Pest Management Strategic Plan for Strawberry in the Northeast 2015

Northeastern IPM Center

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Cover photo by David Handley, University of Maine Extension

In Memoriam

Cathy Heidenreich, Cornell School of Integrative Plant Science Horticulture Section, passed away shortly after participating in this PMSP meeting. Her work with the berry industry and input on this document was invaluable. She will be greatly missed by both colleagues and growers.
This PMSP is dedicated to Cathy.

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Key Pest Name Abbreviations

Insects
TPB = Tarnished Plant Bug*
CM = Cyclamen Mite
RW = Root Weevils^
SWD = Spotted Wing Drosophila
WG = White Grubs^

Diseases
GM = Gray Mold (*Botrytis*)*
BRR = Black Root Rot Complex ^
AFR = Anthracnose Fruit Rot^
LS = Leaf Spot (*Mycosphaerella*)*
PM = Powdery Mildew*

Weeds
Pre = Pre-emergent Weeds
Post = Post-emergent Weeds

*Key Pest in 2007 PMSP
^Occasional pest noted in 2007 PMSP

Previous Pest Management Strategic Plan

The previous Strawberry Pest Management Strategic Plan (PMSP) was developed in 2007 through the New England Pest Management Network. This network was comprised of researchers and extension personnel from the six New England Land Grant Universities with the goal of developing and communicating effective, economical, environmentally-sound, and socially-sensitive pest management information for New England.

Before the 2007 Strawberry PMSP was developed, a 2004 New England Strawberry Pest Management Tactic Survey for growers identified the key pests driving pesticide use, current use patterns for pesticides, and alternative methods of strawberry pest management. The results from this New England-wide survey were described in the New England Strawberry Crop Profile published in 2005 (http://www.ipmcenters.org/cropprofiles/docs/NewEnglandstrawberries.pdf).

In December 2006, a review group of strawberry growers, researchers, and industry stakeholders from New England met for two days in Concord, New Hampshire to develop the PMSP. The resulting PMSP document was released May 2007 (http://www.ipmcenters.org/pmsp/pdf/NewEnglandStrawberryPMSP.pdf). This was the first Strawberry PMSP produced in the Northeast.

Outcomes

The development of a Small Fruit IPM Working Group was a direct result of the 2007 Strawberry PMSP educational goal to 'encourage organization and coordination of small fruit growers and small fruit extension, university and grower association personnel within and among the six New England states to present a strong voice' (http://www.ipmcenters.org/pmsp/pdf/NewEnglandStrawberryPMSP.pdf). The group has since expanded to include small fruit pest management and IPM personnel from the six New England states in addition to New Jersey and New York and is currently called the Northeast Small Fruit IPM Working Group. The group has also had representation from organic grower associations, including NOFA-VT, MOFGA and Red Tomato. The group has met each year since forming and has discussed and shared new pest information, regionally applicable research, coordination, meetings, educational events, and collaborative publications specific to strawberry production.

A second educational priority from the 2007 Strawberry PMSP was to investigate the use and impact of day-neutral strawberry varieties and plasticulture on the key pests. The following 2015 PMSP document addresses these impacts and changes in cultural, biological plus organic and conventional pesticide management strategies for both day neutral strawberries AND June-bearing strawberries for each of the identified key pests.

Executive Summary

Prior to the 2014 Strawberry PMSP meeting, members of the Northeast Small Fruit IPM Working Group (researchers, extension and organic association personnel) plus identified key strawberry growers in the region were asked to list the key pests, diseases and weeds in order of importance in strawberry. This survey was substituted as a cost-effective and efficient replacement for a Crop Profile and Survey. The list of key pests for strawberry included five insects, five diseases, and the weeds and vertebrates common in agricultural settings. The key pests are typically persistent problems that need to be managed every year. Cyclamen Mite and Spotted Wing Drosophila are new key pests in the 2015 Strategic Plan. Root Weevils, White Grubs, Black Root Rot complex, and Anthracnose Fruit Rot have advanced to key pest status from occasional pests noted in the 2007 Strawberry Pest Management Strategic Plan (http://www.ipmcenters.org/pmsp/pdf/NewEnglandStrawberryPMSP.pdf).

Of special note, there are other current and emerging pests that annually affect the crop to lesser degrees but can be extremely devastating when outbreaks occur. Strawberry bud weevil (or clipper) is one current pest which may become problematic if not properly managed. Strawberry sap beetle, Strawberry mottle virus, strawberry mild yellow edge virus, and *Verticillium* wilt have been noted as emerging pest issues.

Contributing to these emerging pest problems is a shift in production to include using day-neutral varieties grown in plasticulture. False chinch bug (*Nysius raphanus*), strawberry seed beetle (*Harpalus rufipes),* and leather rot (*Phytophthora cactorum*) are noted to potentially emerge as problematic in day-neutral production systems.

Critical Needs

Research

- Clear verification of efficacy of materials is paramount to successful pest management. Many available materials, particularly organic and alternative products such as biopesticides, do not have substantiated efficacy claims.
    - Companies that release products need to better define efficacy claims.
    - Funding and personnel are needed to conduct material demonstrations or trials and document efficacy data.
    - Efficacy of organic materials and methods for white grub management is especially desired.
    - A better understanding of pest lifecycles will improve timing and efficacy of available materials.
    - Refinement of scouting techniques and thresholds for many pests, particularly for organic operations, is especially desired to optimize treatments, timing of scouting and treatment, and pollinator protection close to bloom.
- Breeding and release of more day neutral varieties for use in the Northeast is desired.
- Research of alternatives to manage problem pests, including cultural practices, trapping and biological control.

Regulatory

- Funding for small fruit specialist research and support positions, particularly in the Northeast is strongly desired. Growers need to be more vocal in their demand for these positions.
- The industry has become highly dependent on foreign breeding programs for new varieties and stock. Publicly funded domestic breeding programs need to be encouraged and supported.
- Establishment of certification inspection programs to verify nursery stock as clean of pests are desired. Such programs would be useful for pests such as Cyclamen Mite, Anthracnose Fruit Rot, strawberry aphids, and viruses.

Education

- Understanding of pesticide modes of action are critical to prolonging the effectiveness of available materials.
    - Growers desire guides to better define mode of action of materials and how to use in rotation.
    - Decision tools for growers are especially desired to plan rotation options tailored to different goals (marketing, severity tolerance, pest focus) that balance application restrictions with different pests over an entire season, days to harvest between crops, and optimization of materials useful to several crops.
- Pest management guides need to be updated to include day-neutral variety production, which requires different pest management schedules than June-bearing varieties.
- Consumer education to improve acceptance of light pest damage would allow growers to adjust pest management tactics and reduce application of pesticide materials.
- More advanced education for certified crop advisors and advanced growers are especially desired. "Advanced growers need advanced education."

I. Introduction

Background of Strawberry in the Northeast

Strawberries are an important crop throughout the Northeast (CT, MA, ME, NH, NY, RI, VT) and represent a high value and critical component of many diversified vegetable farms. In 2012, there were 1,213 acres of strawberries grown in Northeast with an average yield of 5,000 lbs /acre. At the average price of $2.80/ lb, each acre of berries is worth $14,000, with the entire Northeast crop representing almost 17 million dollars over 1,213 acres (USDA NASS., 2012). In 2012, New York grew 1,400 acres of strawberries with the average value of the crop in the state being worth $6,880,000 (USDA NASS., 2012). The crop is grown for primarily for fresh retail and wholesale markets with Pick Your Own (PYO) operations widespread throughout the Northeast, offering valuable opportunities for agro-tourism on many farms. A high percentage of the crop is sold on a PYO basis and is viewed as a family activity. Many children are present in these PYO strawberry fields, potentially increasing their risk of exposure to pesticides. Making the proper choice of the most effective, yet lowest risk pest management strategy is critical.

Strawberries are attacked by variety of pests, including insects, mites, pathogens (including nematodes) and weeds. With the increased movement of insects, diseases, plant products, and invasive weeds coupled with the pressure from climate change, the scope of pests and diseases causing problems in strawberries is continually expanding. Spotted Wing Drosophila and brown marmorated stink bug are new and emerging pests in Northeast that are potentially devastating to strawberry (Koehler, G., 2011, Jacobs, S., 2010). The increased incidence and impact of Black Root Rot Complex in strawberry was noted on all four farms visited during the 2013 Northeast Small Fruit IPM Working Group meeting in Vermont and New Hampshire. This complex of key fungal pathogens and lesion nematodes was causing the growers to abandon plantings after one season, representing a significant loss in production and income. During the course of the 2014 growing season it was found these losses may also be related to virus-contaminated nursery plants. Increased disease incidence and severity caused by Anthracnose on strawberry foliage as a result of recent warmer, wetter summers along with increased Cyclamen Mite damage in strawberry crowns has also been noted by the Northeast Small Fruit IPM Working Group.

In recent years, there have been changes in many of the cultural practices in strawberry that can influence and increase the impacts from pests and diseases. Spotted Wing Drosophila has proven to be devastating in the past 3 years in small fruits produced later in the season in the Northeast, but with the increased interest in the use of day-neutral varieties to expand harvest time and increase production, SWD will likely become a larger problem in strawberries. The widespread adoption in the use of high tunnels and low tunnels on many Northeast farms has also spurred new challenges and approaches to pest management. The development of new bio-rational and conventional pesticide materials along with the loss of key pesticides also presents new challenges in pest management strategies. As a result, the most recent Northeast Strawberry Pest Management Strategic Plan (PMSP) done in 2007, based on a strawberry survey done in 2004, does not accurately reflect the current pests and strategies critical for strawberry pest management in the Northeast (Hazelrigg, A., et al. 2007)

How this plan was created

A diverse review group Northeast of strawberry growers, researchers, organic association technical personnel, IPM practitioners and extension specialists met for two days in December of 2014 to develop the Pest Management Strategic Plan (PMSP) following the guidelines as outlined on the Northeast IPM Center website under 'PMSP checklist' at http://www.ipmcenters.org/pmsp/PMSP_CHECKLST.pdf and 'PMSP revisions' at http://www.ipmcenters.org/pmsp/PMSPRevisionGuidelines.pdf.

Key pests driving pesticide use were identified from a survey of participants prior to the meeting (see note). Seventeen participants responded, representing every participating state. Key pest summaries and currently registered pesticides for each key pest were adapted from the *2013-2014 New England Small Fruit Management Guide* and the *2014 Cornell Pest Management Guidelines for Berry Crops* with input from participants. Information was updated following the meeting to include the *2015-2016 New England Small Fruit Management Guide* (https://extension.umass.edu/fruitadvisor/ne-small-fruit-management-guide) and the *2015 Cornell Pest Management Guidelines for Berry Crops* (http://www.nysipm.cornell.edu/guidelines.asp).

The group took a pest by pest approach and identified current pest management strategies that included both chemical (conventional and organic) and cultural methods. With each pest, the group discussed the efficacy, practicality, advantages and disadvantages of the 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 Northeast University and private sector experts for accuracy and completeness. At least one person in each Northeast state reviewed the draft PMSP and approved it as representative for their state.

NOTE: In the past, the PMSP was typically done after a crop survey and crop profile, but to save time and money, the process was streamlined and limited to the PMSP. The Northeast Small Fruit IPM Working Group (http://www.northeastipm.org/working-groups/small-fruit/) felt a crop survey was not necessary since key growers and extension small fruit specialists from each state will be represented and have agreed to be involved in the PMSP process. Each specialist is well versed in the insect, weed and disease issues in strawberries and pest management options in his or her state. University of Vermont has played the lead role in development and delivery of all previous Northeast PMSPs based on small fruits (Hazelrigg, et al., 2010; Hazelrigg, et al., 2007; Hazelrigg, et al., 2006).

Benefits to the Northeast Strawberry Industry

Pest Management Strategic Plans have been long recognized as a valuable conduit for researchers, growers, IPM practitioners and extension to communicate with regulators and granting agencies. Through the PMSP process growers, researchers, extension and other IPM practitioners also identify critical priorities in research, extension and regulation that researchers and extension personnel use to drive critical grant and research requests for future work. The PMSP process also identifies gaps in knowledge of pests and management strategies that can be addressed in newsletters, at future grower meetings and through site visits with growers.

This Strawberry PMSP will benefit growers; researchers; grower associations such as New England Vegetable and Berry Growers Association, Vermont Vegetable and Berry Growers Association, New York State Berry Growers Association, etc.; organic grower associations such as NOFA-VT, MOFGA, etc.; IPM practitioners and other stakeholders, such as Red Tomato, working with strawberries in the Northeast. This PMSP will also be relevant and beneficial to strawberry stakeholders in the Midwest and North Central regions. Additionally, this strategic plan identifies regional needs for consideration in EPA regulatory decisions, strawberry grower education and strawberry research needs. A current and accurate Strawberry PMSP is an essential tool for stakeholders and will be used to direct successful pest management decisions based on IPM strategies. Current pest management programs will benefit from this review of advantages and constraints of current practices contained within this strategic plan.

The stakeholder-identified priority lists provide guidance for researchers to help secure future grant funding and research to benefit strawberry growers. This PMSP will be valuable to extension specialists to identify educational gaps in knowledge of pests and to develop and provide topics to be presented throughout the region in meetings, newsletters, websites and site visits on pests and pest management strategies for strawberry growers.

The members of the Northeast Small Fruit IPM Working Group find PMSPs capture a realistic and extremely valuable snapshot of the pest issues and management strategies for a specific crop. Several in the Working Group mentioned they find listing all the cultural, organic and conventional pest management strategies for one crop in a thorough document like a PMSP very helpful when working with growers. The Northeast Small Fruit IPM Working Group has listed “Updating Pest Management Strategic Plans” as a top priority for the Northeast region in their 2012 and 2013 meetings (http://www.northeastipm.org/neipm/assets/File/Priorities/Priorities-SmallFruitIPMWG-2013.pdf).

II. Summary

Key Strawberry Pests Summary

Insects and Mites

Tarnished Plant Bug (*Lygus lineolaris)*

- This is an annual pest beginning in early spring and continuing until heavy frost. Early blooming June-bearing varieties may not be as significantly affected as day-neutral varieties.
- Both adults and nymphs feed on the developing flower buds and fruit, resulting in deformed fruit that are generally unmarketable. Cultivars that bear later in the season may suffer more damage as pest populations increase.
- Management of weeds near the planting may reduce populations of this insect. Cultural management with weed management around site begins the year prior to planting.
- Insecticide sprays may be necessary when flower buds appear prior to bloom. Waiting to until nymphs are detected pushes spraying into the bloom period and increases bee toxicity. However, while spraying before bloom reduces pollinator exposure this may overtreat for pest.
- Parasitic wasp releases, originally in New Jersey and New Hampshire, has reduced total pest population pressure (evidence of efficacy in apples).

Cyclamen Mite (*Steneotarsonemus pallidus*)

- Day neutral varieties are less likely to be affected as pest population does not establish on annual crops.
- This pest is on the rise in strawberry and peppers. This pest can arrive via infested planting stock but symptoms do not appear until the following year or more, beginning in early spring through late summer. Presence and symptoms can be cyclical, appear in waves or flare-ups, or as hotspots in sites. Warm dry spring conditions exacerbate pest population and symptoms.
- These mites feed on new leaves in the plant crown, resulting in stunted plants, distorted purplish leaves, and buds that fail to open. Blossom feeding results in deformed fruit. Pest is very small and requires a microscope to see.
- Management by pre-plant treatment is a best practice for reducing the pest population on incoming nursery stock before it becomes established in fields.
- Management includes spot treatments with *high gallonage* miticide sprays (much higher than required for foliar mites). Very difficult to get spray penetration.
- It is often too late for effective management when symptom appear. Site is usually put into rotation sooner than otherwise would be.
- 'Cabot' variety is particularly susceptible.

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

- Day neutral varieties are less likely to be affected as pest population does not establish on annual crops.
- These larvae are a persistent pests where they appear, with symptoms appearing in early spring through autumn. Infestations are generally in patches in the site where they appear. Adults emerge mid-summer and lay eggs late summer through fall. Adults can overwinter in warmer areas and lay eggs in following season.
- Pest appears to be associated with site history of nursery production and can be moved between sites on equipment.

- Management includes soil applications of insect pathogenic nematodes in early spring or late summer or insecticide sprays as a soil drench or as a spray targeting adults to inhibit egg laying. It is usually easier to put site into rotation than to manage.
- Larvae feed on the crown and roots, resulting in declining, stunted plants with reduced yield. This is especially damaging where root diseases are also present. Symptoms appear when plants are under fruit load stress. Nothing to do about it at that point for the crop. Can treat bed for future seasons and prevent spread to other sites.
- Adult weevils feed on leaves, causing notching on leaf edge. Need to scout for adult leaf notching to time pesticide applications. Adults are very robust. Sprays MUST be applied at night when adults are active (in soil/mulch during day).
- Mowing during renovation in an infested site causes stress on plants and should be avoided.

Spotted Wing Drosophila (*Drosophila suzukii*)

- Populations of this invasive insect do not cause significant damage until mid-late summer and autumn. This pest is a specific threat to day-neutral varieties while June-bearing varieties are not significantly affected. A complete life cycle can be as little as 14 days.
- Female flies are able to insert eggs through the skin of ripening fruit. Larvae feed on the flesh of fruits, resulting in premature softening, decay and very reduced shelf life.
- Management is through frequent and repeated insecticide sprays throughout the day neutral ripening and harvest period. Netting can be effective on smaller plantings and removal of waste fruit may keep populations in check.

