2009 New England Raspberry Pest Management Strategic Plan

Compiled for the PRONewEngland Pest Management Network
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Key Pest Name Abbreviations

Insects
JB = Japanese Beetle
TPB = Tarnished Plant Bug
PLH = Potato Leafhopper

Diseases
Bot = *Botrytis*
PM = Powdery Mildew
Cane = Cane diseases: Cane Blight, Spur Blight, Anthracnose
Phyt = *Phytophthora*

Weeds
Pre = Pre-emergent
Post = Post-emergent

Executive Summary

The list of key pests for raspberry in New England consists of three insects, four diseases, and the weeds and vertebrates common to agricultural settings. These key pests are persistent problems that need to be managed every year when and where they occur. *Botrytis* is the most common pest encountered by growers and where the greatest need for management occurs. Fortunately, there are at least some materials available that are effective at managing this disease.

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

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

Research Needs

- Increase development of insecticides available for use on raspberry, particularly materials with short pre-harvest intervals.
- Develop organic materials and production techniques for all pest management.
- Explore impact of lower material application rates on beneficial predator populations.
- Develop models for *Botrytis* infection on raspberry (models exist for strawberry) with the goal of reducing number of material applications.
- Determine cost benefit of reducing number of material applications to manage *Botrytis*.
- Identify differences in virulence among different *Phytophthora* species and races on different crops.
- Determine more methods and materials, including biocontrol and organic, to manage *Phytophthora* species and races on different crops.
- Breed more disease-resistant raspberry varieties, include resistance against *Phytophthora*.
- Identify the impact of nematodes and viruses on production.
- Explore scope of below-ground insects and nematodes and potential for damage.
- More options are desired for Japanese beetle management.
- Develop methods of mechanical harvesting that exclude Japanese beetle.
- Develop information on pest complexes and disease management specific to high tunnel production systems.
- Explore trellis mounted material application systems for use on raspberries (systems exist for other crops) to facilitate frequent applications.

Regulatory Needs

- PHI of captan limits use in late season. A shorter PHI (24 hours) for captan would provide allow more management options, particularly to mitigate resistance development.
- Alter regulations on high tunnel production systems to allow customer access in pick-your-own operations.
- Create incentives for pesticide packaging that is practical for small-acreage growers. Smaller quantities are needed for small-acreage application. (JB, Phyt)
- Expand labels for many materials to include raspberry.
- Clarify and support chain of communication necessary for Section 18 emergency exemptions and 24(c) special local needs. Make available an online process to apply and report use (fewer staff extension specialists available to manage).
- Provide incentive for the New England states to expand cooperation in pest management and crop production.
- Encourage EPA to recognize the New England region as a state-like entity instead of as individual states.

Education Needs

- Develop diagnostic keys for growers to differentiate the various cane diseases on different raspberry cultivars.
- Raise awareness of resistance development possibilities with overuse of mefenoxam (Ridomil) against *Phytophthora*.
- Increase awareness of potential differences in disease management specific to high tunnel production systems, particularly benefit of potential reduction in material applications, increased production, and reduced post-harvest disease potential. Include economic cost benefit analysis.
- Provide information on winter moth as a potential pest.
- Develop recommendations for application of organic materials and production techniques for all pest management.
- Foster communication between NRCS compliance officers and growers. Include raising awareness of EQIP program assistance.

I. Introduction

Background of Raspberry in New England

The six New England states combine to comprise a total of 521 acres of raspberries according to the 2002 Census of Agriculture (CT 100 acres, MA 155, ME 101, NH 61, RI 16, VT 88) (NASS 2007). Most (96.6%) of these raspberries are grown for the fresh market with the remainder sent for processing. 71.4% of the fresh market raspberries are sold to pick-your-own or retail markets and 13.2% to wholesale distributors. While only contributing 2.6% to the national production of raspberries (NASS 2002), the raspberry field is an integral part of the New England economy both in direct value and in its attraction and appeal as part of the New England landscape.

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

Benefits to the New England Raspberry Industry

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

The Raspberry Pest Management Strategic Plan Process

A review group of Raspberry growers, researchers, and industry stakeholders throughout New England met for two days in December of 2008 to develop this Strategic Plan based on the 2008 New England Raspberry Crop Profile. Key pests driving pesticide use were suggested by the 2006 New England Raspberry Survey which was used to generate the Crop Profile. The survey was sent to 324 growers throughout New England and had a 66% return rate. The list of key pests was edited/approved by the review group.

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

II. Summary of the Raspberry Pest Management Strategic Plan

Key Raspberry Pest Strategic Issues

Summaries adapted from the *2008 New England Raspberry Crop Profile*.

Insects

Japanese Beetle (*Popillia japonica*)
This pest is most troublesome during the first 2-3 years after a planting is established and is somewhat more significant in southern New England than in colder regions of northern New England. The larvae develop in turf, where they live in the soil and feed on the roots of grasses. The adults begin to emerge in mid-summer and move to raspberries to feed on flowers, leaves and fruit. They feed on foliage but prefer ripe red raspberries, especially those exposed to full sunlight. Leaves are skeletonized and ripe berries destroyed. Additional damage is caused when beetles defecate on unharvested fruit. Weakening of plants from root feeding of grubs is undetermined. Management with protective materials targeted at adults usually occurs in mid-summer. Management targeted at larvae usually occurs at bloom or late-summer. Parasitic nematode and Milky Spore applications may be effective in some locations but are currently too expensive. Good crop rotation practices or fallow and cover crop treatments before planting raspberry in high-risk locations may suppress this pest. Periodic tilling of sod row middles can suppress populations

Tarnished Plant Bug *(Lygus lineolaris)*
This pest overwinters in vegetation and stubble that provide protection from the extreme cold. In the spring adults are attracted to flower buds and shoot tips of many plants, including raspberries. There are several generations each year from early spring until a heavy frost in the fall. Populations tend to be higher in weedy locations. Feeding by adults and nymphs results in malformed berries, failed druplets, and/or whitening of damaged druplets. Injured fruit tend to crumble easily and are generally unmarketable. Management with protective materials targeted at egg-laying females may occur prior to bloom if scouting indicates presence. After bloom materials are applied if scouting determines threshold is exceeded. Reducing weeds and avoiding mowing during bloom in areas surrounding the field may aid in management. Avoiding use of broad spectrum insecticides encourages predators (esp. spiders) and parasites.

Potato Leafhopper (*Empoasca fabae*)
This pest does not overwinter in New England and migrates up on storm fronts. Timing of its arrival varies but is found every year by mid-summer. They feed mostly on the undersides of young raspberry leaves. This feeding causes the leaves to yellow between the veins and become curled and distorted. Under heavy infestation internodes on primocanes can become significantly shortened resulting in severely stunted canes.

No direct damage to fruit is caused, but overall plant health can be affected, especially in primocane bearing varieties.

Diseases

Gray Mold/Botrytis Fruit Rot (*Botrytis cinerea*)
This pest can cause great damage during wet, warm seasons. The fungus overwinters in infected plant debris. In the spring spores are spread by wind and deposited on blossoms and fruit where they germinate when moisture is present. The fungus usually enters the fruit through flower parts. As the fruit matures, the fungus becomes active and rots the fruit. Even though infection occurs during bloom, symptoms are usually not observed until harvest. Management with protective materials usually occurs during early to mid-bloom with later applications needed only if weather is wet. Fungicide resistance is a concern and materials of differing chemistries should be alternated in a spray program to avoid resistance development. Pruning, row spacing, and avoidance of over-fertilization (which leads to dense canopies) to maximize air circulation and good drying conditions will reduce infection periods. Frequent harvesting will avoid build up of inoculum on ripe and over-ripe fruit.

Powdery Mildew (*Sphaerotheca macularis*)
This pest is more likely to become severe during humid weather conditions, although periods of wetness are not required for infection. The fungus overwinters within infected cane buds. Shoots that emerge from these buds the following spring are infected, and spores are distributed by air currents. Repeat cycles of infection can continue throughout the summer. Highly susceptible cultivars may be stunted and less productive. The infection of flower buds reduces fruit quantity. Infected fruit may be lower in quality or unmarketable. Management with protective materials usually begins at early bloom. Fungicide resistance is a concern and materials of differing chemistries should be alternated in a spray program to avoid resistance development. Pruning, row spacing, and avoidance of over-fertilization (which leads to dense canopies) to maximize air circulation and good drying conditions will reduce infection periods. Avoid planting highly susceptible cultivars.

