crisis; issued; withdrawn	gray mold
mepanipyrim	IR4	Potential (Fungicide)	Controls Botrytis. Mostly a preventive material, but has curative properties.

Milsana Bioprotectant	IR4	Pending (Fungicide)	Induces phytoalexins which infer resistance to powdery mildew and other diseases such as Botrytis.
nocobifen-BAS 510	IR4	Pending (Fungicide)	Manages powdery mildew, Alternaria, Botrytis, Sclerotinia and Monilinia
phosphoric Acid	IR4	Potential (Fungicide)	Downy mildew, scab, and root rot.
phosphorous acid and its sodium, potassium, and ammonium salts	Pipeline	Biopesticide (fungicide); Tolerance Accepted (fungicide)	Phytophthora and Pythium diseases, downy mildew
pyraclostrobin	IR4	Pending (Fungicide)	Broad spectrum activity on Anthracnose, Alternaria, downy mildew, Cercospora leaf spot, rust, powdery mildew, Septoria, Phytophthora, Pythium, Rhizoctonia.
pyrimethanil	IR4	Pending (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.
simeconazole	IR4	Potential (Fungicide)	Effective as seed treatment against Basidiomycetes.

Pesticide and Non-chemical Methods for Weeds

Tables adapted from *New England Small Fruit Pest Management Guide 2003/2004*. http://www.umass.edu/fruitadvisor/nesfpmg/index.htm.

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

Ratings:
4 = 90% control or better
3 = 75-90% control
2 = 50-75% control
1 = 5-50% control
0 = less than 5% control
x = listed in 2005 *New England Strawberry Crop Profile* but not labeled in *New England Small Fruit Pest Management Guide 2003/2004*

* = See comments below table

Active ingredient or Method	Brand name(s)	Pre-plant	Pre-Emergence			Post-Emergence		
			PER	AG	AB	PER	AG	AB
2,4-D[c]	Formula 40, Amine 4		x	x	x	0-4	0	2-4
clethodim	Select 2EC					x	x	x
DCPA[f]	Dacthal F, W75	x	0	2-4	0-4			
glyphosate[i]	Roundup Ultra 4S	x	3-4	4	4	x	x	x
metam-sodium	Vapam HL*	x						
methyl bromide + chloropicrin	Terr-O-Gas 33	x	x	x	x			
napropamide[e]	Devrinol 50DF		1	4	0-4	x	x	x
oxyflourfen[h]	Goal 2XL	x	0	2	2-4	x	x	x
paraquat[b]	Gramoxone Max	x	x	x	x	1	4	4
pelargonic acid[a]	Scythe					1	2	3
sethoxydim[d]	Poast					0-3	4	0
terbacil[g]	Sinbar	x	0-2	2-3	2-4	x	x	x

a. Scythe; non-selective contact herbicide. See information on rates and timings earlier in this section.
b. Gramoxone Extra; non-selective contact herbicide. Excellent for use on emerged vegetation. Use between rows, with directed spray; use shields to prevent contact with non-target plants; extremely toxic to birds and wildlife.
c. Amine 4; systemic broadleaf herbicide. Typically used just before renovation; allow 5 days before mowing; also can be used when strawberries are dormant on winter annuals and perennial broadleaf weeds. Never use an ester or low-volatile ester formulation.
d. Poast; systemic grass herbicide; use on actively growing grasses; will not kill old established grasses. Use with crop oil, avoid applying on hot humid days.
e. Devrinol; preemergent selective herbicide, must be activated with water or cultivation. Application after renovation for summer annual weed control or in late summer for winter annual weed control. Application before mulching will control volunteer grain from mulch. Heavy rates can inhibit daughter plant rooting.
f. Dacthal; preemergent selective herbicide, use after mulch removal in spring or in late fall; water or cultivation after application improves control. May be ineffective on cool heavy soils. Do not apply between bloom and harvest. Safe on new plantings.
g. Sinbar; selective preemergent herbicide. Moisture is required to activate the chemical; also provides early postemergence control.
h. Goal: selective preplant herbicide. Must be applied at least 30 days prior to transplanting. The soil must be worked to a depth of at least 2.5 inches prior to transplanting the crop. The use of a preemergence herbicide after transplanting is also recommended.
i. Roundup Ultra; non-selective preplant herbicide. Must be applied at least 30 days prior to transplanting. Provides control of most annual and perennial weeds. Application to perennial weeds should take place the Fall prior to transplanting for best control.

New Pest Management Technologies for Weeds

Method	Source	Status	Pests Affected
carfentrazone-ethyl	IR4	Pending (Herbicide)	Numerous broadleaf weeds, including cocklebur and water hemp.
clopyralid	IR4	Pending (Herbicide)	Controls a broad spectrum of broadleaf weeds including hard to control Canada thistle.
flumioxazin	IR4	Pending (Herbicide)	Low use rate pre-emergence broadleaf herbicide with contact activity and residual soil activity.
oxyfluorfen	Section 18	issued	weeds
sulfentrazone	IR4	Pending (Herbicide)	Controls broadleaf and grass species.
sulfentrazone	Section 18	issued; withdrawn	common grandsel
thiazopyr	IR4	Potential (Herbicide)	Annual and perennial broadleaf weeds, including crabgrass and nutsedge.
triflusulfuron-methyl	IR4	Potential (Herbicide)	Broadleaf weeds.

V. Acknowledgements

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To protect privacy of private sector participants, their mailing, phone and email address are not included in the published document.

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