White Grubs (*Scarabaeidae* family)

- These larvae are primarily planting year pests when going into sod ground in autumn and early spring. High populations of larvae are more likely following a dry summer. Adults emerge and lay eggs from late spring to mid-summer. Populations of these pests are not established in every site.
- Larvae feed on the roots, resulting in stunted growth and plant dieback, especially where other diseases are present. Mobile adults feed on leaves, causing skeletonized leaves. Adults may injure leaves of day neutral varieties but management is rarely necessary.
- Management includes soil applications of insect pathogenic nematodes or insecticide sprays as a soil drench or as a spray targeting adults feeding on leaves and to inhibit egg laying. Segregation of plantings from turf areas is recommended. It is often too late for effective management for current crop when symptom appear.
- Can salvage sites through grass management against Japanese beetle, others. However, many new and different species are increasingly problematic and no longer easy to group and manage.
- Oriental and Asiatic Garden beetles are increasingly problematic, will breed in non-sod, don't disperse as much, and prefer the high level of moisture in drip irrigation environments.

<u>Diseases</u>

Gray Mold (*Botrytis cinerea*)

- This is an annual fungal disease beginning in spring through late summer into fall with day neutrals, favored by cool and wet weather.
- Symptoms include powdery gray growth on softened fruit and leaf tissue, firm brown areas on fruit, or berries that retain shape but become tough and dry. Storage rots may also occur.

- Management with protective sprays during bloom and maintaining air circulation between plants is common.
- Resistance to chemical sprays is highly possible. Resistance has occurred in Pennsylvania and North Carolina. It is possible for new plants to carry resistant strains from the nursery.
- Spray material rotation is key to avoid resistance development. Growers are advised to ask suppliers for records of what new plant stock had been sprayed with prior to shipping to plan for rotation.

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

- This is an endemic complex that is favored by plant stress conditions such as drought, winter injury, poor nutrition, soil compaction, older beds and sites, or improper herbicide use with symptoms appearing in early spring through autumn. Climate change irregularities may further stress plants.
- Symptoms include lack of plant vigor and productivity and eventual collapse with a progression of blackened feeder, structural, then perennial roots. Structural roots retain a white core as the rot occurs from the outside to the center.
- Management of plant stress conditions through proper site selection and long crop rotation are common management techniques. There are no 'silver bullet' treatments. Most products are labelled against *Rhizoctonia* only, with few products available to target other complex species. It is usually easier to put site into rotation than to manage.
- Very little is known about this pest complex and research is needed.

Anthracnose Fruit Rot (*Colletotrichum acutatum*)

- This is an annual fungal disease beginning in spring through late summer, favored by warm and humid spring weather. More common on day-neutral varieties. This pest has been seen in Pennsylvania, New York and Vermont.
- Symptoms include circular, sunken, water-soaked tan to brown lesions on fruit. A slimy spore mass spreads by splashing with rain and irrigation. Under dry conditions the fruit may become mummified and black. This fungus may also attack stolons, petioles, and crown tissues.
- Management with site sanitation and crop rotation is common. Sprays against GM will also manage this pest. One spray will typically manage when pest occurs although sometimes go a few weeks before see again then have to spray again. Protective sprays may be less effective in hot, humid conditions.
- Growers with no history of this pest and not scouting for it may be unprepared when this pest does occur.
- Spray product labels are not necessarily specific to fruit Anthracnose.

Leaf Spot (*Mycosphaerella fragariae*)

- This is an annual fungal disease beginning in early spring through late summer, spread favored by splashing rain. If pest is present in fall then it will also be present in the spring.
- Symptoms appear as irregular to circular purple spots with grayish centers on leaves, petioles, stems, and runners. Lesions can occasionally develop on fruit (black seed). Heavy infections can inhibit production of flower buds.
- Management with resistant varieties, maintaining air circulation between plants, sanitation, and removal of plant tops at renovation is common. Late fall renovation sprays are also used.
- Will spread from old sites to new sites. Keep out of new planting.
- The action or economic thresholds for this pest is unknown.

- There a several similar fungal foliar diseases that may be considered more of a complex than individual diseases including Leaf Spot (*Mycosphaerella*), Leaf Scorch (*Diplocarpon*), Leaf Blight (*Phomopsis*), and Leaf Blotch (*Zythia*). Angular Leaf Spot (*Xanthomonas*) is a bacterial disease.

Powdery Mildew (*Sphaerotheca macularis*)

- This is an annual fungal disease beginning in late spring through late summer, favored by warm and humid conditions. Pest incidence has been increasing earlier in year. More common on day-neutral varieties.
- Symptoms include white powdery growth on the lower leaf surface, causing the leaf edges to roll upward. Infected flowers and fruit may fail to ripen.
- Management with protective sprays to reduce inoculum and maintaining air circulation between plants are common. Easy to manage if pest is monitored.
- Special attention must be paid to pest development in new plantings and stressed plantings. Not necessarily a key pest on older plantings
- Pest develops resistance very rapidly and must rotate spray materials. There may be resistant strains developing.
- The action or economic thresholds for this pest is unknown.

Weeds

Annual Grass Weeds
Annual Broadleaf Weeds
Perennial Grass Weeds
Perennial Broadleaf Weeds

- Weed infestations occur in mixed populations including annual grasses, annual broadleaf, perennial grasses, perennial broadleaf, woody perennial and vine weeds. Weed populations vary across regions and farms.
- Weed pressure impacts plant development and productivity 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. Weeds can inhibit spray penetration, air circulation, and drying conditions.
- Weed pressure early in the season, or early in the year-of-planting, is more problematic than weed pressure later in the season.
- Management with herbicides is common from pre-plant through post-plant pre-emergence and post-emergence applications. Good pre-plant preparation to remove perennial weeds and reduce the weed seed bank is essential to maximize crop performance.
- False buckwheat, red sorrel, purple deadnettle, shepherd's purse are notably problematic in some locations.
- Some weeds have become problematic (clover, perennial grasses, thistle) due to a limited number of effective spray materials. Clopyralid (Stinger) not available throughout the Northeast.
- Herbicide resistant groundsel and bedstraw are becoming problematic in New York.
- Cover crops can mask presence of fall winter annuals, causing problems in the spring.

Vertebrate 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 in sites near woods.
- Management with various cultural control practices is common.
- Local authorities control size of populations
- Low electric fencing sometimes for short periods and can be cost effective, baited helps
- Tall fencing can be long term and effective if gates kept closed, expensive
- Taste repellants: Hinder, Neptune's Harvest (can be phytotoxic, difficult to apply), use in fall to break feeding pattern, liquid manure around perimeter of site, Thiram is labelled as deer repellent. Repellents don't tend to be rainfast

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

- Voles directly feed on underground plant parts, can introduce weed seeds to site, and their tunnel systems interfere with crop irrigation.
- Mice frequently coexist and can introduce seed, some situations plant feeding
- Management with various cultural control practices is common.
- Problem in mulch, plastic, chew dripline, attract coyotes
- No rodenticides are legal for application in strawberry sites, some may be in certain situations in high tunnels in bait stations in some states
- Narrow rows and good weed management with discourage meadow vole, good mowing around site

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.
- Turkeys especially scratch off straw before heavy snow, require labor to recover. Avoid barley straw, straw with grains.
- Geese graze and may introduce foodborne pathogens before harvest, feet puncture plastic
- Songbird species (cedar waxwings) federally protected.
- Visual and auditory devices, combinations work best
- Some hail/insect netting can be laid over crop and be effective (vs. on poles)

Porcupines *(Erethizon dorsatum)*

- Will eat foliage and crowns

Specific Pest Management Tactics Summary

Insecticides –Key Pest(s)

IRAC = Insecticide Resistance Action Committee (with mode of action classification code)
OMRI = Organic Materials Review Institute
Key Pest Name Abbreviations = see page 3

abamectin (Agri-Mek) -CM

IRAC 6

- Good efficacy
- Gallonage on label for foliage mites does not provide good efficacy for CM -increased gallonage volume improves efficacy.
- Not labelled for CM specifically
- Not listed in Cornell Guide for CM

acequinocyl (Kanemite) -CM

IRAC 20B

- Good efficacy
- Gallonage on label for foliage mites does not provide good efficacy for CM -increased gallonage volume improves efficacy.
- Not labelled for CM specifically
- Not listed in Cornell Guide for CM

acetamiprid (Assail) –TPB, SWD, WG

IRAC 4A

- Slow acting against TPB
- Good efficacy against SWD if add sugar to water at 1-2lb/100 gal (very dilute so sugar doesn't clog nozzles, attract ants, yellow jackets, etc.)
- Short residual activity
- Translaminar (systemic-like)
- One day to harvest
- Least toxic neonicotinoid (bee toxicity concerns)
- Neonicotinoid (bee toxicity concerns)
- Must rotate after two applications
- Applications must be seven days apart
- Labelled for Japanese beetle
- Not labelled for SWD
- Use against WG not discussed at meeting
- Not listed in New England Guide for WG

azadirachtin (Aza-Direct) –TPB, CM, SWD, WG

IRAC UN - OMRI listed

- Poorly effective against SWD at best
- Organic growers use in rotation against SWD with spinosad (Entrust)
- Labelled for Japanese beetle
- Not labelled for SWD

- Use against TPB, CM, and WG not discussed at meeting
- Not listed in New England Guide for TPB or WG
- Not listed in Cornell Guide for TPB or WG

***Beauvaria bassiana* (Mycotrol) –TPB, RW, WG**
IRAC UN - OMRI listed

- Very slow acting
- Inconsistent efficacy
- More effective in wet years
- Low bee toxicity
- Not compatible with some fungicides
- Labelled for beetles
- Not listed in New England Guide for TPB, RW, or WG

bifenthrin (Brigade, Bifenture) –TPB, CM, RW, SWD
IRAC 3A

- Effective against TPB
- Excellent efficacy against SWD
- Zero days to harvest
- Less expensive than alternatives for TPB, SWD
- Negative effects on predators
- Triggers mite outbreaks
- Groundwater issues
- Potential for overuse in day neutrals leading to resistance of TPB, SWD
- Many RW individuals survive long-term
- Have to use highest label rate against RW
- Targets RW adults only
- Not labelled for SWD
- Use against CM not discussed at meeting
- Not listed in Cornell Guide for CM

Capsicum oleoresin extract, garlic oil, soybean oil (Captiva) –TPB, CM
IRAC NC

- Efficacy unknown against TPB
- Repellant concept against TPB
- There is perceived potential for effect on fruit flavor (except when used at renovation or early season)
- Not labelled for TPB or CM specifically
- Not listed in New England Guide for TPB, CM
- Not listed in Cornell Guide for TPB, CM
- New material in 2014

carbaryl (Sevin) –TPB, RW, WG
IRAC 1A

- Broad spectrum
- Days to harvest long

- Inexpensive
- Does not require license
- Bee toxicity
- Phytotoxicity possible
- If acetamiprid (Assail) goes away, will see more use against TPB
- Use against RW, WG not discussed at meeting
- Not listed in New England Guide for RW, WG
- Not listed in Cornell Guide for TPB, RW

chlorantraniliprole (Coragen)-WG
IRAC 28

- Foliar use against Japanese beetle
- Not listed in New England Guide for WG

chlorpyrifos (Lorsban) –TPB, WG
IRAC 1B

- Extremely long days to harvest
- Bee toxicity
- Not labelled for TPB
- Not listed in Cornell Guide for TPB, WG

diazinon (Diazinon) –TPB, CM, RW, SWD, WG
IRAC 1B

- Excellent efficacy in blueberry against SWD
- Five days to harvest
- Bee toxicity
- Hard to get
- Not labelled for TPB, RW, SWD, WG
- Not listed in Cornell Guide for TPB, CM, RW, SWD, WG

dicofol (Kelthane, Dicofol) -CM
IRAC UN

- Growers use
- Low bee toxicity
- Strong odor
- Not supposed to use during high temp 90F (during renovation)
- Not labelled for CM specifically
- Not listed in Cornell Guide for CM

endosulfan (Thionex) –TPB, CM
IRAC 2A

- Very effective
- Quick acting
- Maximum two applications per year
- 15 days between TPB applications; 35 days between CM applications when fruit is present
- Hard to get

- Grower cutoff date July 31, 2016 (worker protection issues)
- Prohibited use on annuals (phased out in 2012)
- Not listed in Cornell Guide for TPB

fenpropathrin (Danitol) –TPB, RW, SWD
IRAC 3A

- Effective against TPB, RW
- Excellent efficacy against SWD
- Low days to harvest
- Bee toxicity
- Negative effects on predators
- Groundwater issues
- Not labelled for RW
- Not labelled for SWD
- Not listed in Cornell Guide for RW

fenpyroximate (Portal) -CM
IRAC 21A

- Effective, growers use
- Must have contact, stops feeding, doesn't kill
- Use when see symptoms (too late)
- Must rotate
- Best use at renovation or early spring

flonicamid (Beleaf) -TPB
IRAC 9C

- Narrow spectrum
- No bee toxicity warning
- Slow to kill, feeding stops quickly
- Not listed in New England Guide for TPB

imidacloprid (Admire Pro, Provado) –CM, SWD, WG
IRAC 4A

- Good efficacy against CM, SWD
- Effective against Japanese Beetle
- Seven days to harvest too long for SWD
- Bee toxicity
- Timing very important against WG
- Post-harvest best time for treatment against WG
- Must water in against WG
- Must rotate against WG
- Admire listed for strawberry (not in NY)
- Not labelled for CM specifically
- Not labelled for SWD

***Issaria fumarosea* (PFR-97) –TPB, RW, WG**
IRAC UN – OMRI listed

- Foliar application against TPB
- Soil application against RW, WG
- Labelled for both Root Weevils
- Not listed in New England Guide for TPB, RW, WG
- New material

malathion (Malathion) –TPB, RW, SWD
IRAC 1B

- Good efficacy at high rate against TPB
- Not effective against clipper
- Two days to harvest
- Inexpensive
- Low mammalian toxicity
- Strong odor
- Some additives can make the smell better
- May want to avoid TPB applications so may use for SWD later season
- Not labelled for SWD specifically
- Use against RW not discussed at meeting
- Not listed in New England Guide for TPB, RW
- Not listed in Cornell Guide for TPB, RW

mineral oil (SuffOil) –CM
FRAC NC

- Contains petroleum distillates
- Not labelled for CM specifically
- Use against CM not discussed at meeting

naled (Dibrom) -TPB
IRAC 1B

- One day to harvest
- Less expensive
- High human toxicity
- Not common use
- Seen use increase with onset of day neutrals
- Older material but not a lot of information
- Not listed in New England Guide for TPB

neem extract/derivatives (Trilogy) -CM
IRAC NC - OMRI listed

- Slight efficacy
- Also effective against PM
- Ability to reach pest doubted
- Not labelled for CM specifically
- Not listed in Cornell Guide for CM

paraffinic oil (JMS Stylet Oil) -CM
IRAC NC - OMRI listed

- Ability to reach pest doubted
- Not labelled for CM specifically
- Not listed in Cornell Guide for CM

potassium salts of fatty acids (Des-X, M-Pede) –TPB, CM
IRAC NC - OMRI listed

- Might be effective against TPB nymphs
- Efficacy unknown against CM
- Might penetrate to reach CM
- Could also act as deer repellent
- Phytotoxicity possible
- Not labelled for CM specifically
- Not listed in New England Guide for TPB, CM
- Not listed in Cornell Guide for TPB, CM
- New material in 2014

pyrethrins (Pyganic) –TPB, RW, SWD, WG
IRAC 3A - OMRI listed

- Not very effective against TPB
- Most effective of OMRI listed against TPB
- Poor efficacy against SWD
- Broad spectrum
- Higher bee toxicity than other organic options
- Alternate with spinosad (Entrust) for SWD -only choices in NY
- Labelled for Japanese Beetle
- Use against RW, WG not discussed at meeting
- Not listed in New England Guide for RW, WG
- Not listed in Cornell Guide for RW

spinetoram (Radiant) -SWD
IRAC 5

- Excellent efficacy
- One day to harvest
- 5-7 day schedule
- Must rotate every two sprays
- Five applications max per season
- Very expensive
- Next generation of spinosad (not OMRI listed)

spinosad (Entrust) -SWD
IRAC 5 - OMRI listed

- Very good to excellent efficacy
- One day to harvest
- Must rotate every two sprays

- Five applications max per season
- Very expensive
- Not labelled for SWD specifically

sulfoxoflor(Closer) -TPB
IRAC 4C
- Neonicotinoid (bee toxicity concerns)
- Not listed in Cornell Guide for TPB
- New material in 2014

thiamethoxam (Platinum, Actara) –TPB, RW, WG
IRAC 4A
- Effective against eggs/immature TPB
- Effective against White Grubs and Root Weevils as soil application
- More effective against strawberry root weevil than black vine weevil
- Only fair efficacy on some WG species
- Relatively low mammalian toxicity
- Neonicotinoid (bee toxicity concerns)
- Relatively expensive
- High runoff risk as WG application
- Labelled for TPB as foliar application

Fungicides, Bactericides –Key Pest(s)
FRAC = Fungicide Resistance Action Committee (with mode of action classification code)
OMRI = Organic Materials Review Institute
Key Pest Name Abbreviations = see page 3

azoxystrobin (Abound) –GM, BRR, AFR, LS, PM
FRAC 11
- Suppression activity on foliage against GM
- Not much used against GM
- Root dip or banded in-row applications against BRR
- Broad spectrum
- Zero days to harvest
- Phytotoxicity possible
- Can cause significant problems with apples if use same sprayer
- Requires extra special attention to tank mixes, rotation
- Not labelled in NY, NE against GM
- Strawberry Leaf Spot not on label; *Mycosphaerella* spp. on label for other berries

azoxystrobin + propoconozol (Quilt Xcel) –AFR, PM
FRAC 11+3
- Provides kickback efficacy against PM
- Also effective against Leaf Spot (*Cercospera*)
- Broad spectrum
- Zero days to harvest