CANE DISEASES
Cane Blight (*Leptosphaeria coniothyrium*)
This pest is more likely to cause infections during extended periods of warm, wet weather. The fungus overwinters in infected or dead canes and spores are released during rainy periods in the spring. The spores are dispersed by wind or splashing rain, and infect through wound sites. New spores are produced from these infection sites for further disease spread. The pathogen can continue to release infective spores for up to four years if the cane debris is not destroyed. Cane tissue in the infected region is weak and bends easily with cankers and wilting leaves. Management with protective materials usually occurs during dormant or very early spring before buds reach ½ ".

Anthracnose (*Elsinoe veneta*)
This pest, one of the most common and widespread diseases of brambles in the US, may be more prevalent in Southern New England. The fungus overwinters in infected canes. In early spring, spores are rain-splashed, blown or carried by insects to actively growing plant tissue. If numerous, cane lesions may merge and partially girdle the cane. In the following year, fruit produced on severely diseased canes may fail to develop to normal size. Management with protective materials usually occurs during budbreak through bloom. Fungicide resistance is a concern and materials of differing chemistries should be alternated in a spray program to avoid resistance development. Thinning primocanes, pruning, row spacing, and avoidance of over-fertilization (which leads to dense canopies) to maximize air circulation and good drying conditions will reduce infection periods. Sanitize by removing prunings from the production area before new canes emerge in spring. Avoid planting highly susceptible cultivars.

Spur Blight (*Didymella applanata*)
This pest can become epidemic during excessively wet years. The fungus overwinters in infected canes, and spores are released in the spring during wet, rainy periods. The spores are dispersed by wind. A second type of spore is produced within new infection sites during the summer. This type is spread by splashing rain. Buds within infected areas either fail to grow or produce weak shoots the following year. Management with protective materials usually occurs during dormant or budbreak to early bloom. Fungicide resistance is a concern and materials of differing chemistries should be alternated in a spray program to avoid resistance development. Thinning primocanes, pruning, row spacing, and avoidance of over-fertilization (which leads to dense canopies) to maximize air circulation and good drying conditions will reduce infection periods. Sanitize by removing prunings from the production area. Avoid planting highly susceptible cultivars.

Phytophthora Root Rot (*Phytophthora* spp.)
This pest persists in infected roots and in the soil. When the soil is saturated, motile zoospores swim through free water in the soil to reach new plant parts and cause infections. Water-saturated soil is oxygen-depleted and the plant is progressively less capable of resisting infection. Infected plants produce fewer and weaker canes. Leaves on the canes may be stunted and necrotic along the edges and between the veins. Infected plants may wilt and collapse under heat stress or heavy fruit load. If spring weather is very wet, primocanes may wilt and die, showing dark water-soaked tissue near the soil line. During the early stages of infection roots and crowns may be reddish. By comparison, healthy roots will be white. Plants in low or poorly drained field sites are frequently infected. Management with protective materials usually occurs during early spring or fall. Fungicide resistance is a concern and materials of differing chemistries should be alternated in a spray program to avoid resistance development. Avoid planting highly susceptible cultivars in areas with heavy wet soils.

Weeds

Weeds reduce yields by competing with the crop for water, light, and nutrients. Weeds serve as habitat and alternate hosts for insects, diseases, nematodes, and small vertebrate pests. They can inhibit spray penetration, air circulation, and drying conditions.

Weed infestations occur in mixed populations including annual grasses, annual broadleaf, perennial grasses, perennial broadleaf, woody perennial and vine weeds. Management tactics include cultivation, crop rotation, and herbicides. Herbicides are used as both pre-emergence and post-emergence applications. Management actions often target a range of weeds at one time.

Vertebrates

Birds (various species)
Bird pressure varies widely with location. Birds feed on ripe fruit in the field by pecking at it. This damage renders the fruit unmarketable. Feeding damage varies widely by location and year. Management practices usually occur in early season before birds begin feeding on fruit. Once feeding has started, bird management is much more difficult. A method for predicting high pressure locations, aside from field history, has not been established.

Mice and Voles (*Peromyscus sp, Microtus pennsylvanicus, Microtus pinetorum*)
These pests feed on underground plant parts. When populations are high, crop damage to roots and crowns can be extensive. In addition to direct feeding on the raspberry plants, their extensive tunnel systems cause root destruction and interfere with crop irrigation. In late summer and fall, voles store seeds, tubers, bulbs and rhizomes in their tunnels which can add to weed control problems in the field. Management practices in early season are most important, especially in newly planted fields. Year-round control must be maintained in high pressure locations.

> **White-footed mice** are commonly found in diverse habitats and feed in an area from 1/3 to 4 acres. They overwinter as a family group in nests underground or in protected areas such as hollow logs or buildings. Breeding occurs from spring to fall, with two to four litters per year with one to eight young per litter. Mice born in spring or summer may breed that same year.
>
> **Voles** are active day and night the entire year. They construct a complex tunnel system with surface runways and numerous burrow entrances. Breeding occurs primarily in spring and summer, producing from one to five litters per year with three to six young per litter. Voles have short life spans, ranging from two to sixteen months, and females mature in 35 to 40 days.

Strategic Issues of Specific Pest Management Tactics

Insecticides

acetamiprid (Assail) – JB
- New material
- Effective
- Low PHI
- More expensive than other materials
- Large volume packaging problematic for small acreage
- Repellant and antifeedant
- Neonicotinoid

azadirachtin (Aza-Direct) – JB, TPB
- OMRI listed
- Expensive
- Variably effective (JB)
- Fresh material necessary to be effective
- Repellant and antifeedant
- Not widely used (TPB)

bifenthrin (Brigade) –TPB*
- Harmful to beneficials
- Restricted Use Material
- *Not labeled for TPB on raspberry

carbaryl (Sevin) – JB, TPB, PLH
- Inexpensive
- Effective (JB) Not very effective (TPB)
- Harmful to beneficials
- Long PHI (7 days) (JB, TPB)
- Used to be standard use material when PHI was shorter (JB)

endosulfan (Thiodan) –TPB*
- *Not labeled for raspberry

esfenvalerate (Asana) – JB*, TPB*
- Restricted Use Material
- *Not labeled for JB or TPB on raspberry

fenpropathrin (Danitol) –TPB*
- Harmful to beneficials
- Restricted Use Material
- *Not labeled for raspberry

imidacloprid (Provado) – JB*, PLH
- Apply via irrigation (PLH)
- Neonicotinoid (PLH)
- *Not labeled for Japanese Beetle on raspberry

malathion (various formulations) – JB, TPB*, PLH
- Not very effective (JB)
- Offensive odor
- Scents available to offset odor
- *Not labeled for TPB on raspberry

phosmet (Imidan) – JB*
- *Not labeled for raspberry

pyrethrins (Pyganic, Pyrenone Crop Spray) – JB, TPB, PLH
- Some formulations are OMRI listed
- Effective at knocking adults off of plants (JB, TPB)
- Effective against nymphs (TPB)
- Phytotoxicity possible
- Not effective at killing (JB)
- Not effective against adults (TPB)

thiamethoxam (Actara) – JB, PLH
- New material
- Effective
- More expensive than other materials
- Large volume packaging problematic for small acreage
- Neonicotinoid

Fungicides

FRAC = *Fungicide Resistance Action Committee (FRAC) Code List: Fungicides sorted by mode of action. 2009.* *http://www.frac.info/frac/publication/anhang/FRAC_CODE_LIST.pdf*

azoxystrobin (Abound) – PM

- Very effective
- Expensive
- Resistance development likely
- Highly phytotoxic to some apple cultivars
- Products in same chemical family available that are not phytotoxic to apples
- FRAC Code: 11