- Can cause significant problems with apples if use same sprayer
- Requires extra special attention to tank mixes, rotation
- Restrictions on crops rotated with, plant back restrictions on label
- Not listed in New England Guide for AFR, PM
- New material in NY

***Bacillus amyloliquefaciens* (Double Nickel) –GM, BRR, AFR, PM**
FRAC 44 - OMRI listed

- Effective in combination with coppers against fireblight on apples
- Root dip against BRR
- Zero days to harvest
- Good rotation alternative
- Unknown to growers
- Not listed in New England Guide for BRR
- New material in 2014

***Bacillus pumilus* (Sonata) -PM**
FRAC NC

- Use against PM not discussed at meeting
- Not listed in New England Guide for PM

***Bacillus subtilis* (Serenade) –GM, AFR, PM**
FRAC 44 - OMRI listed

- Listed in NY against AFR
- Use against GM, PM not discussed at meeting
- Not listed in Cornell Guide for PM

captan (Captan, Captec, others) –GM, AFR, LS
FRAC M4

- Strictly preventative activity
- Zero days to harvest
- No resistance risk
- 24-48 hour reentry interval
- Some formulations clog sprayer nozzles
- Phytotoxicity possible when applied with oil
- Can leave obvious residue when used close to harvest
- Captan formulations do not all have the same functionality
- MUST CHECK LABEL for AFR –product labels vary

captan + fenhexamid (CaptEvate) –GM, AFR, LS
FRAC M4+17

- Not very different from captan (fenhexamid has no AFR activity)
- Zero days to harvest
- Expensive

copper hydroxide (Champ, Nucop, Kocide) -LS
FRAC M1 - OMRI listed (except for Kocide)

- Effective when applied as two sprays before bloom
- Also listed for Angular Leaf Spot (Kocide only)
- Phytotoxicity possible during bloom, high temperatures
- Not listed in New England Guide for LS

copper hydroxide + copper oxychloride (Badge) –LS, PM
FRAC M1 - OMRI listed

- Many copper labels also list frost protection activity
- Phytotoxicity possible during bloom, high temperatures
- Use against PM not discussed at meeting
- Not listed in Cornell Guide for PM
- New material in 2014

copper octanoate (Cueva) –GM, AFR, LS, PM
FRAC M1 - OMRI listed

- Can get fruit injury during bloom
- Listed in NY, registered in NE
- Phytotoxicity possible during bloom, high temperatures
- Use against GM not discussed at meeting
- Not listed in New England Guide for GM, AFR, LS, PM

copper sulfate (Cuprofix) –LS
FRAC M1

- Phytotoxicity possible during bloom, high temperatures
- Not listed in New England Guide for LS

copper sulfate + copper oxychloride (C-O-C-S) -LS
FRAC M1

- Phytotoxicity possible during bloom, high temperatures
- Not listed in New England Guide for LS

cyflufenamid (Miltrex, Torino)--PM
FRAC U6

- Torino effective on pumpkins
- Zero days to harvest
- Two applications per year
- Minimum 14 day spray interval
- Minimum gallonage restrictions
- No good information available for use on strawberry

cyprodinil + fludioxinil (Switch) –GM, AFR, PM
FRAC 9+12

- Zero days to harvest
- Good rotation alternative

- Not listed in New England Guide for AFR, PM

dodine (Syllit) -LS
FRAC U12
- Highly toxic
- Strawberry not on label
- Leaf Spot not on label
- Not listed in Cornell Guide for LS

fenhexamid (Elevate) -GM
FRAC 17
- Pretty effective
- Less expensive
- Different active ingredient than other materials
- Resistance noted in Southern US
- Must rotate or tank mix

hydrogen peroxide (Oxidate) –GM, PM
FRAC NC - OMRI listed
- Poor efficacy against GM
- Good efficacy ONLY IF proper timing of application against PM
- No residual effect
- Use as clean up, follow with protective spray like copper, against PM
- Phytotoxicity possible
- Not listed in New England Guide for GM, PM

hydrogen peroxide + peroxyacetic acid (Rendition) –GM, AFR, PM
FRAC NC
- Use against GM, AFR, PM not discussed at meeting
- Not listed in New England Guide for GM, AFR, PM

iprodione (Rovral) –GM, AFR, LS
FRAC 2
- Good tank mix, rotation alternative
- Pre-plant dip labelled against GM
- Cannot apply more than 1-4 times per season, depending on formulation
- NY must use early season
- Use against AFR not discussed at meeting
- Not listed in New England Guide for GM, AFR, LS

mineral oil (SuffOil) --PM
FRAC NC - OMRI listed
- Contains petroleum distillates

myclobutanil (Rally, Agristar Sonoma) –LS, PM
FRAC 3

- Good rotation alternative
- Resistance issues growing

neem extract/ derivatives (Trilogy) –GM, AFR, LS, PM
FRAC NC - OMRI listed

- Good efficacy against PM
- Efficacy unknown against GM, AFR
- Good rotation alternative
- Use against LS not discussed at meeting
- Not listed in New England Guide for LS
- New material in 2014

paraffinic oil (JMS Stylet Oil) –GM, PM
FRAC NC - OMRI listed

- Some mite, PM management efficacy
- Zero days to harvest
- Need high spray pressure during application
- Phytotoxicity possible when applied with captan
- Compatibility issues

penthiopyrad (Fontelis) –GM, PM
FRAC 7

- Unusual FRAC code
- Label variety specific, not all tested
- Requires special attention with captan, thiram
- Not listed in New England Guide for GM, PM
- Not listed in Cornell Guide for GM, PM
- Newer material

phosphorous acid (Phostrol, Rampart, Agri-Fos) –BRR, PM
FRAC 33

- Not effective against PM
- Aimed more at *Phytophthora*
- Rampart has strawberry label
- Use against BRR not discussed at meeting
- Not listed in New England Guide for BRR, PM

polyoxin D zinc salt (Tavano, Ph-D) –GM, BRR, AFR, PM
FRAC 19

- Suppression activity, not eradication of AFR
- Zero day to harvest
- Widely used in ornamental/greenhouse industry
- Rotation strongly recommend
- New material in 2014

potassium bicarbonate (Milstop, Kaligreen) –GM, AFR, PM
FRAC NC - OMRI listed

- Very effective during early PM infection
- Good efficacy against GM
- Also useful in greenhouse operations
- Not listed in New England Guide for AFR

propiconazole (Tilt) –AFR, PM
FRAC 3

- Possible bee issues
- Must rotate
- Not listed in New England Guide for AFR, PM

pyraclostrobin (Cabrio) –GM, AFR, LS, PM
FRAC 11

- Effective against GM, AFR, LS, PM
- No problems with apples
- Resistance noted in Southern US
- Must rotate
- Not listed in New England Guide for GM

pyraclostrobin + boscalid (Pristine) –GM, AFR, LS, PM
FRAC 11+7

- Effective against GM, AFR, LS, PM
- Used as finish spray before harvest
- Broad spectrum
- No problems with apples
- More expensive than pyraclostrobin (Cabrio) alone
- Resistance noted in Southern US with GM
- Possible bee issues
- Must rotate
- Not listed in Cornell Guide for GM, LS

pyraclostrobin + fluxapyroxad (Merivon) –GM, AFR, LS, PM
FRAC 11+7

- Zero days to harvest
- Must rotate
- Strawberry not on regular label, supplemental label, not NY
- Not listed in Cornell Guide for AFR, PM
- New material in 2014

pyrimethanil (Scala) -GM
FRAC 9

- Effective
- One day to harvest
- Need tank mix at lower rate

- Same FRAC group as cyprodinil + fludioxinil (Switch)
- Been around a while

quinoxyfen (Quintec) -PM
FRAC 13

- Very effective
- Resistance issues in other crops
- Must be applied prior to infection
- Must rotate
- Not more than 2 applications consecutively, 4 applications per crop

***Reynoutria sachalienensis* (Regalia) -PM**
FRAC P5

- Use against PM not discussed at meeting
- Not listed in Cornell Guide for PM

***Streptomyces lydicus* (Actinovate) –GM, BRR, AFR, PM**
FRAC NC - OMRI listed

- Fairly effective against GM
- Efficacy unknown against BRR
- Use with spreader sticker prior to PM infection
- Not listed in New England Guide for GM, BRR, AFR, PM

sulfur (Microthiol, Kumulus, Thiolux) -PM
FRAC M2 - OMRI listed (not Microthiol)

- Varietal susceptibility
- Phytotoxicity possible
- Residue
- Thiolux Not listed in Cornell Guide for PM

tetraconazole (Mettle) –LS, PM
FRAC 3

- 14-21 day spray interval
- Only four applications per season
- New material in 2014

thiophanate methyl (Topsin) –GM, PM
FRAC 1

- Resistance noted in Southern US for GM
- Not recommended on ornamentals due to resistance
- Usually recommend as tank mix with captan

thiram (Thiram) -GM
FRAC M3

- Also effective as deer repellent
- Broad spectrum

- One day to harvest, reentry interval
- Good rotation alternative
- Not listed in Cornell Guide for GM

***Trichoderma* (Root Shield) -BRR**
FRAC NC

- Particularly good efficacy against Pythium, Rhizoctonia, Thielaviopsis
- Pre-plant, root dip, spray applications
- Many studies have not been included in guidelines
- Not listed in Cornell Guide for BRR

triflumizole (Procure) -PM
FRAC 3

- Should be effective
- Some kickback activity
- One day to harvest
- 14 day spray interval
- Requires special attention to rotation

Herbicides –Key Pest(s)
HRAC = Herbicide Resistance Action Committee (with mode of action classification code)
OMRI = Organic Materials Review Institute
Key Pest Name Abbreviations = see page 3

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

- Strong odor
- Drift issues for tomato and grape
- Increased use in fall, few other options

ammonium nonanoate (Axxe) -Pre
HRAC NC - OMRI listed but not strawberry

- Not listed in New England Guide for weeds

caprylic acid + capric acid (Supress) -Post
OMRI listed

- Use as a post-emergent not discussed at meeting
- Not listed in New England Guide for weeds
- Not listed in Cornell Guide for weeds

carfentrazone-ethyl (Aim) -Post
HRAC E

- Only between row applications

clethodim (Select, Arrow, Intensity) -Post
HRAC A

- Variable results, but better than Poast
- Require crop oil or nonionic surfactant
- Phytotoxicity possible during high temperatures

clopyralid (Stinger) -Post
HRAC O

- Not listed in New England Guide for weeds

DCPA (Dacthal) -Pre
HRAC K1

- Most effective againast grass
- Good efficacy against field pansy
- Not a lot activity in cold
- Not broad spectrum
- Relatively expensive
- Alternative to napropamide (Devrinol)
- Shorter residual effect than napropamide (Devrinol)

fluazifop-butyl (Fusilade) -Post
HRAC A

- Most effective against quackgrass
- Requires crop oil, nonionic surfactant, or other adjuvant
- Will be labelled in not too distant future on perennial strawberries
- Not listed in New England Guide for weeds

flumioxazin (Chateau) -Pre
HRAC E

- Good efficacy with plasticulture (day neutral varieties)
- More effective against many perennials than any other material
- Broad spectrum
- Long lasting
- Phytotoxicity possible on some varieties
- Only for dormant applications in row
- Using 30 days pre-plant

glyphosate (Roundup) -Pre, Post
HRAC G

- Inexpensive
- Effective against most perennials
- Zero residue
- Good efficacy as cleanup prior to planting
- Good efficacy when mixed with flumioxazin (Chateau) and applied on edge of fields, drive rows, and as spot treatment
- Overuse may help select for resistance

- Most common pre-plant treatment
- Strawberries tolerant of
- Been breeding roundup resistant in Canada

napropamide (Devrinol) -Pre
HRAC K3

- Effective ONLY IF ideal application conditions
- Poor efficacy
- Will get chickweed
- Moisture requirement on label is a hindrance
- Requires rainfall or irrigation after application
- Impedes runnering, shouldn't be used early in first year or after runners set

oxyfluorfen (Goal) -Pre
HRAC E

- Pre-plant, tank mixed with glyphosate, 30 days ahead, till in

paraquat (Gramoxone, Firestorm) -Post
HRAC D

- Between row management NY
- Renovation tool, burn back runners, no need disturb soils and stir up weeds
- Prevents soils from building up around crown in longer term beds, ok for short term beds

pelargonic acid (Scythe) -Post
HRAC Z

- Burn back
- Strong odor

pendimethalin (Prowl, Satellite Hydrocap) -Pre
HRAC K1

- Pre-plant, Dormant plants only
- Must not disturb soil

sethoxydim (Poast) -Post
HRAC A

- Require crop oil or nonionic surfactant
- Phytotoxicity possible during high temperatures

terbacil (Sinbar) -Pre
HRAC C1

- Used in renovation process before new leaf growth
- Phytotoxicity possible if not watered in
- Some varieties very susceptible
- Label confusing based on rates of organic matter

Research, Regulatory, and Education Priorities Summary

Research Needs

New chemistries and tools

- More efficacy data on spray materials is needed to fill gaps in regional guides. (TBP)
- Explore the efficacy of:
  - Cover cropping with mustard and other biofumigants to impact pest population. (BRR)
  - Organic materials and methods. (WG)
  - Straw over plastic to prevent splashing and spread of pest. (AFR)
  - Removal of infected leaves to reduce inoculum and improve yield in the following season. (LS)
  - Targeting adults to manage larvae. (WG)
- Continue breeding work to develop more resistant varieties. (TBP, LS)
- Determine varietal differences in susceptibility:
  - As germplasm base becomes more diversified with new European stock. (TBP)
  - Depending on the pathogen present. (BRR)
  - For newer varieties (in older varieties this was part of the breeding program). (PM)
  - For Cyclamen Mite. (CM)
  - For Anthracnose Fruit Rot. (AFR)
- Determine which varieties are able to pollinate under netting or row covers that excludes insect pollinators. (TBP)
- Develop tools to screen for virus and/or Black Root Rot Complex as causative agent of symptoms. (BRR)
- Develop PCR screening methods to verify clean stock from nurseries. (AFR)
- Determine a recommended ratio of raspberry trap crop to strawberry crop to be effective. (SWD)

Specific materials and equipment

- Explore whether hydrogen peroxide (Oxidate) has efficacy on insect pests. (TBP)
- Explore the usefulness and efficacy of mite predators. (CM)
- Study methods to manage pest prior to planting (hot water dip, irradiation) and preventative sprays at planting in anticipation of the loss of pre-plant pesticide dips. (CM)
- Identify effective species of insect pathogen nematodes. (RW, WG)
- Select for more virulent strains of insect pathogen nematodes that are active at different soil depths. (RW, WG)
- Develop 'curveball' attract-and-kill alternative technology for pesticide delivery. (SWD)
- Explore how 'curveball' attract-and-kill alternative technology for pesticide delivery can become acceptable for use in certified organic operations. (SWD)
- Alternatives to imidacloprid as a management tools are desperately needed. (WG)
- Explore the efficacy of chlorantraniliprole (Coragen) against different pest species (currently labelled against Japanese beetle adults). (WG)
- Test the foliar reddening effects of penthiopyrad (Fontelis) on different varieties. Not all varieties have been tested. (GM)

- Explore the potential for fall spray materials, particularly hydrogen peroxide (Oxidate), to reduce pest. (GM)
- Assess efficacy and crop safety (phytotoxicity) data necessary to get clopyralid (Stinger) registered throughout the Northeast. (Weeds)
- Explore the use of dilute rates of 2,4-D for broadleaf control during the growing season. (Weeds)
- Explore the long term effects of 2,4-D on fruit distortion and determine how soon use in fall can occur safely. (Weeds)

Scouting, lifecycles, habitat

- Refine scouting techniques and thresholds, particularly for organic operations< to optimize treatments, timing of scouting and treatment, and pollinator protection close to bloom. (TBP, SWD, WG, LS)
- Refine landscape management techniques around site to reduce pest habitat and pest pressure. (TBP)
- Explore the relationship between pest habitat and habitat that encourages beneficial insects and pollinators. (TBP)
- Determine pest overwintering habitat to improve management. (TBP)
- More information is needed on crop rotation period length and choosing cover crops and alternate crops that are not hosts. (RW, AFR)
- Increase understanding of lifecycle, overwintering or migration activity, landscape habitat, and potential invasive plant (buckthorn, barberry) hosts. (SWD)
- Increase understanding of mortality factors of pest, including parasites and predators, weather, and cultural conditions (airflow, humidity, etc.). (SWD)
- Determine if trap cropping with raspberry will increase the pest population to pressure strawberry. (SWD)
- Characterize the different pest species and their behaviors, particularly Oriental and Asiatic Garden beetles, to improve management efficacy (WG)
- Characterize environmental conditions that affect the different pest species. (WG)
- Explore the role of nematodes in pest activity, conditions that affect nematodes (warmer soil temperatures, population spread), and testing options. (BRR)
- Explore the use and/or impacts of multispecies cover crops, improvement of soil health, soil compaction management, rotations, compost, crop residue/inoculum levels even with long rotations (BRR)
- Develop testing, standards and recommendations for assessing foliar nitrogen; explore use of portable meter/kit use (GM)

Surveys and actions

- Encourage listing Black Root Rot Complex as a priority problem to this crop. (BRR)
- Survey Northeast growers to document presence or suspected presence; verify samples for virus and/or Black Root Rot Complex as causative agent of symptoms. (BRR)
- Ascertain if pests may be spread on equipment. (CM)
- Explore the impact of infection on photosynthesis, flower bud initiation, and yield over time. (LS)
- Explore the cost effectiveness of netting for pest management. (SWD)

Regulatory Needs

Packaging and labels

- Create incentives for pesticide packaging in smaller quantities (especially water soluble bags) more appropriate for smaller acreage. (TBP)

Specific materials

- Encourage pesticide distributors to carry live materials, such as pathogenic nematodes, to improve grower access. (RW, WG)
- Re-registration of carbofuran (Furadan) for use in strawberry is desired for its high efficacy against pests, although unlikely due to toxicity. (RW)
- Speed registration of cyantraniliprol (Exirel) through approval pipeline for strawberry; desired despite projected expense of material. (SWD)
- Encourage registration and labelling of more products, particularly organic products, which can be used in rotation against SWD. (SWD)
- Register more materials to enable effective rotation with current strobilurin fungicide materials. (AFR)
- Register clopyralid (Stinger) throughout the Northeast. (Weeds)

Nursery and/or government actions

- Encourage state agriculture departments to participate in the National Pesticide Information Retrieval System by subscription. (TBP)
- Establish certification inspection programs to verify nursery stock as clean of pests. Such programs would be useful for Cyclamen Mite, Anthracnose Fruit Rot, strawberry aphids, and viruses. (CM, AFR)
- Establish traceability protocols (e.g. lots, distribution records) for plant stock to track pest movement. (CM)
- Provide incentives to conduct research studies on efficacy of existing and new materials; Specialists doing research need to be encouraged and supported to maintain and improve upon the number and quality of professionals in practice. (WG)
- Require nurseries to supply records of what new plant stock had been sprayed with prior to shipping to allow growers to plan for material rotation. (GM)
- Require nurseries to declare if Black Root Rot Complex is a potential issue on stock. (BRR)

Education Needs

Scouting and identification

- Clarify the proper identification features of:
  - Cyclamen Mite symptoms. (CM)
  - Anthracnose Fruit Rot. (AFR)
- Clarify the proper identification features and differences between:
  - Black Root Rot Complex and Strawberry Mottle Virus. (BRR)
  - White grub species. (WG)

- Healthy pathogenic nematode materials and dead pathogenic nematode materials prior to application. (RW)
- Foliar diseases including Leaf Spot (*Mycosphaerella*), Leaf Scorch (*Diplocarpon*), Leaf Blight (*Phomopsis*), Leaf Blotch (*Zythia*) and Angular Leaf Spot (*Xanthomonas*). (LS)

Timing

- Promote proper timing of management for:
  - Cyclamen Mite, including understanding of lifecycle. (CM)
  - White Grubs. (WG)
  - Gray mold. (GM)
  - Powdery mildew, particularly end-of-season management and reminders to do so. (PM)
- Promote understanding of residual effects of management and coordination with frost protection measures. (GM)
- Clarify the management of Anthracnose Fruit Rot. (AFR)

Methods

- Provide decision-making tools for growers to plan rotation with options tailored to different goals (marketing, severity tolerance, pest focus) that balance application restrictions with different pests over an entire season and days to harvest between crops, plus optimization of materials useful to several crops. (TBP)
- Promote a systems approach when problems occur including management of adults, use of prophylactic soil treatments, and spring follow-up methods. (RW)
- Promote monitoring, site sanitation, and postharvest handling to reduce impact of pest. (SWD)
- Provide compatibility charts for tank mixes. (GM)
- Clarify the function of hydrogen peroxide (Oxidate) in pest management plans. (GM)
- Clarify the management differences between fungal and bacterial foliar diseases. (LS)
- Promote the proper use products according to label. Not all labels list the same target pests and not all states allow use against unlisted pests or crops. (LS)
- Promote the use of biodegradable mulch systems for weed management. (Weeds)

Awareness

- Raise awareness of:
  - The differences in management for June-bearing and day-neutral varieties. (TBP)
  - The effects of management materials on pollinators. (TBP)
  - The need for high gallonage requirement and use of spreaders to improve penetration of sprays. (CM)
  - The potential of bare plasticulture used with day neutral varieties to facilitate splashing and spread of disease. (AFR)
  - The differences in symptoms between Powdery Mildew and Leafhopper damage, particularly among new growers. (PM)
  - The reason and importance of rotation plans to curtail resistance development, particularly explaining mode of action codes and use of strobilurin fungicide materials. (TPB, SWD, GM, AFR)
  - Emerging weed species that are becoming more problematic. (Weeds)

- Public awareness of the presence of Spotted Wing Drosophila could potentially be detrimental to marketing of crop. (SWD)
- Include mode of action codes in regional crop guides. (AFR)
- Provide more advanced education to certified crop advisors and advanced growers. (BRR)

III. Strategic Issues for Key Strawberry Pests

Key Insects and Mite pests

IRAC = Insecticide Resistance Action Committee (with mode of action classification code)
OMRI = Organic Materials Review Institute
Key Pest Name Abbreviations = see page 3

➢**Tarnished Plant Bug** (*Lygus lineolaris)*

- This is an annual pest beginning in early spring and continuing until heavy frost. Early blooming June-bearing varieties may not be as significantly affected as day-neutral varieties.
- Both adults and nymphs feed on the developing flower buds and fruit, resulting in deformed fruit that are generally unmarketable. Cultivars that bear later in the season may suffer more damage as pest populations increase.
- Management of weeds near the planting may reduce populations of this insect. Cultural management with weed management around site begins the year prior to planting.
- Insecticide sprays may be necessary prior to bloom when flower buds appear. Waiting until nymphs are detected pushes spraying into the bloom period and increases bee toxicity. However, while spraying before bloom reduces pollinator exposure this may over treat for pest.
- Parasitic wasp releases, originally in New Jersey and New Hampshire, have reduced total pest population pressure (evidence of efficacy in apples).
- **Yield Losses:** 10-100% without management, 5-20% with management (New Hampshire); 8-23% early season, 30-50% later season, 5-10% day-neutral (New York)

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
acetamiprid (Assail) IRAC 4A	• One day to harvest • Least toxic neonicotinoid (bee toxicity concerns)	• Neonicotinoid (bee toxicity concerns) • Slow acting	•
azadirachtin (Aza-Direct) IRAC UN	•	•	• Not discussed at meeting • Not listed in New England Guide • Not listed in Cornell Guide
Beauvaria bassiana (Mycotrol) IRAC UN	• Low bee toxicity	• Inconsistent efficacy • Not compatible with some fungicides • Very slow acting	• Not listed in New England Guide • OMRI listed • More effective in wet years
bifenthrin (Brigade, Bifenture) IRAC 3A	• Zero days to harvest • Effective • Less expensive than alternatives	• Negative effects on predators • Triggers mite outbreaks • Groundwater issues	• Potential for overuse in day neutrals leading to resistance

Capsicum oleoresin extract, garlic oil, soybean oil (Captiva) IRAC NC	•	• There is perceived potential for effect on fruit flavor (except when used at renovation or early season)	• Not listed in New England Guide • Not listed in Cornell Guide • New material in 2014 • Repellant concept • Efficacy unknown • Not labelled for TPB specifically
carbaryl (Sevin) IRAC 1A	• Inexpensive • Broad spectrum	• Bee toxicity • Days to harvest long • Phytotoxicity possible • Broad spectrum	• Not listed in Cornell Guide • Does not require license • If acetamiprid (Assail) goes away, will see more use
chlorpyrifos (Lorsban) IRAC 1B	•	• Bee toxicity • Extremely long days to harvest	• Not listed in Cornell Guide • Not labelled for TPB
diazinon (Diazinon) IRAC 1B	•	• Bee toxicity • Hard to get	• Not listed in Cornell Guide • Not labelled for TPB
endosulfan (Thionex) IRAC 2A	• Very effective • Also effective against CM • Quick acting	• 15 days between applications • Hard to get	• Not listed in Cornell Guide • Maximum two applications per year • Grower cutoff date July 31, 2016 (worker protection issues)
fenpropathrin (Danitol) IRAC 3A	• Low days to harvest • Effective • Also effective against weevils, other insects	• Bee toxicity • Negative effects on predators • Groundwater issues	•
flonicamid (Beleaf) IRAC 9C	• Narrow spectrum • No bee toxicity warning	• Narrow spectrum • Slow to kill, feeding stops quickly	• Not listed in New England Guide

Issaria fumarosea (PFR-97) IRAC UN	•	•	• Not listed in New England Guide • New material • OMRI listed • Foliar application • Also labelled for weevils and White Grubs as soil application
malathion (Malathion) IRAC 1B	• Inexpensive • Low mammalian toxicity • Two days to harvest	• Not effective against clipper • Strong odor	• Not listed in New England Guide • Not listed in Cornell Guide • May want to save applications for SWD later season • Some additives can make the smell better
naled (Dibrom) IRAC 1B	• One day to harvest • Less expensive	• High human toxicity	• Not listed in New England Guide • Seen increased use with onset of day neutrals • Not common use • Older material but not a lot of information
potassium salts of fatty acids (Des-X, M-Pede) IRAC NC	•	•	• Not listed in New England Guide • Not listed in Cornell Guide • New material in 2014 • OMRI listed • Might be effective against nymphs
pyrethrins (Pyganic) IRAC 3A	• Broad spectrum • Most effective of OMRI listed	• Not very effective • Broad spectrum • Higher bee toxicity than other organic options	• OMRI listed • Alternate with spinosad (Entrust) for SWD -only choices in NY
sulfoxoflor (Closer) IRAC 4C	•	• Neonicotinoid (bee toxicity concerns)	• Not listed in Cornell Guide • New material in 2014
thiamethoxam (Platinum, Actara) IRAC 4A	• Effective against eggs/immature • Relatively low mammalian toxicity	• Neonicotinoid (bee toxicity concerns) • Relatively expensive	• Also effective against White Grubs and Root Weevils as soil application

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Site selection away from pest habitat (hayfields, open pasture)	• Reduces pest pressure	•	•
Weed management around site	• Reduces pest habitat and pest populations	•	•
Avoid cutting hayfields during strawberry bloom	• Reduces pest pressure	• Haying practices have changed recently: less dry hay, more cuts	•
Plant resistant varieties	•	•	• There are differences in varietal susceptibility • 'Darselect' particularly susceptible
Netting and row covers	• Exclusion of pest • One-time expense • In early spring or over winter before pest emerges • May provide frost protection	• Must time to allow pollinator access • Very expensive	• Might not need the pollinators if wind, rain is sufficient
Parasitic wasp releases	• Reduces pest population	•	• Evidence of efficacy in apples

Research Needs:

- Determine varietal differences in susceptibility, especially as germplasm base becomes more diversified with new European stock.
- Continue breeding work to develop more resistant varieties.
- Determine which varieties are able to pollinate under netting or row covers that excludes insect pollinators.
- Refine scouting techniques and thresholds to optimize treatments, timing of scouting and treatment, and pollinator protection close to bloom.
- More efficacy data on spray materials are needed to fill gaps in regional guides.
- Explore whether hydrogen peroxide (Oxidate) has efficacy on insect pests.
- Refine landscape management techniques around site to reduce pest habitat and pest pressure.
- Determine pest overwintering habitat to improve management.
- Explore the relationship between pest habitat and habitat that encourages beneficial insects and pollinators.

Regulatory Needs:

- Encourage state agriculture departments to participate in the National Pesticide Information Retrieval System by subscription.
- Create incentives for pesticide packaging in smaller quantities, especially water soluble bags that are more practical for small acreage.

Education Needs:

- Provide decision-making tools for growers to plan rotation with options tailored to different goals (marketing, severity tolerance, pest focus) that balance application restrictions with different pests over an entire season and days to harvest between crops, plus optimization of materials useful for several crops.
- Raise awareness of the effects of management materials on pollinators.
- Raise awareness of the reason and importance of rotation plans to curtail resistance development, particularly explaining mode of action codes.
- Raise awareness of the differences in management for June-bearing and day-neutral varieties.

➢**Cyclamen Mite** (*Steneotarsonemus pallidus*)

- Day neutral varieties are less likely to be affected as pest population does not establish on annual crops.
- This pest is on the rise in strawberry and peppers. This pest can arrive via infested stock but symptoms do not appear until the following year or more, beginning in early spring through late summer. Presence and symptoms can be cyclical, appear in waves or flare-ups, or as hotspots in sites. Warm dry spring conditions exacerbate pest population and symptoms.
- These mites feed on new leaves in the plant crown, resulting in stunted plants, distorted purplish leaves, and buds that fail to open. Blossom feeding results in deformed fruit. Pest is very small and requires a microscope to see.
- Management by pre-plant treatment is a best practice for reducing the pest population on incoming nursery stock before it becomes established in fields.
- Management in fields includes spot treatments with *high gallonage* miticide sprays (much higher than required for foliar mites). Very difficult to get spray penetration.
- It is often too late for effective management when symptoms appear. Site is usually put into rotation sooner than otherwise would be.
- 'Cabot' variety is particularly susceptible.
- **Yield Losses:** 50-80% without management, 0-50% with management

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
abamectin (Agri-Mek) IRAC 6	• Good efficacy	• Gallonage on label for foliage mites does not provide good efficacy for CM -increased gallonage volume improves efficacy.	• Not listed in Cornell Guide • Not labelled for CM specifically
acequinocyl (Kanemite) IRAC 20B	• Good efficacy	• Gallonage on label for foliage mites does not provide good efficacy for CM -increased gallonage volume improves efficacy.	• Not listed in Cornell Guide • Not labelled for CM specifically

azadirachtin (Aza-Direct) IRAC UN	•	•	• Not discussed at meeting
bifenthrin (Brigade, Bifenture) IRAC 3A	•	•	• Not discussed at meeting • Not listed in Cornell Guide
Capsicum oleoresin extract, garlic oil, soybean oil (Captiva) IRAC NC	•	• There is perceived potential for effect on fruit flavor (except when used at renovation or early season)	• Not listed in New England Guide • Not listed in Cornell Guide • New material in 2014 • Not labelled for CM specifically
diazinon (Diazinon) IRAC 1B	•	• Bee toxicity • Hard to get	• Not listed in Cornell Guide
dicofol (Kelthane, Dicofol) IRAC UN	• Growers use • Low bee toxicity	• Strong odor • Not supposed to use during high temp 90F (during renovation)	• Not listed in Cornell Guide • Not labelled for CM specifically
endosulfan (Thionex) IRAC 2A	• Very effective • Also effective against TPB	• 35 days between applications when fruit is present • Hard to get • Prohibited use on annual (phased out in 2012)	• Maximum two applications per year • Grower cutoff date July 31, 2016 (worker protection issues)
fenpyroximate (Portal) IRAC 21A	• Growers use • Effective	• Must have contact, stops feeding, doesn't kill • Use when symptoms appear is too late	• Must rotate • Best used at renovation or early spring
imidacloprid (Admire Pro, Provado) IRAC 4A	• Good efficacy	•	• Not labelled for CM specifically
mineral oil (SuffOil) FRAC NC	•	•	• Not discussed at meeting • Not labelled for CM specifically • Contains petroleum distillates
neem extract/derivatives (Trilogy) IRAC NC	• Slight efficacy • Also effective against PM	• Ability to reach pest doubted	• Not listed in Cornell Guide • OMRI listed • Not labelled for CM specifically

paraffinic oil (JMS Stylet Oil) IRAC NC	•	• Ability to reach pest doubted	• Not listed in Cornell Guide • OMRI listed • Not labelled for CM specifically
potassium salts of fatty acids (Des-X, M-Pede) IRAC NC	• Might penetrate to reach pest • Efficacy unknown • Could also act as deer repellent	• Phytotoxicity possible	• Not listed in New England Guide • Not listed in Cornell Guide • New material in 2014 • OMRI listed • Not labelled for CM specifically

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Longer rotations between crops	• Reduces pest habitat, population	•	•
Increase renovation intervals	• Pest population does not establish	• Increased expense	•
Plant day neutral varieties	• Pest population does not establish	•	• One year lifespan of crop
Hot water dip prior to planting	• Reduces pest population	• Not much research on efficacy	•

Research Needs:

- Determine varietal differences in susceptibility.
- Explore the usefulness and efficacy of mite predators.
- Study methods to manage pest prior to planting (hot water dip, irradiation) and preventative sprays at planting in anticipation of the loss of pre-plant pesticide dips.
- Ascertain if pest may be spread on equipment.

Regulatory Needs:

- Establish certification inspection programs to verify nursery stock as clean of pest. Such programs would also be useful for other pests and diseases such as Anthracnose Fruit Rot (*Colletotrichum*), strawberry aphids, and viruses.
- Establish traceability protocols (e.g. lots, distribution records) for plant stock to track pest movement.

Education Needs:

- Clarify the proper identification features of symptoms.
- Promote understanding of lifecycle and proper timing of management.
- Raise awareness of need for high gallonage requirement and use of spreaders to improve penetration of sprays.

➢**Root Weevils** (*Otiorhynchus* spp.*, Polydrusus* spp.)