***B. subtilis* (Serenade) – PM**

- OMRI listed
- Expensive
- Poor efficacy

captan (Captan, Captec) – Bot, Cane

- Also labeled for other diseases and crops
- Inexpensive
- Poor efficacy under high disease pressure (Bot)
- Effect strictly prophylactic
- Long PHI (3 days)
- Phytotoxicity possible when applied at same time as oil
- Commonly used early in season (Long PHI) (Bot)
- Different REI for different crops
- Phytotoxicity more severe during cold temperatures
- Labeled for Spur Blight on raspberries (Cane)
- FRAC Code: M4

chlorothalonil (Bravo) – PM*

- *Not labeled for raspberry
- FRAC Code: M5

copper – Bot

- Questionable efficacy
- Half rate application to avoid phytotoxicity
- FRAC Code: M1

copper hydroxide, copper sulfate (Kocide, Champ, Cuprofix etc.) – Cane

- Some formulations are OMRI listed
- FRAC Code: M1

cyprodinil fludioxonil (Switch) – Bot, PM*
- No PHI (0 days)
- Extends post-harvest shelf life
- No residual effect
- Expensive
- Commonly used closer to harvest
- FRAC Codes: 9 and 12
- *Not labeled for PM on raspberry

fenbuconazole (Indar) – Bot*
- *Not labeled for raspberry

fenhexamid (Elevate) – Bot
- Good option to rotate with other chemistries
- Also labeled for other crops
- Specifically targets Botrytis
- Resistance development likely
- Usually tank mixed with captan
- Formulations combined with captan available
- FRAC Code: 17

fosetyl al or aluminum tris (Aliette) – Phyt
- Very effective
- Resistance development possible
- Rotate with Ridomil Gold to offset resistance development
- Fall & spring applications require wet soil, 55 degrees
- FRAC Code: 33

horticultural oil (JMS Stylet oil) – PM
- OMRI listed
- Phytotoxicity possible
- Phytotoxicity more severe during hot temperatures

hydrogen dioxide (Oxidate) – Bot, PM
- OMRI listed, one of few organic materials available
- No resistance development likely
- No PHI (0 days)
- Improves salable quality of berries (Bot)
- Requires frequent application, no residual
- May be good material for high tunnel production systems (PM)
- Also labeled for other diseases - frequently tank mixed with other materials
- FRAC Code: NC

iprodione (Rovral) – Bot

- Effective preventative in a dry year
- Resistance development likely
- Used to be standard use material
- FRAC Code: 2

lime sulfur (Miller's Lime Sulfur, Sulforix) – Bot, Cane

- Also labeled for other diseases
- OMRI listed
- Cleanup is difficult
- Offensive odor
- Corrosive to equipment
- Hazardous to applicator
- Fall dormant/Spring application
- Sulforix® formula is less odorous
- FRAC Code: M2

mefenoxam (Ridomil Gold) – Phyt

- Very effective
- Resistance development likely
- Fall & spring applications require wet soil, 55 degrees
- FRAC Code: 4

myclobutanil (Nova, Rally) – PM, Cane

- Very effective (PM)
- Resistance development likely (PM)
- Also effective against orange rust
- Not effective against Botrytis
- FRAC Code: 3

phosphorous acid (Phostrol, Nutriphyte) – Phyt

- Very effective
- Less expensive than other materials
- Resistance development possible
- Fall & spring applications require wet soil, 55 degrees
- Rotate with Ridomil Gold to offset resistance development
- FRAC Code: 33

potassium bicarbonate (Milstop) – Bot, PM
- OMRI listed
- More effective against mildew (Bot)
- Very effective (PM)
- No residual effect (PM)
- Requires frequent application (PM)
- Changes pH of leaf surface so spores don't penetrate
- FRAC Code: NC

pyraclostrobin (Cabrio) – Bot, PM, Cane
- Also useful against orange rust
- Effective against mildew, anthracnose
- Labeled "for suppression only" (Bot)
- Expensive
- Resistance development likely, must rotate with other chemistries
- FRAC Code: 11

pyraclostrobin + boscalid (Pristine) – Bot, PM
- Also labeled for other diseases
- Resistance development less likely
- Good option to rotate with other chemistries (Bot)
- Expensive
- Limits on number of applications per year, sequence
- FRAC Codes: 7 and 11

Sulfur (Microthiol) – PM
- Inexpensive
- OMRI listed
- Phytotoxicity possible
- Corrosive
- Offensive odor
- Visible residue
- Newer formulas less phytotoxic

thiophanate-methyl (Topsin-M) – Bot*
- *Not labeled for raspberry

Herbicides

WSSA = *Herbicide Resistance Action Committee (HRAC) Classification of Herbicides by Mode of Action List (includes Weed Science Society of America (WSSA) groups).*
http://www.hracglobal.com/%20Publications/ClassificationofHerbicideModeofAction/tabid/222/Default.aspx

2,4-D (Formula 40) – Post*
- *Not labeled for raspberry

clopyralid (Stinger) – Post*
- Good efficacy against vetch
- Permanent injury possible to raspberry (interveinal whitening, leaf curling)
- Timing of application critical
- *Not labeled for raspberry

DCPA (dimethyl tetrachloroterephthalate) (Dacthal) – Pre*
- Targets crabgrass, annual grasses
- *Not labeled for raspberry

dichlobenil (Casoron) – Pre
- CS formulation is easier to use than 4G
- Granules easier for smaller growers without sprayers
- Granules difficult to calibrate and evenly spread
- CS formulation has broader label than 4G formulation
- WP formulation not available
- WSSA Group: 20

fluazifop (Fusilade) – Post
- Targets grasses only
- Weather conditions can affect efficacy
- Phytotoxicity possible when applied at same time as oil during hot weather
- WSSA Group: 1

glyphosate (Roundup, Touchdown) – Post
- Very effective against perennial weeds
- Injury very possible, direct contact not necessary to cause injury to raspberry
- Must apply when raspberry dormant
- Timing of application narrow in fall – raspberry dormant, weeds active
- Some formulations not for use on raspberry
- WSSA Group: 9

metam sodium (Vapam) – Pre*
- fumigant
- *Not labeled specifically for raspberry

napropamide (Devrinol) – Pre

- Poor efficacy against perennial weeds
- Good efficacy against grasses and broadleaf weeds
- Safe for raspberry
- Use on tissue culture plants
- Expensive
- Photodegrades
- Requires tillage and rain to incorporate
- WSSA Group: 15

norflurazon (Solicam) – Pre

- Targets nutsedge, dandelion
- Can injure and bleach raspberry, but it can grow out of damage
- WSSA Group: 12

oryzalin (Surflan) – Pre

- Targets annual grasses and broadleaf weeds
- Less effective against perennial weeds
- Use on tissue culture plants
- WSSA Group: 3

paraquat (Gramoxone) – Post

- Effective burn down of all weeds
- Slight injury to raspberry does not affect yield
- Restricted Use Material
- High oral toxicity
- WSSA Group: 22

pelargonic acid (Scythe) – Post

- Strictly for burn down
- Expensive
- Offensive odor
- WSSA Group: 27

sethoxydim (Poast) – Post

- Targets quackgrass, crabgrass
- Poor efficacy against some other grasses
- Phytotoxicity possible when applied at same time as oil during hot weather
- More effective than fluazifop on many same weeds
- WSSA Group: 1

simazine (Princep) – Pre

- Relatively inexpensive
- Targets broadleaf weeds
- Some efficacy against Post-emergent weeds
- Resistance development possible for certain broadleaf weeds
- Must be applied prior to crop bud break
- WSSA Group: 5

terbacil (Sinbar) – Pre, Post

- Good option to rotate with simazine when resistance possible (Pre)
- Some efficacy against post-emergent small weeds
- Injury possible when plants are growing
- More damage likely with lighter soils
- WSSA Group: 5

Research priorities

New chemistries and options

- Develop materials with short pre-harvest intervals. (JB, TPB)
- Identify and develop more organic management materials. (Bot, PM)
- Pursue new and different chemistries as additional options to mitigate resistance development. (Bot, PM)
- Develop and test new chemistries and management options for milkweed, bindweed, and other hard-to-control perennials. (Weeds)
- Develop and test new chemistries (e.g. antifeedants) for bird management. (Birds)
- Develop and test new management options (robotic hawks, sound devices that attract predators) against birds. (Birds)
- Develop alternatives to soil drench applications. (Phyt)
- Breed more disease-resistant raspberry varieties. (Bot, PM, Phyt)

Specific materials and options

- Determine efficacy of spinosad (SpinTor, Entrust) against Japanese Beetles on raspberries (labeled against other beetles in other crops). (JB)
- Determine efficacy of azadirachtin (Aza-direct) against PLH on raspberries. (PLH)
- Determine if newer chemistries (neonicotinoids, spinosad) are effective against TPB. (TPB)
- Define efficacy of hydrogen dioxide (Oxidate) and most efficient timing of applications. (Bot)
- Explore the efficacy of phosphorous acid (Aliette, ProPhyt, Agri-Fos, etc.) against cane diseases. (CB)
- Explore efficacy of *Trichoderma* biocontrol against *Phytophthora* as a substitute for or in combination with soil drench fungicides. (Phyt)
- Determine efficacy expiration dates on chemical materials, such as azadirachtin (Aza-direct). (JB)
- Explore and develop the use of trap crops to attract and concentrate pest for efficient application of chemical management methods. (JB, TPB)
- Explore and develop more parasites to manage TPB populations. (TPB)
- Explore the use of biofumigants to mitigate *Phytophthora*. (Phyt)
- Explore the use of compost and soil biodiversity to mitigate *Phytophthora*. (Phyt)
- Explore effects of primocane suppression techniques to reduce inoculum. (Bot, PM)

Research priorities (continued)

Models

- Determine population levels of other species of root grubs (scarabs) and if the populations are increasing. Explore of management options against other species of root grubs. (JB)
- Determine over-wintering sites and seasonal movement of PLH through monitoring, mapping and trapping to determine current geographical ranges. (PLH)
- Develop information pest complexes and disease management specific to high tunnel production systems. (Bot, PM)
- Identify raspberry varieties that are less-susceptible to *Botrytis*, powdery mildew, and/or *Phytophthora*. (Bot, PM, Phyt)
- Identify differences in virulence among different *Phytophthora* species and races. (Phyt)
- Develop a test kit for grower to check for *Phytophthora* presence. (Phyt)

Regulatory priorities

Packaging and labels

- Create incentives for pesticide packaging that is practical for small-acreage growers. (JB, Phyt)
- Expand labeling for materials used against TPB on other crops to include raspberry. (TPB)

Specific materials

- Expand labeling for spinosad (SpinTor, Entrust) against Japanese Beetles on raspberries to provide more options to growers. (JB)
- PHI of captan limits its use in late season. A shorter PHI for captan would provide allow more options to mitigate resistance development. (Bot)
- Expand labeling for clethodim (Select), clopyralid (Stinger), and isoxaben (Gallery) for use on raspberries to provide more options to growers. (Weeds)
- Expand labeling for diuron (Karmex) for use on raspberries in New England. (Weeds)

Desired revisions

- Define registered use instructions for field vs. high tunnel production systems, particularly at the state level. (Bot, PM)
- Fast-track registration of new and different chemistries to provide more options to mitigate resistance development. (Bot, Phyt)
- Streamline and speed local permitting processes for installing drainage in fields. (Phyt)

Education priorities

Scouting and identification

- Provide information on pest lifecycles, pest movement and dispersal that are critical to scouting. (PLH)
- Develop diagnostic keys for growers to differentiate the various cane diseases on different raspberry cultivars. (Cane)
- Develop and distribute identification information for pest and damage. (PLH)
- Encourage checking irrigation sources for disease inoculum. (Phyt)

Specific materials and options

- Define efficacy of hydrogen dioxide (Oxidate) and most efficient timing of applications. (Bot)
- Encourage ozone disinfection of water from open sources. (Phyt)
- Raise awareness of resistance development possibilities to triazine (atrazine, simazine, etc.) family of herbicides. (Weeds)
- Educate growers of the proper timing and methods of application for different herbicide chemistries. (Weeds)
- Promote value of pruning following fruit harvest to reduce plant stress and potential for winter injury. (Cane)
- Promote benefits of cleaning of equipment to prevent the spread of inoculum between fields. (Phyt)

Awareness

- Increase awareness of potential differences in disease management specific to high tunnel production systems, particularly for powdery mildew. (PM)
- Increase awareness that powdery mildew is more likely to occur on fall bearing raspberry varieties. (PM)
- Increase awareness of potential for cane disease to establish in older fields that are less rigorously managed. (Cane)
- Promote value of proper pruning and thinning to keep all cane diseases in check. (Cane)
- Increase awareness that late season infections are the cause of following spring disease. (Cane)
- Promote awareness of the primary importance of water management practices and the minimal efficacy of chemicals in disease management. (Phyt)
- Define and encourage proper site selection and row orientation to mitigate disease pressure. (Phyt)
- Foster understanding among growers of watershed location and potential for herbicide leaching. (Weeds)
- Encourage placement of perches and houses to encourage predatory birds to nest and hunt near raspberry fields. (Birds, Mice/voles)
- Create awareness among growers of availability of captive predatory birds that may be exercised in raspberry fields. (Birds, Mice/voles)

III. Strategic Issues for Key Raspberry Pests

Key Insect pests

Japanese Beetle (*Popillia japonica*)

% Acres Affected: 81%
Yield Losses: Direct feeding on fruit under high infestations can result in up to 50% yield loss. Foliar feeding may also result in yield loss especially when due to defecation on fruit. Weakening of plants from root feeding of grubs is undetermined.

- Highly mobile populations
- Tend to be cyclical populations
- Populations appear to have increased in recent years
- Feeding damage on berries renders them unsalable
- Very problematic with mechanical harvesting
- Pick-Your-Own customers do not like to see
- Zero customer tolerance in pre-picked
- Need materials with very short days to harvest
- Need materials with no smell for Pick-Your-Own operations
- Root feeding does not seem to be a problem on raspberry, pest prefers sod

Currently Registered Pesticides

Pesticide alphabetically by a.i.	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
acetamiprid (Assail)		• New material • Effective • Low PHI	• More expensive than other materials • Large volume packaging problematic for small acreage	• Repellant and antifeedant • Neonicotinoid
azadirachtin (Aza-Direct) 3% growers 4% acres	67% Exc. 33% Good	• OMRI listed	• Expensive • Variably effective • Fresh material necessary to be effective	• Repellant and antifeedant
carbaryl (Sevin 80S, 80WSB, XLR) 21% growers 21% acres	54% Exc. 42% Good 4% Poor	• Inexpensive • Effective	• Harmful to beneficials • Long PHI (7 days)	• Used to be standard use material when PHI was shorter

esfenvalerate (Asana XL) 1.6% growers <1% acres	50% Exc. 50% Good		• Restricted Use Material	• Not labeled for Japanese Beetle on raspberry
imidacloprid (Provado 1.6F, Solupak) 1% growers 2.3% acres	100% Exc.			• Not labeled for Japanese Beetle on raspberry
malathion (various formulations) 13% growers 14% acres	6% Exc. 81% Good 13% Poor	• Not very effective	• Offensive odor	• Scents available to offset odor
phosmet (Imidan 70WSB, 70W) 1% growers 1.7% acres	100% Poor			• Not labeled for raspberry
pyrethrins (Pyganic, Pyrenone Crop Spray) 10% growers 11% acres	38% Exc. 46% Good 16% Poor	• Some formulations are OMRI listed • Effective at knocking adults off of plants	• Phytotoxicity possible • Not effective at killing	
thiamethoxam (Actara)		• New material • Effective	• More expensive than other materials • Large volume packaging problematic for small acreage	• Neonicotinoid

Cultural and Biological Alternatives

Practices Reported	Survey Data Efficacy Rating	Pros	Cons	Comments
Netting		• Effective		
Hand Picking 6% growers 4% acres	40% Exc. 40% Good 20% Poor	• Effective if very small grower	• Labor intensive	
Traps 4% growers 7% acres	20% Exc. 60% Good 20% Poor		• Attract pest to field	
Trap crops		• Not effective when pest populations very high		
Tilling of sod row middles		• May suppress populations	• Only local control – populations are mobile	
Parasitic nematode and Milky Spore		• May be effective in some locations	• Currently too expensive • Quality control issues with product	• Postharvest applications of materials to control grubs

Research Needs:

- Determine efficacy expiration dates on chemical materials, such as azadirachtin (Aza-direct).
- Determine efficacy of spinosad (SpinTor, Entrust) against Japanese Beetles on raspberries (labeled against other beetles in other crops).
- Explore the use of trap crops to attract and concentrate pest for efficient application of chemical management methods.
- Develop materials with short pre-harvest intervals.
- Determine population levels of other species of root grubs (scarabs) and if the populations are increasing. Explore management options against other species of root grubs.