- Day neutral varieties are less likely to be affected as pest population does not establish on annual crops.
- These larvae are persistent pests where they appear, with symptoms appearing in early spring through autumn. Infestations are generally in patches. Adults emerge mid-summer and lay eggs late summer through fall. Adults can overwinter in warmer areas and lay eggs in following season.
- Pest appears to be associated with site history of nursery production and can be moved between sites on equipment.
- Management includes soil applications of insect pathogenic nematodes in early spring or late summer or insecticide sprays as a soil drench or as a spray targeting adults to inhibit egg laying. It is usually easier to put site into rotation than to manage.
- Larvae feed on the crown and roots, resulting in declining, stunted plants with reduced yield. This is especially damaging where root diseases are also present. Symptoms appear when plants are under fruit load stress. Nothing to do about it at that point for the crop. Can treat bed for future seasons and prevent spread to other sites.
- Adult weevils feed on leaves, causing notching on leaf edge. Need to scout for adult leaf notching to time pesticide applications. Adults are very robust. Sprays MUST be applied at night when adults are active (in soil/mulch during day).
- Mowing during renovation in an infested site causes stress on plants and should be avoided.
- **Yield Losses:** 40% without management.

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
Beauvaria bassiana (Mycotrol) IRAC NC	• Low bee toxicity	• Inconsistent efficacy • Not compatible with some fungicides • Very slow acting	• Not listed in New England Guide • OMRI listed • More effective in wet years
bifenthrin (Brigade, Bifenture) IRAC 3A	• Zero days to harvest	• Negative effects on predators • Triggers mite outbreaks • Many individuals survive long-term • Groundwater issues	• Have to use highest label rate • Targets adults only
carbaryl (Sevin) IRAC 1A	•	•	• Not discussed at meeting • Not listed in New England Guide • Not listed in Cornell Guide
diazinon (Diazinon) IRAC 1B	•	• Bee toxicity • Hard to get	• Not listed in Cornell Guide • Not labelled for Root Weevils

fenpropathrin (Danitol) IRAC 3A	• Low days to harvest • Effective • Also effective against TPB, other insects	• Bee toxicity • Negative effects on predators • Groundwater issues	• Not listed in Cornell Guide • Not labelled for Root Weevils
Issaria fumarosea (PFR-97) IRAC NC	•	•	• Not listed in New England Guide • New material • Soil application • Labelled for both Root Weevils • Also labelled for White Grubs as soil application and TPB as foliar application
malathion (Malathion) IRAC 1B	•	•	• Not discussed at meeting • Not listed in New England Guide • Not listed in Cornell Guide
pyrethrins (Pyganic) IRAC 3A	•	•	• Not discussed at meeting • Not listed in New England Guide • Not listed in Cornell Guide
thiamethoxam (Platinum, Actara) IRAC 4A	• Relatively low mammalian toxicity	• Neonicotinoid (bee toxicity concerns) • Relatively expensive • More effective against strawberry root weevil than black vine weevil	• Also labelled for White Grubs as soil application and TPB as foliar application

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Avoid sites with history of nursery crops	• Reduces pest pressure	•	•
Rotate out of strawberry with at least one resistant crop	• Elimination of larval hosts • Reduces pest habitat, population	• 40+ hosts	•
Plant resistant varieties	•	•	• New variety 'Rubicon' is tolerant
Plant day neutral varieties	• Pest population does not establish	•	• One year lifespan of crop

Fences of plastic sheeting, sticky materials, trenches	• Exclusion of pest	• Equipment disrupts	• Adults cannot fly
Pathogenic nematodes	• Well characterized • Can be effective • Reduces pest population	• Very tricky to apply properly • Can be very expensive • Sold as mix of species that doesn't give good proportion of effective species • May affect other ground insects	• Hard to tell how effective • Do not apply via drip irrigation (settles out)

Research Needs:

- More information is needed on choosing cover crops and alternate crops that are not hosts for the pests.
- Identify effective species of insect pathogen nematodes.
- Select for more virulent strains of insect pathogenic nematodes that are active at different soil depths.

Regulatory Needs:

- Re-registration of carbofuran (Furadan) for use in strawberry is desired for its high efficacy against pests, although unlikely due to toxicity.
- Encourage pesticide distributors to carry live materials, such as pathogenic nematodes, to improve grower access.

Education Needs:

- Clarify the proper identification features and differences between healthy pathogenic nematode materials and dead pathogenic nematode materials prior to application.
- Promote a systems approach when problems occur including management of adults, use of prophylactic soil treatments, and spring follow-up methods.

➢**Spotted Wing Drosophila** (*Drosophila suzukii*)

- Populations of this invasive insect do not cause significant damage until mid-late summer and autumn. This pest is a specific threat to day-neutral varieties while June-bearing varieties are not significantly affected. A complete life cycle can be as little as 14 days.
- Female flies are able to insert eggs through the skin of ripening fruit. Larvae feed on the flesh of fruits, resulting in premature softening, decay and very reduced shelf life.
- Management is through frequent and repeated insecticide sprays throughout the day neutral ripening and harvest period. Netting can be effective on smaller plantings and removal of waste fruit may keep populations in check.
- **Yield Losses:** 0-75% with management.

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
acetamiprid (Assail) IRAC 4A	• One day to harvest • Least toxic neonicotinoid (bee toxicity concerns)	• Neonicotinoid (bee toxicity concerns) • Must rotate after two applications • Applications must be seven days apart	• Improved efficacy if add sugar to water at 1-2lb/100 gal (very dilute so sugar doesn't clog nozzles, attract ants, yellowjackets, etc.) • Short residual activity • Translaminar (systemic-like) • Not labelled for SWD
azadirachtin (Aza-Direct) IRAC UN	•	• Poorly effective at best	• OMRI listed • Organic growers use in rotation with spinosad (Entrust) • Not labelled for SWD
bifenthrin (Brigade, Bifenture) IRAC 3A	• Zero days to harvest • Excellent efficacy • Less expensive than alternatives	• Negative effects on predators • Triggers mite outbreaks • Groundwater issues	• Potential for overuse in day neutrals leading to resistance • Not labelled for SWD
diazinon (Diazinon) IRAC 1B	• Excellent efficacy in blueberry	• Bee toxicity • Hard to get • Five days to harvest	• Not listed in Cornell Guide • Not labelled for SWD
fenpropathrin (Danitol) IRAC 3A	• Two days to harvest • Excellent efficacy • Also effective against weevils, other insects	• Bee toxicity • Negative effects on predators • Groundwater issues	• Not labelled for SWD
imidacloprid (Admire Pro, Provado) IRAC 4A	• Good efficacy	• Seven days to harvest (too long)	• Admire listed for strawberry (not in NY) • Not labelled for SWD
malathion (Malathion) IRAC 1B	• Inexpensive • Low mammalian toxicity • Good efficacy at high rate	• Strong odor • Three days to harvest	• May want to avoid TPB applications so may use for SWD later season • Some additives can make the smell better • Not labelled for SWD specifically
pyrethrins (Pyganic) IRAC 3A	• Broad spectrum	• Poor efficacy • Broad spectrum • Higher bee toxicity than other organic options	• OMRI listed • Alternate with spinosad (Entrust) for SWD -only choices in NY

spinetoram (Radiant) IRAC 5	• One day to harvest • Excellent efficacy	• 5-7 day schedule • Must rotate every two sprays • Five applications max per season • Very expensive	• Next generation of spinosad (not OMRI listed)
spinosad (Entrust) IRAC 5	• Very good to excellent efficacy • One day to harvest	• Very expensive • Must rotate every two sprays • Five applications max per season	• OMRI listed • Not labelled for SWD specifically

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Raspberry trap crop	• Diverts pests	• Will increase populations	•
Plant June-bearing varieties	• Fruit finished before pest pressure increases	•	•
Removal of ripe fruit	• Reduces pest habitat, population	• Every ripe berry must leave the field	•
Chill all harvested fruit	• Reduces pest development	• Immediately after harvest	•

Research Needs:

- Determine if trap cropping with raspberry will increase the pest population to pressure strawberry.
- Determine a recommended ratio of raspberry trap crop to strawberry crop to be effective.
- Explore the cost effectiveness of netting for pest management.
- Refine scouting standards and action thresholds to optimize treatments.
- Develop 'curveball' attract-and-kill alternative technology for pesticide delivery.
- Explore how 'curveball' attract-and-kill alternative technology for pesticide delivery can become acceptable for use in certified organic operations.
- Increase understanding of mortality factors of pest, including parasites and predators, weather, and cultural conditions (airflow, humidity, etc.).
- Increase understanding of lifecycle, overwintering or migration activity, landscape habitat, and potential invasive plant (buckthorn, barberry) hosts.

Regulatory Needs:

- Speed registration of cyantraniliprol (Exirel) through approval pipeline for strawberry; desired despite projected expense of material.
- Encourage registration and labelling of more products, particularly organic products, which can be used in rotation against SWD.

Education Needs:

- Public awareness of the presence of this pest could potentially be detrimental to marketing of crop.
- Raise awareness of the reason and importance of rotation plans to curtail resistance development, particularly explaining mode of action codes.
- Promote monitoring, site sanitation, and postharvest handling to reduce impact of pest.

➢**White Grubs** (*Scarabaeidae* family)

- These larvae are primarily planting year pests when going into sod ground in autumn and early spring. High populations of larvae are more likely following a dry summer. Adults emerge and lay eggs from late spring to mid-summer. Populations of these pests are not established in every site.
- Larvae feed on the roots, resulting in stunted growth and plant dieback, especially where other diseases are present. Mobile adults feed on leaves, causing skeletonized leaves. Adults may injure leaves of day neutral varieties but management is rarely necessary.
- Management includes soil applications of insect pathogenic nematodes or insecticide sprays as a soil drench or as a spray targeting adults feeding on leaves and to inhibit egg laying. Segregation of plantings from turf areas is recommended. It is often too late for effective management for current crop when symptom appear.
- Can salvage sites through grass management against Japanese beetle, others. However, many new and different species are increasingly problematic and no longer easy to group and manage.
- Oriental and Asiatic garden beetles are increasingly problematic, will breed in non-sod, don't disperse as much, and prefer the high level of moisture in drip irrigation environments.
- **Yield Losses:** 20-30% without management dependent on species

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
acetamiprid (Assail) IRAC 4A			• Not discussed at meeting • Not listed in New England Guide • Labelled for Japanese Beetle
azadirachtin (Aza-Direct) IRAC UN			• Not discussed at meeting • Not listed in New England Guide • Not listed in Cornell Guide • Labelled for Japanese Beetle

Beauvaria bassiana (Mycotrol) IRAC NC	• Low bee toxicity	• Inconsistent efficacy • Not compatible with some fungicides • Very slow acting	• Not listed in New England Guide • OMRI listed • More effective in wet years • Labelled for beetles
carbaryl (Sevin) IRAC 1A	•	•	• Not discussed at meeting • Not listed in New England Guide
chlorantraniliprole (Coragen) IRAC 28	•	•	• Not listed in New England Guide • Foliar use against Japanese Beetle
chlorpyrifos (Lorsban) IRAC 1B	•	• Bee toxicity • Extremely long days to harvest	• Not listed in Cornell Guide
diazinon (Diazinon) IRAC 1B	•	• Bee toxicity • Hard to get	• Not listed in Cornell Guide • Not labelled for grubs
imidacloprid (Admire Pro, Provado) IRAC 4A	• Effective against Japanese Beetle	• Bee toxicity • Timing very important • Must water in	• Post-harvest best time for treatment • Must rotate
Issaria fumarosea (PFR-97) IRAC NC	•	•	• Not listed in New England Guide • New material • OMRI listed • Soil application • Also labelled for both Root Weevils as soil application and TPB as foliar application
pyrethrins (Pyganic) IRAC 3A	•	•	• Not discussed at meeting • Not listed in New England Guide • Labelled for Japanese Beetle
thiamethoxam (Platinum, Actara) IRAC 4A	• Only fair efficacy on some species • Relatively low mammalian toxicity	• Neonicotinoid (bee toxicity concerns) • Relatively expensive • High runoff risk	• Also labelled for both Root Weevils as soil application and TPB as foliar application

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Pathogenic nematodes	• Well characterized • Can be effective • Reduces pest population	• Very tricky to apply properly • Can be very expensive • Sold as mix of species that doesn't give good proportion of effective species • May affect other ground insects	• Hard to tell how effective • Do not apply via drip irrigation (settles out)
Turf management	• Effective against Japanese beetle • Reduces pest population	• Not very effective against Asiatic garden or Oriental beetles	•

Research Needs:

- Characterize the different pest species and their behaviors, particularly Oriental and Asiatic garden beetles, to improve management efficacy
- Characterize environmental conditions that affect the different pest species.
- Determine efficacy of targeting adults to manage larvae.
- Verify efficacy of organic materials and methods.
- Refine scouting techniques and thresholds to optimize treatments, particularly for organic operations.
- Identify effective species of insect pathogen nematodes.
- Select for more virulent strains of insect pathogen nematodes that are active at different soil depths.
- Alternatives to imidacloprid as a management tools are desperately needed.
- Explore the efficacy of chlorantraniliprole (Coragen) against different pest species (currently labelled against Japanese beetle adults).

Regulatory Needs:

- Provide incentives to conduct research studies on efficacy of existing and new materials; Specialists doing research need to be encouraged and supported to maintain and improve upon the number and quality of professionals in practice.
- Encourage pesticide distributors to carry live materials, such as pathogenic nematodes, to improve grower access.

Education Needs:

- Clarify the proper identification features and differences between grub species.
- Promote proper timing of management.

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 Northeast. Listed alphabetically by common name.

False Chinch Bug (*Nysius* sp.)
- Very sporadic problem
- Causes cosmetic damage that makes fruit unsaleable
- More potential of a problem on day-neutral varieties

Potato Leafhopper (*Empoasca fabae*)
- Key Pest in 2007 PMSP
- Of importance in establishment year
- Adult and nymph feeding causes stunting and yellowing of leaves

Strawberry Aphids (*Chaetospihon fragaefolii*, others species)
- Of importance in establishment year
- Vector for viruses

Strawberry Bud Weevil or Strawberry Clipper (*Anthonomus signatus*)
- May become problematic if not properly managed
- Egg-laying activity 'clips' blossom buds from plants

Strawberry Rootworm (*Paria fragariae*)
- Occasional problem
- Larvae feed on roots; Adults chew holes in leaves

Strawberry Sap Beetle (*Stelidota geminata*)
- Growing problem
- Pest populations moving North
- Adults bore into berries

Strawberry Seed Beetle (*Harpalus rufipes*)
- More of a problem on day-neutral varieties
- Adults remove seeds from fruit, causing fruit to ooze and opening avenues for infection

Two-Spotted Spider Mite (*Tetranychus urticae*)
- May become a problem under row covers
- Feeding causes yellowing of leaves

Slugs (multiple species)
- Mulch and irrigation can exacerbate problem by providing pest habitat
- Less of a problem on day-neutral varieties due to the use of plasticulture
- Management must occur before fruit ripens
- Baiting in fall may reduce overwintering population
- Bait materials include: iron phosphate (Sluggo), metaldehyde (Deadline)

- Metaldehyde baits can be toxic to mammals

Key Diseases

FRAC = Fungicide Resistance Action Committee (with mode of action classification code)
OMRI = Organic Materials Review Institute
Key Pest Name Abbreviations = see page 3

➢**Gray Mold** (*Botrytis cinerea*)

- This is an annual fungal disease beginning in spring through late summer into fall with day neutrals, favored by cool and wet weather.
- Symptoms include powdery gray growth on softened fruit and leaf tissue, firm brown areas on fruit, or berries that retain shape but become tough and dry. Storage rots may also occur.
- Management with protective sprays during bloom and maintaining air circulation between plants is common.
- Resistance to chemical sprays is highly possible. Resistance has occurred in Pennsylvania and North Carolina. It is possible for new plants to carry resistant strains from the nursery.
- Spray material rotation is key to avoid resistance development. Growers are advised to ask suppliers for records of what new plant stock had been sprayed with prior to shipping to plan for rotation.
- **Yield Losses:** Up to 100% without management dependent on weather.