Regulatory Needs:

- Expand labeling for spinosad (SpinTor, Entrust) against Japanese Beetles on raspberries to provide more options to growers.
- Create incentives for pesticide packaging that is practical for small-acreage growers. Smaller quantities are needed for small-acreage application.

Education Needs:

- None identified

Tarnished Plant Bug *(Lygus lineolaris)*

% Acres Affected: 45% of raspberries acres affected annually.
Yield Losses: 25% without management, 5% with management

- Attacks multiple crops
- Active from bloom through harvest
- Damage (various fruit deformities) may affect marketability
- Damage often goes unrecognized as caused by pest
- Once damage recognized it is too late for management in current season
- Partial second generation ; eggs in spring, nymphs hatched during season do not leave plants
- Managed along with cane borers and other insect pests
- Constrained management options during bloom due to pollinator presence
- Difficult to time management applications later in season with PHI requirements

Currently Registered Pesticides

Pesticide alphabetically by a.i.	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
azadirachtin (Aza-Direct) 3% growers 6% acres	100% Exc.	• OMRI listed	• Expensive • Fresh material necessary to be effective	• Repellant and antifeedant • Not widely used
bifenthrin (Brigade 2EC, WSB) 1% growers 2.3% acres	100% Exc.		• Harmful to beneficials • Restricted Use Material	• Not labeled for TPB on raspberry
carbaryl (Sevin 80S, 80WSB, XLR) 21% growers 23% acres	26% Exc. 67% Good 7% Poor	• Inexpensive • Not very effective	• Harmful to beneficials • Long PHI (7 days)	
endosulfan (Thiodan EC) 1% growers <1% acres	100% Good			• Not labeled for raspberry
esfenvalerate (Asana XL) 4% growers 4% acres	20% Exc. 60% Good 20% Poor		• Restricted Use Material	• Not labeled for TPB on raspberry

fenpropathrin (Danitol 2.4EC) 1% growers 1.7% acres	100% Good		• Harmful to beneficials • Restricted Use Material	• Not labeled for raspberry
malathion (various formulations) 3.0% growers 2.8% acres	100% Good		• Offensive odor	• Scents available to offset odor • Not labeled for TPB on raspberry
pyrethrins (Pyganic, Pyrenone Crop Spray) 7.2% growers 11.3% acres	44% Exc. 56% Good	• Some formulations are OMRI listed • Effective at knocking adults off of plants • Effective against nymphs	• Phytotoxicity possible • Not effective against adults	

Cultural and Biological Alternatives

Practices Reported	Survey Data Efficacy Rating	Pros	Cons	Comments
Beauveria bassiana (BotaniGard ES)		• Available commercially	• Expensive • Efficacy unproven	• Fungal pathogen of Lygus bugs
Imported parasites		• *Peristenis digoneutis* suppress pest population	• None are commercially available at this time	• parasites are established in US
Trap crops			• New method to research	• Spray trap crop • Trap crop needs to bloom earlier than raspberry
Reducing weeds in areas surrounding the field		• May inhibit migration of pests • Helps suppress populations		
Avoid mowing around crop area during bloom		• May inhibit migration of pests		
Avoid use of broad spectrum insecticides		• Encourages predators and parasites	• Currently available materials are broad spectrum	

Research Needs:

- Explore and develop more parasites to manage TPB populations.
- Explore and develop the use of trap crops to attract and concentrate pest for efficient application of chemical management methods.
- Develop materials with short pre-harvest intervals.
- Determine if newer chemistries (neonicotinoids, spinosad) are effective against TPB.

Regulatory Needs:

- Expand labeling for materials used against TPB on other crops to include raspberry.

Education Needs:

- None identified

Potato Leafhopper (*Empoasca fabae*)

% Acres Affected: Unknown
Yield Losses: Unknown

- Does not overwinter in New England
- Sporadic occurrence dependent on weather systems carrying immigrant populations
- Activity may vector viruses and/or fire blight
- Damage can stunt growth
- Damage often goes unrecognized as caused by pest and may be mistaken for herbicide injury
- Scouting, especially following storm activity, is important for determining management
- May be managed by materials targeting other insects, such as Japanese Beetle
- Thorough spray coverage is necessary to target nymphs on underside of leaves

Currently Registered Pesticides

Pesticide alphabetically by a.i.	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
carbaryl (Sevin 80WSP)	none reported	• Inexpensive	• Harmful to beneficials	
imidacloprid (Admire)				• Apply via irrigation • Neonicotinoid
malathion (various formulations)			• Offensive odor	• Scents available to offset odor
pyrethrins (Pyganic, Pyrenone Crop Spray)		• Some formulations are OMRI listed	• Phytotoxicity possible	
thiamethoxam (Actara)		• Newer material	• More expensive than other materials • Large volume packaging problematic for small acreage	• Neonicotinoid

Cultural and Biological Alternatives

Practices Reported	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
Scouting				• Scout following storm activity

Research Needs:

- Determine over-wintering sites and seasonal movement of PLH through monitoring, mapping and trapping to determine current geographical ranges.
- Determine efficacy of azadirachtin (Aza-direct) against PLH on raspberries.

Regulatory Needs:

- None identified

Education Needs:

- Develop and distribute identification information for pest and damage.

- Provide information on pest lifecycles, pest movement and dispersal that are critical to scouting.

Selected Comments on Other Insects

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

Raspberry Aphids (*Amphorophora agathonica*, *A. sensoriata, A. idaei,* and *Aphis rubicola*)

- Pest presence is secondary to the viruses they transmit:
    - *A.agathonica* transmits raspberry mosaic virus, raspberry vein chlorosis
    - *A.sensoriata* transmits viruses
    - *A.idaei* transmits raspberry mosaic virus, raspberry vein chlorosis
    - *A.rubicola* transmits raspberry leaf curl virus
- Aphids themselves don't do much damage
- Unchecked, they will attract wasps, sooty mold
- Sooty mold will affect photosynthesis
- Must kill aphids before removing plants infected with virus
- Some genetic resistance to aphids ('Royalty' 'Titan' 'Canby')
- More resistant varieties needed
- May be managed by materials targeting other insects
- Use of broad spectrum insecticides targeted at other pests can flare populations by killing natural predators

Raspberry/Red Necked Cane Borer (*Oberea bimaculata* and *Agrilus ruficollis)*

- More of a problem for homeowners than commercial operations
- Scouting for incidence is beneficial
- Pruning and removal of wild brambles reduces population
- May be managed by materials targeting other insects

Raspberry Crown Borer (*Pennisetia marginata*)

- Sporadic occurrence
- Overwinter in canes
- Seeing populations increase recently, perhaps due to mild winters
- Potential to kill plants
- Damage often goes unrecognized as caused by pest and may be mistaken for disease injury (wilting)
- Difficult to manage - bifenthrin (Capture) only material available

Raspberry Fruit Worm (*Byturus unicolor*)

- Chew buds, active in evening
- Zero customer tolerance for presence
- May be more of a problem in weedy fields
- Manage in spring, during evening active periods

Stink Bugs (various species)

- Zero customer tolerance for presence
- Ruin raspberry flavor
- Presence on ripe fruit makes it difficult to time applications with PHI requirements
- Materials labeled specifically for are unknown to growers

Strawberry Bud Weevil (*Anthonomus signatus*)

- Clips off flower buds
- Common pest but does not cause significant loss of yield
- Raspberries compensate for injury
- May be managed by materials targeting other insects (fruit worm)

Strawberry Sap Beetle/Picnic Beetle (*Stelidota geminata* and *Glischrochilus* spp.)

- Pick-Your-Own customers do not like to see
- Manage option to remove overripe fruit (attracts pest)

Two-spotted Spider Mite (*Tetranychus urticae***)**

- Can get on fruit
- Hot dry weather and dust will exacerbate
- Scouting for incidence is beneficial
- Many new materials are available for management
- Oil applied early in season is good management tool
- Use of broad spectrum insecticides targeted at other pests can flare populations by killing natural predators
- <u>Research needed on efficacy of early release of predators against first generation</u>

Winter Moth (*Operophthera brumata*)

- Occasional raspberry pest in other areas of the country
- Emerging pest in other crops in New England
- Larvae can cause feeding damage to buds

Yellow Jackets, etc. (*Paravespula* spp., *Vespa* spp., and *Vespula* spp.)

- Pick-Your-Own customers do not like to see
- Damage fruit
- More common when rotten fruit or compost near or in field
- Early detection key to control
- Presence on ripe fruit makes it difficult to time management applications with PHI requirements
- Traps available that are specific to species and/or season
- Baited traps can harm beneficial bees

Key Diseases

Gray Mold / Botrytis Fruit Rot (*Botrytis cinerea*)

% Acres Affected: 65% of raspberry acres affected annually.
Yield Losses: >50% without management, <10% with management.

- Most serious problem of raspberry
- Most pest management of raspberry is to manage this disease
- Requires annual management in damp coastal regions
- Wide host range
- Fungus always present in environment, will infect under right conditions
- 'Right conditions' are fairly flexible, i.e. any moisture from heavy dew to rain
- Disease seems to be increasingly infecting canes also
- Infection without management limits shelf-life of harvested fruit
- Management materials applied weekly, starting at 10% bud break, with more emphasis during infection conditions
- Less expensive fungicides are used earlier in the season, more expensive later in the season towards harvest
- Materials of differing chemistries should be alternated in a spray program to avoid resistance development.

Currently Registered Pesticides

Pesticide alphabetically by a.i.	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
captan (Captan 50W, 80WDG, Captec 4L) 21% growers 37% acres	30% Exc. 67% Good 3% Poor	• Also labeled for other diseases and crops • Inexpensive	• Poor efficacy under high disease pressure • Effect strictly prophylactic • Long PHI (3 days) • Phytotoxicity possible if applied with oil	• Commonly used early in season (Long PHI) • Different REI for different crops • Phytotoxicity more severe during cold temperatures • FRAC Code: M4
copper			• Questionable efficacy	• Half rate application to avoid phytotoxicity • FRAC Code: M1

cyprodinil fludioxonil (Switch 62.5WG) 16% growers 29% acres	80% Exc. 20% Good	• No PHI (0 days) • Extends post-harvest shelf life	• No residual effect • Expensive	• Commonly used closer to harvest • FRAC* Codes: 9 and 12
fenbuconazole (Indar 2F, 75WSB) <1% growers 1.7% acres	100% Good			• Not labeled for raspberry
fenhexamid (Elevate 50WDG) 22% growers 41% acres	75% Exc. 25% Good	• Good option to rotate with other chemistries • Also labeled for other crops • Specifically targets Botrytis	• Resistance development likely	• Usually tank mixed with captan • Formulations combined with captan available • FRAC* Code: 17
hydrogen dioxide (Oxidate) 1% growers <1% acres	100% Good	• OMRI listed, one of few organic materials available • Resistance unlikely • No PHI (0 days) • Improves salable quality of berries	• Requires frequent application, no residual	• Also labeled for other diseases - frequently tank mixed with other materials • FRAC* Code: NC
iprodione (Rovral 4F) 10.3% growers 10.4% acres	23% Exc. 77% Good	• Effective preventative in a dry year	• Resistance development likely	• Used to be standard use material • FRAC* Code: 2
lime sulfur (Miller's Lime Sulfur, Sulforix) <1% growers <1% acres	100% Good	• Also labeled for other diseases • OMRI listed	• Cleanup is difficult • Offensive odor • Corrosive to equipment • Hazardous to applicator	• Fall dormant/Spring application • Sulforix® formula is less odorous • FRAC* Code: M2
potassium bicarbonate (Milstop) 1% growers <1% acres	100% Good	• OMRI listed		• More effective against mildew • Changes leaf surface pH so spores don't penetrate • FRAC* Code: NC
pyraclostrobin (Cabrio EG) 18% growers 28% acres	39% Exc. 61% Good	• Also useful against orange rust	• Resistance development likely • Expensive	• Labeled "for suppression only" • Effective against mildew • FRAC* Code: 11

Pyraclostrobin + boscalid (Pristine WG) 14% growers 21% acres	67% Exc. 33% Good	• Also labeled for other diseases • Resistance unlikely • Good option to rotate with other chemistries	• Expensive • Limits on number of applications per year, sequence	• FRAC* Codes: 7 and 11
thiophanate-methyl (Topsin-M) 1.6% growers 5.1% acres	50% Exc. 50% Good			• Not labeled for raspberry

**Fungicide Resistance Action Committee (FRAC) Code List: Fungicides sorted by mode of action. 2009. http://www.frac.info/frac/publication/anhang/FRAC_CODE_LIST.pdf*

Cultural and Biological Alternatives

Practices Reported	Survey Data Efficacy Rating	Pros	Cons	Comments
Remove moldy berries <1% growers 1.1% acres	none reported	• Can remove during a harvest picking	• Don't usually remove from field	
Pruning 1.6% growers 1.1% acres	100% Good	• Maximize air circulation and drying conditions • Saves spraying time • Improves spray penetration	• Labor intensive (but worth it) • Must remove prunings from the production area	• Primocane suppression would be helpful if possible
Frequent harvesting		• Avoids build up inoculum on ripe and over-ripe fruit		• Some growers harvest every day • Weather dependent
Avoid over-fertilization with nitrogen		• Prevents canopy from becoming too dense • Prevents berries from getting too soft		
Site selection		• Optimize air circulation • Optimize drying conditions		

Research Needs:

- Explore effects of primocane suppression techniques to reduce inoculum.
- Identify and develop more organic management materials.
- Define efficacy of hydrogen dioxide (Oxidate) and most efficient timing of applications.
- Develop information pest complexes and disease management specific to high tunnel production systems.
- Pursue new and different chemistries as additional options to mitigate resistance development.
- Breed more disease-resistant raspberry varieties.
- Identify raspberry varieties that are less-susceptible to *Botrytis*.

Regulatory Needs:

- Define registered uses and instructions for field vs. high tunnel production systems, particularly at the state level.
- PHI of captan limits its use in late season. A shorter PHI for captan would provide allow more options to mitigate resistance development.
- Fast-track registration of new and different chemistries to provide more options to mitigate resistance development.

Education Needs:

- Define efficacy of hydrogen dioxide (Oxidate) and most efficient timing of applications.

Powdery Mildew (*Sphaerotheca macularis*)

% Acres Affected: 32% of raspberry acres affected annually.
Yield Losses: No documented direct yield impact, but may weaken plants and reduce yield indirectly.

- Fungus always present in environment, will infect under right conditions
- Occurrence on other crops is increasing
- Less frequent problem on raspberry now than previously
- Might become a problem in high tunnel production systems
- Air circulation is essential to management
- May be managed by materials targeting other diseases (Botrytis)
- Fungicide resistance is a concern; differing chemistries should be alternated in a spray program to avoid resistance development.