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
azoxystrobin (Abound) FRAC 11	• Broad spectrum • Zero days to harvest	• Phytotoxicity possible • Can cause significant problems with apples if use same sprayer • Suppression activity on foliage • Broad spectrum • Not labelled in NY, NE	• Requires extra special attention to tank mixes, rotation • Not much used
Bacillus amyloliquefaciens (Double Nickel) FRAC 44	• Zero days to harvest	• Unknown to growers	• New material in 2014 • OMRI listed • Good rotation alternative • Effective in combination with coppers against fireblight on apples
Bacillus subtilis (Serenade) FRAC 44	•	•	• Not discussed at meeting

captan (Captan, Captec, others) FRAC M4	• No resistance risk • Zero days to harvest	• Strictly preventative • 24-48 hour reentry interval • Some formulations clog sprayer nozzles • Phytotoxicity possible when applied with oil • Can leave obvious residue when used close to harvest	• Captan formulations do not all have the same functionality
captan + fenhexamid (CaptEvate) FRAC M4+17	• Also effective against AFR, Leaf Spot • Zero days to harvest	• Expensive	• Not very different from captan (fenhexamid has no AFR activity)
copper octanoate (Cueva) FRAC M1	•	•	• Not discussed at meeting • Not listed in New England Guide
cyprodinil + fludioxinil (Switch) FRAC 9+12	• Zero days to harvest • Good rotation alternative • Also effective against AFR	•	•
fenhexamid (Elevate) FRAC 17	• Pretty effective • Less expensive • Different active ingredient than other materials	• Resistance noted in Southern US	• Must rotate or tank mix
hydrogen peroxide (Oxidate) FRAC NC	• Poor efficacy	• No residual effect • Phytotoxicity possible	• Not listed in New England Guide • OMRI listed
hydrogen peroxide + peroxyacetic acid (Rendition) FRAC NC	•	•	• Not discussed at meeting • Not listed in New England Guide
iprodione (Rovral) FRAC 2	• Good tank mix, rotation alternative • Pre-plant dip label	• Cannot apply more than 1-4 times per season, depending on formulation • NY must use early season	• Not listed in New England Guide •
neem extract/ derivatives (Trilogy) FRAC NC	• Efficacy unknown • Also effective against PM	•	• New material in 2014 • OMRI listed

paraffinic oil (JMS Stylet Oil) FRAC NC	• Zero days to harvest • Some mite, PM management efficacy	• Need high spray pressure during application • Phytotoxicity possible when applied with captan • Compatibility issues	• OMRI listed
penthiopyrad (Fontelis) FRAC 7	• Unusual FRAC code	• Label variety specific, not all tested • Requires special attention with captan, thiram	• Not listed in New England Guide • Not listed in Cornell Guide • Newer material
polyoxin D zinc salt (Tavano, Ph-D) FRAC 19	• Zero day to harvest	•	• New material in 2014 • Widely used in ornamental/greenhouse industry • Rotation strongly recommended
potassium bicarbonate (Milstop, Kaligreen) FRAC NC	• Good efficacy • Also useful in greenhouse operations	•	• OMRI listed
pyraclostrobin (Cabrio) FRAC 11	• Effective • No problems with apples	• Resistance noted in Southern US	• Not listed in New England Guide • Must rotate
pyraclostrobin + boscalid (Pristine) FRAC 11+7	• Effective • No problems with apples • Broad spectrum	• More expensive than pyraclostrobin (Cabrio) alone • Resistance noted in southern US • Possible bee issues • Broad spectrum	• Not listed in Cornell Guide • Used as finish spray before harvest • Must rotate
pyraclostrobin + fluxapyroxad (Merivon) FRAC 11+7	• Zero days to harvest	•	• New material in 2014 • Must rotate • Strawberry not on regular label, supplemental label, not NY
pyrimethanil (Scala) FRAC 9	• Effective • One day to harvest	• Need tank mix at lower rate	• Same FRAC group as cyprodinil + fludioxinil (Switch) • Been around a while

Streptomyces lydicus (Actinovate) FRAC NC	• Fairly effective	•	• Not listed in New England Guide • OMRI listed
thiophanate methyl (Topsin) FRAC 1	•	• Resistance noted in southern US	• Not recommended on ornamentals due to resistance • Usually recommend as tank mix with captan
thiram (Thiram) FRAC M3	• Broad spectrum • Also effective as deer repellent • Good rotation alternative • One day to harvest, reentry interval	• Broad spectrum	• Not listed in Cornell Guide

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Narrow rows	• Rapid drying of foliage	•	• Air flow
Raised beds	•	•	•
Remove mowed leaves at renovation	• Reduces pest habitat, population	• Labor intensive	•
Optimize nitrogen management	•	• Use caution in spring	• Affects foliage density, fruit firmness

Research Needs:

- Test the foliar reddening effects of penthiopyrad (Fontelis) on different varieties. Not all varieties have been tested.
- Develop testing, standards and recommendations for assessing foliar nitrogen; explore use of portable meter/kit use
- Explore the potential for fall spray materials, particularly hydrogen peroxide (Oxidate), to reduce pest.

Regulatory Needs:

- Require nurseries to supply records of what new plant stock had been sprayed with prior to shipping to allow growers to plan for material rotation.

Education Needs:

- Provide compatibility charts for tank mixes.
- Promote proper timing of management, understanding of residual effects, and coordination with frost protection measures.
- Clarify the function of hydrogen peroxide (Oxidate) in pest management plans.
- Raise awareness of the reason and importance of rotation plans to curtail resistance development, particularly explaining mode of action codes

➢**Black Root Rot Complex** (*Rhizoctonia*, *Pythium*, *Fusarium*, *Pratylenchus*)

- This is an endemic complex that is favored by plant stress conditions such as drought, winter injury, poor nutrition, soil compaction, older beds and sites, or improper herbicide use with symptoms appearing in early spring through autumn. Climate change irregularities may further stress plants.
- Symptoms include lack of plant vigor and productivity and eventual collapse with a progression of blackened feeder, structural, then perennial roots. Structural roots retain a white core as the rot occurs from the outside to the center.
- Management of plant stress conditions through proper site selection and long crop rotation are common management techniques. There are no 'silver bullet' treatments. Most products are labelled against *Rhizoctonia* only, with few products available to target other complex species. It is usually easier to put site into rotation than to manage.
- Very little is known about this pest complex and research is needed.
- **Yield Losses:** 50% without management

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
azoxystrobin (Abound) FRAC 11	• Broad spectrum • Zero days to harvest • Root dip or banded in-row applications	• Can cause significant problems with apples if use same sprayer • Broad spectrum	• Requires extra special attention to tank mixes, rotation
Bacillus amyloliquefaciens (Double Nickel) FRAC 44	• Zero days to harvest • Root dip	• Unknown to growers	• Not listed in New England Guide • New material in 2014 • OMRI listed • Good rotation alternative • Effective in combination with coppers against fireblight on apples
phosphorous acid (Phostrol, Rampart, Agri-Fos) FRAC 33	•	•	• Not discussed at meeting • Not listed in New England Guide
polyoxin D zinc salt (Tavano, Ph-D) FRAC 19	• Zero day to harvest	•	• New material in 2014 • Widely used in ornamental/greenhouse industry • Rotation strongly recommend
Streptomyces lydicus (Actinovate) FRAC NC	•	• Efficacy unknown	• Not listed in New England Guide • OMRI listed

Trichoderma (Root Shield) FRAC NC	• Pre-plant, root dip, spray applications • Particularly good efficacy against *Pythium*, *Rhizoctonia*, *Thielaviopsis*	•	• Not listed in Cornell Guide • Many studies have not been included in guidelines

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Longer rotation between crops	• Reduces pest habitat, population	•	•
Reduce plant stress	•	•	•
Improve soil health	•	•	•

Research Needs:

- Explore the use and/or impacts of multispecies cover crops, improvement of soil health, soil compaction management, rotations, compost, crop residue/inoculum levels even with long rotations (BRR)
- Explore the efficacy of cover cropping with mustard and other biofumigants to impact pest population.
- Determine varietal differences in susceptibility depending on the pathogen present.
- Develop tools to screen for virus and/or Black Root Rot Complex as causative agent of symptoms.
- Explore the role of nematodes in pest activity, conditions that affect nematodes (warmer soil temperatures, population spread), and testing options.
- Survey Northeast growers to document presence or suspected presence; verify samples for virus and/or Black Root Rot Complex as causative agent of symptoms.
- Encourage priority listing to document this pest complex as a problem to this crop.

Regulatory Needs:

- Require nurseries to declare if pest complex is a potential issue on stock.

Education Needs:

- Clarify the proper identification features and differences between Black Root Rot Complex and Strawberry Mottle Virus.
- Provide more advanced education to certified crop advisors and advanced growers.

➢**Anthracnose Fruit Rot** (*Colletotrichum acutatum*)

- This is an annual fungal disease beginning in spring through late summer, favored by warm and humid spring weather. More common on day-neutral varieties. This disease has been seen in Pennsylvania, New York and Vermont.
- Symptoms include circular, sunken, water-soaked tan to brown lesions on fruit. A slimy spore mass spreads by splashing with rain and irrigation. Under dry conditions the fruit may become mummified and black. This fungus may also attack stolons, petioles, and crown tissues.
- Management with site sanitation and crop rotation is common. Sprays against GM will also manage this pest. One spray will typically manage when pest occurs although sometimes go a

few weeks before see again then have to spray again. Protective sprays may be less effective in hot, humid conditions.

- Growers with no history of this pest and not scouting for it may be unprepared when this pest does occur.
- Spray material labels are not necessarily specific to fruit Anthracnose.
- **Yield Losses:** 50% without management.

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
azoxystrobin (Abound) FRAC 11	• Broad spectrum • Zero days to harvest	• Can cause significant problems with apples if use same sprayer • Broad spectrum	• Requires extra special attention to tank mixes, rotation
azoxystrobin + propoconozol (Quilt Xcel) FRAC 11+3	• Broad spectrum • Zero days to harvest	• Can cause significant problems with apples if use same sprayer • Restrictions on crops rotated with, plant back restrictions on label • Broad spectrum	• Not listed in New England Guide • New material in NY • Also effective against Leaf Spot (*Cercospera*) and PM • Requires extra special attention to tank mixes, rotation
Bacillus amyloliquefaciens (Double Nickel) FRAC 44	• Zero days to harvest	• Unknown to growers	• New material in 2014 • OMRI listed • Good rotation alternative • Effective in combination with coppers against fireblight on apples
Bacillus subtilis (Serenade) FRAC 44	•	•	• Listed in NY • OMRI listed
captan (Captan, Captec, others) FRAC M4	• No resistance risk • Zero days to harvest	• Strictly preventative activity • 24-48 hour reentry interval • Some formulations clog nozzles • Phytotoxicity possible when applied with oil	• MUST CHECK LABEL for AFR –product labels vary
captan + fenhexamid (CaptEvate) FRAC M4+17	• Also effective against GM, Leaf Spot • Zero days to harvest	• Expensive	• Not very different from captan (fenhexamid has no AFR activity)

copper octanoate (Cueva) FRAC M1	•	• Can get fruit injury during bloom	• Not listed in New England Guide • Listed in NY, registered in NE • OMRI listed
cyprodinil + fludioxinil (Switch) FRAC 9+12	• Zero days to harvest • Good rotation alternative • Also effective against GM	•	• Not listed in New England Guide
hydrogen peroxide + peroxyacetic acid (Rendition) FRAC NC	•	•	• Not discussed at meeting • Not listed in New England Guide
iprodione (Rovral) FRAC 2	•	•	• Not discussed at meeting • Not listed in New England Guide
neem extract/ derivatives (Trilogy) FRAC NC	• Efficacy unknown • Also effective against PM	•	• New material in 2014 • OMRI listed
polyoxin D zinc salt (Tavano, Ph-D) FRAC 19	• Zero days to harvest	• Suppression activity, not eradication	• New material in 2014 • Widely used in ornamental/greenhouse industry • Rotation strongly recommend
potassium bicarbonate (Milstop, Kaligreen) FRAC NC	• Also effective against PM	•	• Not listed in New England Guide • OMRI listed
propiconazole (Tilt) FRAC 3	•	• Possible bee issues	• Not listed in New England Guide • Must rotate • Also effective against PM and Leaf Spot
pyraclostrobin (Cabrio) FRAC 11	• Effective • No problems with apples	•	• Must rotate
pyraclostrobin + boscalid (Pristine) FRAC 11+7	• Effective • No problems with apples • Broad spectrum	• More expensive than pyraclostrobin (Cabrio) alone • Possible bee issues • Broad spectrum	• Used as finish spray before harvest • Must rotate

pyraclostrobin + fluxapyroxad (Merivon) FRAC 11+7	• Zero days to harvest	•	• Not listed in Cornell Guide • New material in 2014 • Must rotate • Strawberry not on regular label, supplemental label, not NY
Streptomyces lydicus (Actinovate) FRAC NC	• Also effective against GM	•	• Not listed in New England Guide • OMRI listed

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Mulch between rows and over plastic	• Prevents splashing, spreading	• Bare plastic facilitates splashing, spreading	• Day neutral varieties are typically grown on plastic
Row covers	• Prevents splashing, spreading	•	•
Avoid overhead irrigation	• Prevents splashing, spreading	•	•
Clean equipment between sites	• Prevents spread of pest	•	• Pest may be carried by equipment
Pesticide dip prior to planting	• Reduces pest population	•	•

Research Needs:

- More information is needed on crop rotation period length and alternate crops that are not hosts for the pests.
- Explore the efficacy of straw over plastic to prevent splashing and spread of pest.
- Determine varietal differences in susceptibility.
- Develop PCR screening methods to verify clean stock from nurseries.

Regulatory Needs:

- Register more materials to enable effective rotation with current strobilurin fungicide materials.
- Establish certification inspection programs to verify nursery stock as clean of pest. Such programs would also be useful for other pests and diseases such as Cyclamen Mite, strawberry aphids, and viruses.

Education Needs:

- Clarify the proper identification features and management of pest.
- Raise awareness of the reason and importance of rotation plans to curtail resistance development, particularly explaining mode of action codes and use of strobilurin fungicide materials.
- Include mode of action codes in regional crop guides.

- Raise awareness of the potential of bare plasticulture used with day neutral varieties for facilitating splashing and spread of disease.

➢**Leaf Spot** (*Mycosphaerella fragariae*)

- This is an annual fungal disease beginning in early spring through late summer, spread favored by splashing rain. If pest is present in fall then it will also be present in the spring.
- Symptoms appear as irregular to circular purple spots with grayish centers on leaves, petioles, stems, and runners. Lesions can occasionally develop on fruit (black seed). Heavy infections can inhibit production of flower buds.
- Management with resistant varieties, maintaining air circulation between plants, sanitation, and removal of plant tops at renovation is common. Late fall renovation sprays are also used.
- Will spread from old sites to new sites. Keep out of new planting.
- There a several similar fungal foliar diseases that may be considered more of a complex than individual diseases including Leaf Spot (*Mycosphaerella*), Leaf Scorch (*Diplocarpon*), Leaf Blight (*Phomopsis*), and Leaf Blotch (*Zythia*). Angular Leaf Spot (*Xanthomonas*) is a bacterial disease.
- **Yield Losses:** 50-100% without management

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
azoxystrobin (Abound) FRAC 11	• Broad spectrum • Zero days to harvest	• Can cause significant problems with apples if use same sprayer • Broad spectrum	• Requires extra special attention to tank mixes, rotation • Strawberry Leaf Spot not on label; *Mycosphaerella* spp. on label for other berries
captan (Captan, Captec, others) FRAC M4	• No resistance risk • Zero days to harvest…	• Strictly preventative • 24-48 hour reentry interval • Some formulations clog nozzles • Phytotoxicity possible when applied with oil	• Captan formulations do not all have the same functionality
captan + fenhexamid (CaptEvate) FRAC M4+17	• Also effective against GM, AFR • Zero days to harvest	• Expensive	• Not very different from captan (fenhexamid has no AFR activity)
copper hydroxide (Champ, Nucop, Kocide) FRAC M1	• Effective when applied as two sprays before bloom • Also listed for Angular Leaf Spot (Kocide only)	• Phytotoxicity possible during bloom, high temperatures	• Not listed in New England Guide • OMRI listed (not Kocide)

copper hydroxide + copper oxychloride (Badge) FRAC M1	• Many copper labels also list frost protection activity	• Phytotoxicity possible during bloom, high temperatures	• New material in 2014 • OMRI listed
copper octanoate (Cueva) FRAC M1	•	• Phytotoxicity possible during bloom, high temperatures	• Not listed in New England Guide • OMRI listed
copper sulfate (Cuprofix) FRAC M1	•	• Phytotoxicity possible during bloom, high temperatures	• Not listed in New England Guide
copper sulfate + copper oxychloride (C-O-C-S) FRAC M1	•	• Phytotoxicity possible during bloom, high temperatures	• Not listed in New England Guide
dodine (Syllit) FRAC U12	•	• Highly toxic	• Not listed in Cornell Guide • Strawberry not on label • Leaf Spot not on label
iprodione (Rovral) FRAC 2	• Good tank mix, rotation alternative	• Cannot apply more than 1-4 times per season, depending on formulation • NY must use early season	• Not listed in New England Guide
myclobutanil (Rally, Agristar Sonoma) FRAC 3	• Also effective against PM • Good rotation alternative	• Resistance issues growing	•
neem extract/ derivatives (Trilogy) FRAC NC	•	•	• Not discussed at meeting • Not listed in New England Guide
pyraclostrobin (Cabrio) FRAC 11	• Effective • No problems with apples	•	• Must rotate
pyraclostrobin + boscalid (Pristine) FRAC 11+7	• Effective • No problems with apples • Broad spectrum	• More expensive than pyraclostrobin (Cabrio) alone • Possible bee issues • Broad spectrum	• Not listed in Cornell Guide • Used as finish spray before harvest • Must rotate

pyraclostrobin + fluxapyroxad (Merivon) FRAC 11+7	• Zero days to harvest	•	• New material in 2014 • Must rotate • Strawberry not on regular label, supplemental label, not NY
tetraconazole (Mettle) FRAC 3	•	• 14-21 day spray interval	• New material in 2014

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Plant resistant varieties	•	• Not a lot of difference in varieties	•
Promote air circulation in canopy	• Rapid drying of foliage	•	•
Remove infected leaves	• Reduces pest habitat, population	• Labor intensive	• Effective in theory

Research Needs:

- Define thresholds to optimize treatments.
- Explore the efficacy of removal of infected leaves to reduce inoculum and improve yield in the following season.
- Explore the impact of infection on photosynthesis, flower bud initiation, and yield over time.
- Revive breeding work to develop more resistant varieties (this disease used to be a focus of breeding programs).

Regulatory Needs:

- None specified

Education Needs:

- Clarify the proper identification features and differences between foliar diseases including Leaf Spot (*Mycosphaerella*), Leaf Scorch (*Diplocarpon*), Leaf Blight (*Phomopsis*), Leaf Blotch (*Zythia*) and Angular Leaf Spot (*Xanthomonas*).
- Clarify the management differences between fungal and bacterial foliar diseases.
- Promote the proper use materials according to label. Not all labels list the same target pests and not all states allow use against unlisted pests or crops.

➢**Powdery Mildew** (*Sphaerotheca macularis*)

- This is an annual fungal disease beginning in late spring through late summer, favored by warm and humid conditions. Disease incidence has been increasing earlier the season. More common on day neutral varieties.
- Symptoms include white powdery growth on the lower leaf surface, causing the leaf edges to roll upward. Infected flowers and fruit may fail to ripen.
- Management with protective sprays to reduce inoculum and maintaining air circulation between plants are common. Easy to manage if disease is monitored.

- Special attention must be paid to disease development in new plantings and stressed plantings. Not necessarily a key problem on older plantings
- Fungus develops resistance very rapidly and must rotate spray materials. There may be resistant strains developing.
- **Yield Losses:** Very difficult to quantify.

Currently Registered Pesticides (listed alphabetically)

Pesticide	Pros	Cons	Comments
azoxystrobin (Abound) FRAC 11	• Broad spectrum • Zero days to harvest	• Can cause significant problems with apples if use same sprayer • Broad spectrum	• Requires extra special attention to tank mixes, rotation
azoxystrobin + propoconozol (Quilt Xcel) FRAC 11+3	• Broad spectrum • Zero days to harvest	• Can cause significant problems with apples if use same sprayer • Restrictions on crops rotated with, plant back restrictions on label • Broad spectrum	• Not listed in New England Guide • New material in NY • Also effective against Leaf Spot (*Cercospera*) and PM • Requires extra special attention to tank mixes, rotation • Provides kickback efficacy
Bacillus amyloliquefaciens (Double Nickel) FRAC 44	• Zero days to harvest	• Unknown to growers	• New material in 2014 • OMRI listed • Good rotation alternative • Effective in combination with coppers against fireblight on apples
Bacillus pumilus (Sonata) FRAC NC	•	•	• Not discussed at meeting • Not listed in New England Guide
Bacillus subtilis (Serenade) FRAC 44	•	•	• Not discussed at meeting • Not listed in Cornell Guide
copper hydroxide + copper oxychloride (Badge) FRAC M1	•	•	• Not discussed at meeting • Not listed in Cornell Guide
copper octanoate (Cueva) FRAC M1	•	• Phytotoxicity possible during bloom, high temperatures	• Not listed in New England Guide • OMRI listed

cyflufenamid (Miltrex, Torino) FRAC U6	• Torino effective on pumpkins • Zero days to harvest	• Two applications per year • Minimum 14 day spray interval • Minimum gallonage restrictions	• No good information available for use on strawberry
cyprodinil + fludioxinil (Switch) FRAC 9+12	• Zero days to harvest • Good rotation alternative • Also effective against GM	•	• Not listed in New England Guide •
hydrogen peroxide (Oxidate) FRAC NC	• Good efficacy ONLY IF proper timing of application	• No residual effect • Phytotoxicity possible	• Not listed in New England Guide • OMRI listed • Use as clean up, follow with protective spray like copper
hydrogen peroxide + peroxyacetic acid (Rendition) FRAC NC	•	•	• Not discussed at meeting • Not listed in New England Guide
mineral oil (SuffOil) FRAC NC	•	•	• OMRI listed • Contains petroleum distillates
myclobutanil (Rally, Agristar Sonoma) FRAC 3	• Also effective against Leaf Spot • Good rotation alternative	• Resistance issues growing	•
neem extract/ derivatives (Trilogy) FRAC NC	• Good efficacy • Good rotation alternative	•	• New material in 2014 • OMRI listed
paraffinic oil (JMS Stylet Oil) FRAC NC	• Zero days to harvest • Some mite, PM management	• Need high spray pressure during application • Phytotoxicity possible when applied with captan • Compatibility issues	• OMRI listed

penthiopyrad (Fontelis) FRAC 7	• FRAC code unique-ish	• Label variety specific, will cause damage, not all tested • Requires special attention with captan, thiram	• Not listed in New England Guide • Not listed in Cornell Guide • Newer material
phosphorous acid (Phostrol, Rampart, Agri-Fos) FRAC 33	• Not effective	•	• Not listed in New England Guide • Aimed more at phytophthora • Rampart has strawberry label
polyoxin D zinc salt (Tavano, Ph-D) FRAC 19	• Zero days to harvest	•	• New material in 2014 • Widely used in ornamenta/greenhouse industry • Rotation strongly recommend
potassium bicarbonate (Milstop, Kaligreen) FRAC NC	• Very effective during early infection • Also labelled for AFR	•	• OMRI listed
propiconazole (Tilt) FRAC 3	•	• Possible bee issues	• Not listed in New England Guide • Must rotate • Also effective against PM and Leaf Spot
pyraclostrobin (Cabrio) FRAC 11	• Effective • No problems with apples	•	• Must rotate
pyraclostrobin + boscalid (Pristine) FRAC 11+7	• Effective • No problems with apples • Broad spectrum	• More expensive than pyraclostrobin (Cabrio) alone • Possible bee issues • Broad spectrum	• Must rotate
pyraclostrobin + fluxapyroxad (Merivon) FRAC 11+7	• Zero days to harvest	•	• Not listed in Cornell Guide • New material in 2014 • Must rotate • Strawberry not on regular label, supplemental label, not NY

quinoxyfen (Quintec) FRAC 13	• Very effective	• Resistance issues in other crops	• Must be applied prior to infection • Must rotate • Not more than 2 applications consecutively, 4 applications per crop
Reynoutria sachalienensis (Regalia) FRAC P5	•	•	• Not discussed at meeting • Not listed in Cornell Guide
Streptomyces lydicus (Actinovate) FRAC NC	•	• Use with spreader sticker prior to infection	• Not listed in New England Guide • OMRI listed
sulfur (Microthiol, Kumulus, Thiolux) FRAC M2	•	• Varietal susceptibility • Phytotoxicity possible • Residue	• Thiolux not listed in Cornell Guide • OMRI listed (not Microthiol)
tetraconazole (Mettle) FRAC 3	•	• 14-21 day spray interval • Only four applications per season	• New material in 2014
thiophanate methyl (Topsin) FRAC 1	•	•	• Not recommended on ornamentals due to resistance • Usually recommend as tank mix with captan
triflumizole (Procure) FRAC 3	• Should be effective • Some kickback activity • One day to harvest	• 14 day spray interval	• Requires special attention to rotation

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Plant resistant varieties	•	•	• Some resistant varieties available
Promote air circulation in canopy	• Rapid drying of foliage	•	•

Research Needs:

- Determine varietal differences in susceptibility for newer varieties (in older varieties this was part of the breeding program).

Regulatory Needs:

- None specified

Education Needs:

- Raise awareness among newer growers of the differences in symptoms between PM and Leafhopper damage.
- Encourage the importance of timing in end-of-season management and to remember to do it.

Selected Comments on Other Diseases

These diseases are not considered Key Pests but do warrant special note as existing or emerging issues in Northeast. Listed alphabetically by common name.

Angular Leaf Spot (*Xanthomonas fragariae*)

- Bacterial disease favored by wet rainy conditions
- Infection begins on the underside of leaves and may spread to the fruit
- May become a problem under row covers

Leather Rot (*Phytophthora cactorum*)

- Spreads by splashing with rain and irrigation
- May be more of a problem on day-neutral varieties due to the use of plasticulture creating pockets of pooling water

Red Stele Root Rot (*Phytophthora fragariae*)

- Favored by cold wet spring conditions
- Climate change may affect pest populations and activity
- Breeders have moved away from selecting for resistance in new varieties

Strawberry Mottle Virus (SMoV) and Strawberry Mild Yellow Edge Virus (SMYEV)

- A new pest problem in the USA on new plantings
- Strawberry Mottle Virus symptoms are similar to Black Root Rot Complex symptoms
- Symptoms appear in stressed plants before non-stressed plants and during fruiting
- Scouting and management of strawberry aphid is important to limit vector spread
- Research is needed to determine if mechanical vectors are also possible

Verticillium Wilt (*Verticillium albo-atrum*)

- Becoming more of a problem in recent years
- Research is needed on the impacts of crop rotation practices on soil borne pathogen population that can lead to development of crop rotation guidelines for diversified growers

Weeds

HRAC = Herbicide Resistance Action Committee (with mode of action classification code)
OMRI = Organic Materials Review Institute
Key Pest Name Abbreviations = see page 3

Annual Grass Weeds
Annual Broadleaf Weeds
Perennial Grass Weeds
Perennial Broadleaf Weeds

- Weed infestations occur in mixed populations including annual grasses, annual broadleaf, perennial grasses, perennial broadleaf, woody perennial and vine weeds. Weed populations vary across regions and farms.
- Weeds pressure impacts plant development and productivity 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. Weeds can inhibit spray penetration, air circulation, and drying conditions.
- Management with herbicides is common from pre-plant through post-plant pre-emergence and post-emergence applications.
- False buckwheat, red sorrel, purple deadnettle, shepherd's purse are notably problematic in some locations.
- Some weeds have become problematic (clover, perennial grasses, thistle) due to a limited number of effective spray materials. Clopyralid (Stinger) not available throughout the Northeast.
- Herbicide resistant groundsel and bedstraw are becoming problematic in New York.
- Cover crops can mask presence of fall winter annuals, causing problems in the spring.
- **Yield Losses:** Very difficult to quantify.

Currently Registered Pesticides: Pre-emergence (listed alphabetically) - Most go on in fall after dormancy

Pesticide	Pros	Cons	Comments
ammonium nonanoate (Axxe) HRAC NC	•	•	• Not listed in New England Guide • OMRI listed but not strawberry
DCPA (Dacthal) HRAC K1	• Good efficacy against field pansy	• Relatively expensive • Not broad spectrum • Not a lot activity in cold • Shorter residual effect than napropamide (Devrinol)	• Most effective against grass • Alternative to napropamide (Devrinol)

flumioxazin (Chateau) HRAC E	• Broad spectrum • Good efficacy with plasticulture (day neutral varieties) • Long lasting • More effective against many perennials than any other material	• Phytotoxicity possible on some varieties • Only for dormant applications in row	• Using 30 days pre-plant
glyphosate (Roundup) HRAC G	• Inexpensive • Effective against most perennials • Zero residue • Good efficacy as cleanup prior to planting	• Overuse may help select for resistance	• Most common pre-plant treatment
napropamide (Devrinol) HRAC K3	• Effective ONLY IF ideal application conditions • Will get chickweed	• Poor efficacy • Moisture requirement on label is a hindrance • Requires rainfall or irrigation after application	• Impedes runnering, shouldn't be used early in first year or after runners set
oxyfluorfen (Goal) HRAC E	•	•	• Pre-plant, tank mixed with glyphosate, 30 days ahead, till in
pendimethalin (Prowl, Satellite Hydrocap) HRAC K1	•	• Pre-plant, dormant plants only • Must not disturb soil	•
terbacil (Sinbar) HRAC C1	• Used in renovation process before new leaf growth	• Phytotoxicity possible if not watered in • Some varieties very susceptible • Label confusing based on rates of organic matter	•

Currently Registered Pesticides: Post-emergence (listed alphabetically)

Pesticide	Pros	Cons	Comments
2,4-D (Formula 40, Amine 4) HRAC O	•	• Strong odor • Drift issues for tomato and grape	• Increased use in fall, few other options

caprylic acid + capric acid (Supress)	•	•	• Not discussed at meeting • Not listed in New England Guide • Not listed in Cornell Guide • OMRI listed
carfentrazone-ethyl (Aim) HRAC E	•	• Only between row applications	•
clethodim (Select, Arrow, Intensity) HRAC A	•	• Variable results, but better than Poast • Require crop oil or nonionic surfactant • Phytotoxicity possible during high temperatures	•
clopyralid (Stinger) HRAC O	•	•	• Not listed in New England Guide
fluazifop-butyl (Fusilade) HRAC A	• Most effective against quackgrass	• Requires crop oil, nonionic surfactant, or other adjuvant	• Not listed in New England Guide • Will be labelled in not too distant future on perennial strawberries
glyphosate (Roundup) HRAC G	• Good efficacy when mixed with flumioxazin (Chateau) and applied on edge of fields, drive rows, and as spot treatment	• Overuse may help select for resistance	• Strawberries tolerant of • Been breeding roundup resistant in Canada
paraquat (Gramoxone, Firestorm) HRAC D	• Between row management NY • Renovation tool, burn back runners, no need disturb soils and stir up weeds	• Prevents soils from building up around crown in longer term beds, ok for short term beds	•
pelargonic acid (Scythe) HRAC Z	• Burn back	• Strong odor	•

sethoxydim (Poast) HRAC A	•	• Require crop oil or nonionic surfactant • Phytotoxicity possible during high temperatures	•

Nonchemical (Cultural and Biological) Alternatives

Method	Pros	Cons	Comments
Cultivation	• Effective	• Must use frequently	• Most effective in planting year
Hand removal	• Effective	• Labor intensive • Does not reduce weed seed bank • May not remove all the roots of perennial weeds	• Pull weeds around plants when pick blossoms on day neutral varieties grown on plastic
Biodegradable mulch	• Reduces weed habitat • Straw is traditional system material • Breaks down in time for runners to set	• Individual materials not OMRI approved yet • Straw may contain weed seeds	• For establishing matted row systems • Also may be used with day neutral varieties
Plant cover crop between rows	• Reduces weed habitat	• Competes with crop for nutrients and water	• Annual rye
Prepare site with mustard planting	• Suppresses weeds in following crop	• Timing and method of incorporation important	• Plant season prior to strawberry • Flail then till immediately
Solarization	• Reduces weed population	• Not practical in the Northeastern US or on a large scale	

Research Needs:

- Assess efficacy and crop safety (phytotoxicity) data necessary to get clopyralid (Stinger) registered throughout the Northeast.
- Explore the long term effects of 2,4-D on fruit distortion and determine how soon use in fall can occur safely.
- Explore the use of dilute rates of 2,4-D for broadleaf control during the growing season.

Regulatory Needs:

- Register clopyralid (Stinger) throughout the Northeast.

Education Needs:

- Promote the use of biodegradable mulch systems for weed management.
- Raise awareness of emerging weed species that are becoming more problematic.

Key Vertebrates and other pests

➢**Whitetail Deer** (*Odocoileus virginianus*)

- Deer may occasionally trample crops and pierce plasticulture plastic, 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 in sites near woods.
- Management with various cultural control practices is common.
- Local authorities control size of populations
- Low electric fencing sometimes for short periods and can be cost effective, baiting fence helps
- Tall fencing can be long term and effective if gates kept closed, expensive
- Taste repellants: Hinder, Neptune's Harvest (can be phytotoxic, difficult to apply), use in fall to break feeding pattern, liquid manure around perimeter of site, Thiram is labelled as deer repellent. Repellents don't tend to be rainfast

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

- Voles directly feed on underground plant parts, can introduce weed seeds to site, and their tunnel systems interfere with crop irrigation.
- Mice frequently coexist and can introduce seed, some situations plant feeding
- Management with various cultural control practices is common.
- Problem in mulch, plastic, chew dripline, attract coyotes
- No rodenticides are legal for application in strawberry sites, some may be in certain situations in high tunnels in bait stations in some states
- Narrow rows and good weed management with discourage meadow vole, good mowing around site

➢**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.
- Turkeys scratch off straw before heavy snow, require labor to recover. Avoid barley straw, straw with grains.
- Geese graze and may introduce foodborne pathogens before harvest, feet puncture plastic
- Songbird species (cedar waxwings) federally protected.
- Visual and auditory devices, combinations work best
- Some hail/insect netting can be laid over crop and be effective (vs. on poles)

➢**Porcupines** *(Erethizon dorsatum)*

- Will eat foliage and crowns

IV. Appendices

Crop, Worker, Pest, and Pest Management Timing

➢**June-bearing Matted Row Production System**

	Mar.				Apr.				May				June				July				Aug.				Sep.				Oct.				Nov.			
Crop Stage																																				
Bloom										X	X	X	X																							
Harvest													X	X	X	X	X	X	X	X																
Dormant																																			X	X
Worker Activities																																				
Fertilize			X	X	X	X							X	X	X	X									X	X	X	X								
Weed management			X	X	X	X			X	X	X	X									X	X	X	X									X	X	X	X
Plant dormant crowns					X	X	X	X	X	X	X	X																								
Remove flowers (planting year)													X	X	X	X	X	X	X	X																
Renovation mowing, tilling (second year)															X	X	X	X	X	X	X	X														
Position runners																	X	X	X	X	X	X	X	X	X	X	X	X								
Mulch (fall application, spring removal)	X	X	X	X																															X	X

➢**Day Neutral Plasticulture Production System**

	Mar.				Apr.				May				June				July				Aug.				Sep.				Oct.				Nov.			
Crop Stage																																				
Bloom										X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X									
Harvest (planting year)																			X	X	X	X	X	X	X	X	X	X	X	X						
Harvest (second year)													X	X	X	X					X	X	X	X												
Plant removal (optional)																															X	X	X	X		
Worker Activities																																				
Fertilize			X	X	X	X																														
Weed management			X	X	X	X																														
Plant dormant crowns					X	X	X	X	X	X	X	X																								
Remove flowers (planting year)										X	X	X	X																							
Remove runners																																				
Mulch (optional)																																			X	X