Currently Registered Pesticides

Pesticide alphabetically by a.i.	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
azoxystrobin (Abound) <1% growers <1% acres	100% Good	• Very effective	• Expensive • Resistance development likely • Highly phytotoxic to some apple cultivars	• Products in same chemical family available that are not phytotoxic to apples • FRAC* Code: 11
B. subtilis (Serenade)		• OMRI listed	• Expensive • Poor efficacy	
chlorothalonil (Bravo Ultrex, Weather Stik) <1% growers <1% acres	none reported			• Not labeled for raspberry • FRAC* Code: M5
cyprodinil fludioxonil (Switch 62.5WG) <1% growers <1% acres	100% Good			• Not labeled for PM on raspberry • FRAC* Codes: 9 and 12
horticultural oil (JMS Stylet oil)		• OMRI listed	• Phytotoxicity possible	• Phytotoxicity more severe during hot temperatures
hydrogen dioxide (Oxidate) <1% growers 6% acres	100% Good	• OMRI listed • One of few organic materials available • No resistance development likely • No PHI (0 days)	• Requires frequent application, no residual	• May be good material for high tunnel production systems • Also labeled for other diseases - frequently tank mixed with other materials • FRAC* Code: NC
myclobutanil (Nova, Rally) 8% growers 16% acres	60% Exc. 40% Good	• Very effective • Also effective against orange rust	• Resistance development likely • Not also effective against Botrytis	• FRAC* Code: 3
potassium bicarbonate (Milstop) 1% growers <1% acres	none reported	• OMRI listed • Very effective	• No residual effect • Requires frequent application	• Changes pH of leaf surface so spores don't penetrate • FRAC* Code: NC

pyraclostrobin (Cabrio EG) 14% growers 19% acres	44% Exc. 56% Good	• Also useful against orange rust • Effective	• Expensive • Resistance development likely	• FRAC* Code: 11
pyraclostrobin + boscalid (Pristine WG) 7% growers 14% acres	44% Exc. 56% Good	• Also labeled for other diseases • Resistance development less likely	• Expensive • Limits on number of applications per year	• FRAC* Codes: 7 and 11
Sulfur (Microthiol)		• Inexpensive • OMRI listed	• Phytotoxicity possible • Corrosive • Offensive odor • Visible residue	• Newer formulas less phytotoxic

**Fungicide Resistance Action Committee (FRAC) Code List: Fungicides sorted by mode of action. 2009. http://www.frac.info/frac/publication/anhang/FRAC_CODE_LIST.pdf*

Cultural and Biological Alternatives

Practices Reported	Survey Data Efficacy Rating	Pros	Cons	Comments
Pruning <1% growers 1.1% acres	none reported	• Maximize air circulation and drying conditions • Saves spraying time • Improves spray penetration	• Labor intensive (but worth it) • Must remove prunings from the production area	• Primocane suppression would be helpful if possible
Resistant Cultivars			• Not a lot of information on which cultivars are more/less susceptible • Few resistant cultivars available	• Use more susceptible cultivars for indicators
Site selection		• Optimize air circulation • Optimize drying conditions		

Research Needs:

- Explore effects of primocane suppression techniques to reduce inoculum.
- Identify and develop more organic management materials.

- Develop information on pest complexes and disease management specific to high tunnel production systems.
- Pursue new and different chemistries to provide more options to mitigate resistance development.
- Breed more disease-resistant raspberry varieties.
- Identify raspberry varieties that are less-susceptible to powdery mildew.

Regulatory Needs:

- Define registered uses and instructions for field vs. high tunnel production systems, particularly at the state level.

Education Needs:

- Increase awareness of potential differences in disease management specific to high tunnel production systems, particularly for powdery mildew.
- Increase awareness that powdery mildew is more likely to occur on fall bearing raspberry varieties.

CANE DISEASES

Cane Blight (*Leptosphaeria coniothyrium*)
Anthracnose (*Elsinoe veneta*)
Spur Blight (*Didymella applanata*)

% Acres Affected: 45% of raspberry acres affected annually.
Yield Losses: >50% without management, <10% with management.

- More prevalent in southern New England (due to higher temperatures and humidity)
- Incidence increasing in northern New England
- Anthracnose occurring more frequently on many crops, will infect raspberry fruit
- Spur Blight will impact yield, especially on floricane-fruiting varieties
- Populations increase over time if not suppressed
- Certain fields are more prone to infection than others
- Overhead irrigation contributes to population increase
- Might become a problem in high tunnel production systems
- Damage occurs late in season
- Difficult to determine which cane disease causing damage
- Damage may be unrecognized as caused by a cane disease pest and may be mistaken for winter injury
- Damaged plants are more susceptible to winter injury
- Pruning and removal of infected plant material is essential to management
- Do not prune during wet periods
- Rake/till before mowing in fall
- Fungicides for Anthracnose and Spur Blight also effective against Cane Blight

Currently Registered Pesticides

Pesticide alphabetically by a.i.	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
captan (Captan 50W, 80WDG, Captec 4L) 2% growers 7% acres	67% Good 33% Poor	• Also labeled for other diseases and crops • Inexpensive	• Effect strictly prophylactic • Long PHI (3 days) • Phytotoxicity possible when applied at same time as oil	• Different REI for different crops • Phytotoxicity more severe during cold temperatures • FRAC* Code: M4 • Labeled for Spur Blight on raspberries

copper hydroxide, copper sulfate (Champ, Kocide, Cuprofix, etc.) <1% growers <1% acres	100% Poor	• Some formulations are OMRI listed		• FRAC* Code: M1
lime sulfur (Miller's Lime Sulfur, Sulforix) 14% growers 25% acres	23% Exc. 59% Good 18% Poor	• Also labeled for other diseases • OMRI listed	• Cleanup is difficult • Offensive odor • Corrosive to equipment • Hazardous to applicator	• Standard use material • Fall dormant/Spring application • Sulforix formula is less odorous • FRAC* Code: M2
myclobutanil (Nova 40W) <1% growers <1% acres	100% Poor			• FRAC* Code: 3
pyraclostrobin (Cabrio EG) 1.6% growers 1.7% acres	50% Good 50% Poor	• Also useful against orange rust	• Resistance development likely • Expensive	• Effective against mildew, anthracnose • FRAC* Code: 11

**Fungicide Resistance Action Committee (FRAC) Code List: Fungicides sorted by mode of action. 2009. http://www.frac.info/frac/publication/anhang/FRAC_CODE_LIST.pdf*

Cultural and Biological Alternatives

Practices Reported	Survey Data Efficacy Rating	Pros	Cons	Comments
Pruning and thinning 20% growers 28% acres	41% Exc. 55% Good 4% Poor	• Maximize air circulation and drying conditions • Saves spraying time • Improves spray penetration	• Labor intensive • Must remove prunings from the production area	

Research Needs:

- Explore the efficacy of phosphorous acid (Aliette, ProPhyt, Agri-Fos, etc.) against cane diseases.

Regulatory Needs:

- None identified

Education Needs:

- Develop diagnostic keys for growers to differentiate the various cane diseases on different raspberry cultivars.
- Increase awareness of potential for cane disease to establish in older fields that are less rigorously managed.
- Promote value of proper pruning and thinning to keep all cane diseases in check.
- Increase awareness that late season infections are the cause of following spring disease.
- Promote value of pruning following fruit harvest to reduce plant stress and potential for winter injury.

Phytophthora Root Rot (*Phytophthora* spp.)

% Acres Affected: 24% of raspberry acres affected annually.
Yield Losses: >50% without management in high-risk situations, <10% with management.

- Can completely destroy planting – more drastic damage than any other disease
- Occurring more frequently on many crops
- Once occurs in field, always present in field
- <u>Site selection and water management are essential to disease management</u>
- Fungicides materials will have little effect in the absence of water management
- Raised beds and subsurface drainage are key water management tactics
- Multiple species, multiple races
- Can be present in irrigation water sources
- Damage often goes unrecognized as caused by pest and may be mistaken for winter injury early in season or *Verticillium* wilt (premature dieback before harvest)
- Fungicide effect will be dependent on species and race of pest present
- Fungicide resistance is a concern; materials of differing chemistries should be alternated in a spray program to avoid resistance development.