➢**Key Insect and Mite Pests**

A= adult pest activity only; N = day-neutral plantings only; P= at planting

	Mar.				Apr.				May				June				July				Aug.				Sep.				Oct.				Nov.			
Pest Activity and Monitoring Periods																																				
Tarnished Plant Bug					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N	N	N	N	N	N	N	N	N	N						
Cyclamen Mite (second year)					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												
Root Weevils					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
Spotted Wing Drosophila																	N	N	N	N	N	N	N	N	N	N	N	N								
White Grubs					X	X	X	X	X	X	A	A	A	A	A	A	A	A	A	A	X	X	X	X	X	X	X	X								
Chemical Application Timing																																				
Tarnished Plant Bug					X	X	X	X	X	X	X	X	X	X	X	X	N	N	N	N	N	N	N	N	N	N	N	N	N	N						
Cyclamen Mite (second year)					X	X	X	X													X	X	X	X												
Root Weevils																					X	X	X	X												
Spotted Wing Drosophila																	X	X	X	X																
White Grubs					P	P	P	P													X	X	X	X												
Nonchemical Management Timing –depends on method																																				

➢**Key Disease Pests**

N= day-neutral plantings only; P= at planting; Z = as needed during establishment growing season

	Mar.				Apr.				May				June				July				Aug.				Sep.				Oct.				Nov.			
Pest Activity and Monitoring Periods																																				
Gray Mold									X	X	X	X	X	X	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								
Anthracnose Fruit Rot									X	X	X	X	X	X	X	X	X	X	X	X	N	N	N	N												
Leaf Spot					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												
Powdery Mildew													X	X	X	X	X	X	X	X	X	X	X	X												
Chemical Application Timing																																				
Gray Mold									X	X	X	X	X	X	X	X	X	X	X	X																
Black Root Rot					P	P	P	P																												
Anthracnose Fruit Rot									X	X	X	X	X	X	X	X	X	X	X	X																
Leaf Spot					X	X	X	X	Z	Z	Z	Z	X	X	X	X	Z	Z	Z	Z	X	X	X	X	Z	Z	Z	Z	Z	Z						
Powdery Mildew									Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	X	X	X	X	Z	Z	Z	Z	Z	Z						
Nonchemical Application Timing –depends on method																																				

➢**Key Weeds**

Z = as needed during establishment growing season

	Mar.				Apr.				May				June				July				Aug.				Sep.				Oct.				Nov.			
Pre-Planting Year																																				
																																	X	X	X	X
Planting Year/Day-neutral Plantings																																				
			X	X	X	X	X	X	X	X	X	X	Z	Z	Z	Z	X	X	X	X	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	X	X	X	X
Second Year																																				
						X	X	X	X						X	X	X	X	X	X	X	X	X	X										X	X	X	X

Pesticide Efficacy

Efficacy of common pesticides used on strawberries for Key Pests and other pests
Tables adapted from 2015 New England Small Fruit Pest Management Guide.

➢**Insect and Mite Pests**

Insecticide/ Miticide	IRAC Group[a]	Aphids	Clipper	*Cyclamen Mite	Leaf-hoppers	*Root Weevils	Slugs	Sap Beetles	Spider Mites	*Spotted Wing Drosophila	*Tarnished Plant Bug	*White Grubs
Acramite	25	--	--	--	--	--	--	--	+++	--	--	--
Actara	4A	+++	--	--	+++	--	--	--	--	--	++[c]	--
Admire Pro	4A	+++	--	++	+++	--	--	--	--	+	--	+++
Agree	11B	--	--	--	--	--	--	--	--	--	--	--
‡ Agri-Mek	6	--	--	++	++	--	--	--	++	--	--	--
Assail	4A	++	--	--	--	--	--	+	++	+++	++	--
⊗ Aza-Direct	18B	+	--	+	--	0	--	--	+	0	--	--
‡ Bifenture	3	+++	+++	--	++	++	--	+++	+	+++	+++	
BotaniGard	UN	--	--	--	--	--	--	--	--	--	--	--
‡ Brigade	3	+++	+++	--	++	++	--	+++	+	+++	+++	--
Captiva	repellent	--	--	--	--	--	--	--	--	--	--	--
Closer	4C	--	--	--	--	--	--	--	--	--	++	--
Coragen	28	--	--	--	--	--	--	--	--	--	--	--
Courier	16	--	--	--	--	--	--	--	--	--	--	--
‡ Danitol	3	++	+++	--	++	++	--	++	+	+++	+++	--
Deadline	slug cide	--	--	--	--	--	+++	--	--	--	--	--
Deliver	11	--	--	--	--	--	--	--	--	--	--	--
⊗ Des-X	ins soap	++	--	--	--	--	--	--	+	--	--	--
‡ Diazinon	1B	+++	--	+	+	+	--	++	+	+++	+	++
‡ Dibrom	1B	++	--	--	--	--	--	++	--	--	--	--
⊗ Dipel	11	--	--	--	--	--	--	--	--	--	--	--
⊗ Entrust	5	--	--	--	--	--	--	--	--	+++	--	--
Esteem	7C	++	--	--	--	--	--	--	--	--	--	--
⊗ Grandevo	UN	--	--	--	--	--	--	--	--	--	--	--
Intrepid	18	--	--	--	--	--	--	--	--	--	--	--
⊗ JMS Stylet Oil	UN	--	--	+	--	--	--	--	++	--	--	--
Kanemite	20	--	--	++	--	--	--	--	+++	--	--	--
Kelthane	UN	--	--	++	--	--	--	--	++	--	--	--

‡ Lorsban	1B	++	+++	--	--	--	--	--	--	--	++	++
Malathion	1B	+++	--	--	++	--	--	+	--	++	++	--
Molt-X	18B	--	--	--	--	--	--	--	--	--	--	--
⊗ M-Pede	ins. soap	++	--	--	--	--	--	--	+	--	--	--
⊗ Mycotrol	UN	--	--	--	--	--	--	--	--	--	--	--
Nealta	25	--	--	--	--	--	--	--	++	--	--	--
⊗ Neemix	18B	--	--	--	--	0	--	--	--	0	--	--
Oberon	23	--	--	--	--	--	--	--	+++	--	--	--
⊗ PFR-97	UN	--	--	--	--	--	--	--	--	--	--	--
Platinum	4A	+++	--	--	+++	++	--	--	--	--	--	--
Portal	21A	--	--	++	--	--	--	--	+++	--	--	--
⊗ Pyganic	3	+	--	--	--	--	--	--	--	+	--	--
Radiant	5	--	--	--	--	--	--	--	--	+++	--	--
Savey	10	--	--	--	--	--	--	--	+++[d]	--	--	--
Sevin	1A	+++	+	--	++	--	--	++	--	--	++	--
Sluggo	--	--	--	--	--	--	--	+++	--	--	--	--
⊗ SuffOil-X	UN	--	--	+	--	--	--	--	++	--	--	--
‡ Thionex	2A	++	0	+++	++	--	--	+	--	--	+++	--
⊗ Trilogy	18B	+	--	+	--	--	--	--	+	--	--	--
Vetica	28, 16	--	--	--	--	--	--	--	--	--	-	--
Vendex	12B	--	--	--	--	--	--	--	++	--	--	--
⊗ Venerate	UN	--	--	--	--	--	--	--	--	--	--	--
Zeal	10	--	--	--	--	--	--	--	+++[d]	--	--	--

*Key Pests
‡Restricted use material; pesticide applicator's license required.
⊗OMRI listed - organic production; see www.omri.org for details.

a. Chemistry of insecticides by activity groups: 1A=organophosphates; 2A=chlorinated cyclodienes; 3=pyrethrins and synthetic pyrethroids; 4A=neonicotinoids; 5=spinosyns; 6=avermectins; 7=juvenile hormone mimics; 10=mite growth inhibitors with unknown or nonspecific sites of action; 11=Bt microbials; 12B=organotin miticides; 18=ecdysone agonists/molting disruptors; 20=Site II electron transport inhibitirs; 21=Site I electron transport inhibitors; 23=lipid synthesis inhibitors; un=unknown mode of action.
b. 0=not effective; +=slight effectiveness; ++=moderate effectiveness; +++=very effective, --=insufficient data to rank effectiveness.
c. Moderate effect on nymphs, but little or no effect on adult form.
d. Effective on eggs and immatures (crawlers), but little or no effect on adult form.

➢**Disease Pests**

Fungicide	FRAC Group[a]	*Leaf Spot	Angular Leaf Spot	*Powdery Mildew	*Gray Mold	*Anthracnose Fruit Rot	Leather Rot
Abound	11	+	0	++	+	++	+++
Aliette	33	0	0	0	0	0	+++
Badge SC/X2	M1	+	+	--	--	--	--
Cabrio	11	++	0	++	++	+++	+++
Captan	M4	++	0	0	++	++	+
Captevate	17,M4	+	0	0	+++	++	+
Cease	44	--	++	++	+	++	--
Cueva	M	0	+	0	0	0	0
Copper	M1	0	+	0	0	0	0
⊗ Double Nickel	44	--	+	+	+	+	--
Elevate	17	0	0	0	+++	0	0
Fontelis	7	0	0	+++	+++	0	0
⊗ Kaligreen	UN	0	0	++	0	0	0
Mervion	7, 11	++	0	++	++	++	0
Mettle 125 ME	3	++	0	++	0	0	0
⊗ Microthiol	M2	--	--	++	--	--	--
⊗ Milstop	UN	0	0	+	+	0	0
Orbit, Tilt	3	++	0	+++	0	0	0
Ph-D	19	0	0	++	++	++	0
Phostrol	33	0	0	0	0	0	+++
Pristine	7,11	+++	0	+++	+++	+++	+++
Procure	3	0	0	+++	0	0	0
Quintec	13	0	0	+++	0	0	0
Rally	3	++	0	+++	0	0	0
⊗ Regalia	P5	0	0	+	0	0	0
Ridomil Gold	4	0	0	0	0	0	+++
Rovral	2	+	0	0	+++	0	0
Scala	9	0	0	0	+++	0	0
⊗ Serenade	UN	0	0	+	++	++	0
Syllit	U12	++	0	--	--	--	--
Switch	9,12	+	0	0	+++	++	0
⊗ SuffOil	UN	--	--	+	--	--	--
Tavano	19	0	0	++	++	++	0
Thiram	M3	++	0	0	++	+	+
Topsin-M	1	++	0	+++	+++	0	0
⊗ Trilogy	UN	0	0	+	+	+	0

*Key Pests
⊗OMRI listed - organic production; see www.omri.org for details.

a. Chemistry of fungicides by activity groups: 1=benzimidazoles and thiophanates; 2=dicarboximides; 3=demethylation inhibitors (includes triazoles; 4=acylalanines; 7=carboxamides; 9=anilinopyrimidines;

11=strobilurins; 12=phenylpyrroles; 13=quinolines; 17=hydroxyanilides; 33=unknown (phosphonates); M=chemical groups with multisite activity. Fungicides with 2 activity groups contain active ingredients with different modes of action.
b. 0=not effective; +=slight effectiveness; ++=moderate effectiveness; +++=very effective; --=insufficient data or not labeled

➢**Weeds**

	Pre-emergence					Postemergence					
	Devrinol[5]	**Dacthal[6]**	**Sinbar7**	**Goal[8]**	**Chateau[10]**	**Scythe[1]**	**Gramoxone[2]**	**Formula 40[3]**	**Poast[4]**	**Select**	**Roundup Ultra[9]**
PERENNIALS											
Canada Thistle	N	N	N	N	N	P	P	G	N	N	E
Clovers	N	N	F	N	F	P	P	E	N	N	E
Curly Dock	N	N	N	N	P	P	P	G	N	N	E
Dandelion	N	N	F	N	G	P	P	E	N	N	E
Goldenrods	N	N	P	N	P	P	P	G	N	N	E
Quackgrass	N	N	P	N	P	P	P	N	F	G	E
Red Sorrel	N	N	F	N	F	P	P	E	N	N	E
Yellow Nutsedge	P	N	F	N	F	P	P	F	N	N	G
ANNUAL GRASSES											
Barnyard Grass	E	G	F	F	F	F	E	N	E	E	E
Fall Panicum	E	F	F	F	F	F	E	N	E	E	E
Large Crabgrass	E	E	G	F	F	F	E	N	E	E	E
Oats or Rye (from mulch)	E	E	G	F	F	F	E	N	G	E	E
ANNUAL BROADLEAVES											
Bedstraw	P	P	F	F	F	G	E	E	N	N	E
Carpetweed	G	G	G	F	E	G	E	G	N	N	E
Common Chickweed	E	G	E	F	E	G	E	F	N	N	E
Common Lambs-quarters	G	E	E	G	E	G	E	E	N	N	E
Common Purslane	G	G	G	E	E	G	E	G	N	N	E
Corn Speedwell	F	F	G	F	G	G	E	G	N	N	E
Galinsoga	G	P	G	G	G	G	E	G	N	N	E
Horseweed	N	N	G	G	G	G	E	G	N	N	E

Prickly Lettuce	E	P	E	G	E	G	E	E	N	N	E
Redroot Pigweed	G	E	G	E	E	G	E	E	N	N	E
Shepherd's Purse	P	P	E	E	E	G	E	G	N	N	E
Virginia Pepper-weed	P	P	G	G	G	G	E	E	N	N	E
Yellow Wood Sorrel	P	P	G	E	G	G	E	G	N	N	E

E=90% control or better; G=75-90% control; F=50-75% control; P=5-50% control; N=less than 5% control.

[1]Scythe (pelargonic acid); non-selective contact herbicide. See information on rates and timings earlier in this section.
[2]Gramoxone (paraquat); 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.
[3]Formula 40 (2,4-D); 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.
[4]Poast (sethoxydim); systemic grass herbicide; use on actively growing grasses; will not kill old established grasses. Use with crop oil, avoid applying on hot humid days.
Select (clethodim); systemic grass herbicide; use on actively growing grasses; will not kill old established grasses; improved activity over Poast on cool season and perennial grasses. Use with crop oil; avoid spraying on hot humid days.
[5]Devrinol (napropamide); pre-emergent 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.
[6]Dacthal (DCPA); pre-emergent 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.
[7]Sinbar (terbacil); selective pre-emergent herbicide. Moisture is required to activate the chemical; also provides early post-emergence control.
[8]Goal (oxyflourfen): selective pre-plant 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 pre-emergence herbicide after transplanting is also recommended.
[9]Roundup Ultra (glyphosate); non-selective pre-plant 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.
[10]Chateau (flumioxazin); pre-emergent and post-emergent selective herbicide. Primarily used in the late fall, after strawberry plants become dormant. Used as an alternative at this time to Sinbar.

New Pest Management Technologies

IR-4 'Probable Future Registrations' and 'Studies in Registration Process' pesticides used on strawberries (13-07G = LOW GROWING BERRY SUBGROUP)
Tables adapted from database search results:
http://ir4.rutgers.edu/FoodUse/FutureRegi_1.cfm?simple=5
http://ir4.rutgers.edu/FoodUse/RegiProcess_1.cfm?simple=2

➢**Insect and Mite Pests**

Prnum Pesticide [Manufacturer]	Project Status	Req States	Pest/Reason for need:
Probable Future Registrations			
10328 CYANTRANILIPROLE (HGW86) [DUPONT]	ALL DATA RECEIVED AT HQ	CA NC FL	THRIPS, SPOTTED WINGE DROSOPHILA
10869 TOLFENPYRAD [NAI]	FINAL REPORT SIGNED; READY FOR SUBMISSION	FL CA	THRIPS, APHIDS, LYGUS
Studies in the Registration Process			
10005 CLOTHIANIDIN [VALENT]	NOTICE OF FILING ISSUED/PROPOSAL	CA NJ	LYGUS HESPERUS
5152 MALATHION [CHMNOV]	REREG: TOLERANCE ESTABLISHED	CA NY	ROOT, FRUIT, FOLIAR INSECTS
4527 METALDEHYDE [AMVAC, LONZA]	REREG: TOLERANCE ESTABLISHED	RE	REREG
6902 PYRIDABEN [GOWAN]	TOLERANCE ESTABLISHED	CA NC	MITES, APHIDS, THRIPS, WHITEFLIES

➢**Disease Pests**

Prnum Pesticide [Manufacturer]	Project Status	Req States	Pest/Reason for need:
Studies in the Registration Process			
9442 FENPYRAZAMINE (V-10135) [VALENT]	TOLERANCE ESTABLISHED	CA	BOTRYTIS

➢**Weeds**

Prnum Pesticide [Manufacturer]	Project Status	Req States	Pest/Reason for need:
Probable Future Registrations			
10282 FOMESAFEN [SYNGENTA]	TOLERANCE/USE TO BE PURSUED WITH NO DATA PROPOSAL/PETITION	FL	PRE-EMERGENCE WEEDS
6312 GLYPHOSATE [ADAMA, CHMNOV, DREXEL, MONS]	FINAL REPORT UNDER REVIEW WITH QA/MFG	FL	Magnitude of Residue on Strawberry
Studies in the Registration Process			
1409 GLYPHOSATE [ADAMA, CHMNOV, DREXEL, MONS]	DATA PACKAGE SUBMITTED TO THE MFG/STATE (SLN NONFOOD, SEC 18, ETC.)	AR CA FL LA MD MI NH NY OR PA WA WV	Magnitude of Residue on Strawberry
1676 S-METOLACHLOR/METOLACHLOR [SYNGENTA]	NOTICE OF FILING ISSUED/PROPOSAL	FL MN CA NY MD WI OR WA NC AR WV IN MI	WEEDS, YELLOW NUTSEDGE, GRASSES

V. Acknowledgements

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