Currently Registered Pesticides

Pesticide alphabetically by a.i.	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
fosetyl al or aluminum tris (Aliette WDG) 3.2% growers 2.1% acres	100% Good	• Very effective	• Resistance development possible	• Rotate with Ridomil Gold to offset resistance development • Fall & spring applications require wet soil, 55 degrees • FRAC* Code: 33
mefenoxam (Ridomil Gold EC, 2.5 GR) 14% growers 13% acres	28% Exc. 44% Good 28% Poor	• Very effective	• Resistance development likely	• Fall & spring applications require wet soil, 55 degrees • FRAC* Code: 4
phosphorous acid (Phostrol, Nutriphyte) 2% growers 9% acres	100% Good	• Very effective • Less expensive than other materials	• Resistance development possible	• Fall & spring applications require wet soil, 55 degrees • Rotate with Ridomil Gold to offset resistance development • FRAC* Code: 33

**Fungicide Resistance Action Committee (FRAC) Code List: Fungicides sorted by mode of action. 2009. http://www.frac.info/frac/publication/anhang/FRAC_CODE_LIST.pdf*

Cultural and Biological Alternatives

Practices Reported	Survey Data Efficacy Rating	Pros	Cons	Comments
Raised Beds 8% growers 6% acres	33% Exc. 67% Good			
Resistant Cultivars 6% growers 6% acres	33% Exc. 50% Good 17% Poor		• Not a lot of information on which cultivars are more/less susceptible • Few resistant cultivars available	
Provide supplemental drainage				

Research Needs:

- Develop alternatives to soil drench applications for management
- Explore efficacy of *Trichoderma* biocontrol against *Phytophthora* as a substitute for and/or in combination with soil drench fungicides.
- Breed more disease-resistant raspberry varieties
- Identify raspberry varieties that are less-susceptible to *Phytophthora*
- Identify differences in virulence among different *Phytophthora* species and races.
- Develop a test kit for grower to check for *Phytophthora* presence
- Explore the use of compost and soil biodiversity to mitigate *Phytophthora*
- Explore the use of biofumigants to mitigate *Phytophthora*

Regulatory Needs:

- Fast-track registration of new and different chemistries to provide more management options
- Create incentives for pesticide packaging that is practical for small-acreage growers
- Streamline and speed local permitting processes for installing drainage in fields.

Education Needs:

- Promote awareness of the primary importance of water management practices and the minimal efficacy of chemicals in disease management.
- Encourage checking irrigation sources for disease inoculum.
- Encourage ozone disinfection of water from open sources.
- Promote benefits of cleaning of equipment to prevent the spread of inoculum between fields.
- Define and encourage proper site selection and row orientation to mitigate disease pressure.

Selected Comments on Other Diseases & Nematodes

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

Crown Gall (*Agrobacterium tumefaciens*)

- May be present on plants from nursery
- May be present in field already

Fire Blight (Erwinia amylovora)

- Population present in wild raspberry
- Occurring more frequently on cultivated raspberry
- Spread by insects
- Requires wounds (i.e. winter injury) or open flowers to enter plant
- A potential problem in high tunnel production systems (humidity)
- Overhead irrigation contributes to population increase
- Need to recognize early to effectively manage
- Only see bacterial ooze from infection in early morning
- Nearly impossible to eliminate once established during season
- Materials labeled for raspberry are prone to resistance
- Research needed on infection models
- Research needed on economics of repeated management applications
- Research needed on ability of infection to kill raspberry plant
- Breeding of more disease-resistant raspberry varieties is desired.
- Research and Education needed to determine scope of problem and activity in raspberry/wild raspberry populations
- Education is needed on importance of pruning for air circulation and proper sterilization during pruning
- Fire blight strains that affect raspberry are not pathogenic to apple and vice versa, research on understanding host specificity could identify control mechanisms

Late Leaf Rust (*Pucciniastrum americanum*)

- Occurring more frequently
- Very heavy infection and loss of harvest possible when it occurs
- More common on fall-bearing red and purple raspberry
- ‘Nova’ highly resistant; ‘Festival’ susceptible
- White spruce is alternate host – not easy to eliminate
- Little information on management in New England (most information comes from Ohio State)
- Prevention is beneficial approach
- Newer materials available to manage it are more effective
- Need to apply materials early (mid June)
- Application of lime sulfur in fall will eliminate spores

- Fungicide resistance potential is high
- <u>Research needed on alternate host management tactics (i.e. required distance</u> from raspberry)
- Research is needed on dust management as a management option

Nematodes (various species)

- Occurring more frequently in the north
- May be more of problem than realized, especially in high tunnel production systems
- Play a role in disease
- Key virus transmitters
- Management options once plants established are limited
- <u>Research is desperately needed – very little information is currently known</u>
- <u>Need more nematode specialists and pathologists</u>

Orange Rust (*Arthuriomyces peckianus*)

- Usually on black raspberry and blackberry
- Systemic infection
- No alternate host
- Must prune out
- Few management materials available

Viruses (Mosaic, Leaf Curl, Raspberry Streak, Tomato Ringspot)

- Viruses do not kill plants but reduce fruit size, number, vigor
- Yield loss attributed to other things are often virus-related
- Nematodes are key virus transmitters
- No management materials available – all management options are cultural
- Removal of wild hosts is beneficial to management
- <u>Research is needed to quantify what viruses are present in New England and what the impacts are</u>
- <u>Need more breeding of disease-resistant raspberry varieties</u>
- <u>Education needed about virus presence, symptoms, impacts, and management</u>

Verticillium Wilt (*Verticillium albo-atrum, Verticillium dahliae*)

- May be present on plants from nursery
- May be present in field already

Weeds

% Acres Affected:

Transplant Year 26% Pre-emergent, 27% Post-emergent

Established Plantings: 53% Pre-emergent, 40% Post-emergent

Yield Losses: Unknown

- Morning glory, bindweed and vetch are especially problematic
- Red sorrel and Sweet William are becoming problematic
- Dandelions especially can build up on edges of row
- Some weeds serve as reservoir hosts for viruses
- Weed buildup is greatest on edges of row
- Weeds establish early in season when raspberry plants are young and/or not leafed out
- Mature, full canopy raspberry plants shade out most weeds
- Sod row middles are common; usually mowed weekly
    - Pick-Your-Own customers seem to prefer sod over other groundcover
- Mulch use not common in row; sometimes straw is used, smaller growers may use chip mulch
    - Straw mulch can encourage *Phytophthora* problems
    - Wood chip mulch can throw nutrition off
    - Landscape fabric/plastic and certain mulch options provide habitat for mice/voles
    - Landscape fabric/plastic minimizes dust
- Tilling must be very shallow to avoid damage to raspberry roots
    - Tilling may allow field to warm faster
    - Tilling may minimize local Japanese Beetle population
- There is interest among growers in new 'Round-up ready' fescue groundcover

Currently Registered Pesticides for Pre-emergent Weed Control

Transplant Year and/or Established Plantings

Pesticide alphabetically by a.i.	**Survey Data Efficacy Rating**	**Pros**	**Cons**	**Comments**
DCPA (dimethyl tetrachloroterephthalate) (Dacthal)		• Targets crabgrass, annual grasses		• Not labeled for raspberry
dichlobenil (Casoron 4G, CS) Established 14% growers 24% acres	Established 56% Exc. 44% Poor	• CS formulation is easier to use than 4G • Granules easier for smaller growers without sprayers	• Granules difficult to calibrate and evenly spread	• CS formulation has broader label than 4G formulation • WP formulation not available • WSSA* Group: 20
metam sodium (Vapam HL) Transplant <1% growers 1.1% acres	Transplant 100% Exc.			• Not labeled specifically for raspberry • fumigant
napropamide (Devrinol 50DF) Transplant 6% growers 10% acres Established 7.1% growers 9.3% acres	Transplant 25% Exc. 75% Good Established 33% Exc. 67% Good	• Good efficacy against grasses and broadleaf weeds • Safe for raspberry • Use on tissue culture plants	• Expensive • Poor efficacy against perennial weeds • Photodegrades • Requires tillage and rain to incorporate	• WSSA* Group: 15
norflurazon (Solicam 80DF) Established 2.4% growers 5% acres	Established 33% Exc. 67% Good	• Targets nutsedge, dandelion • Raspberry can grow out of damage	• Can injure and bleach raspberry	• WSSA* Group: 12

oryzalin (Surflan 4AS) Transplant 4.8% growers 8.9% acres	Transplant 17% Exc. 83% Good	• Targets annual grasses and broadleaf weeds • Use on tissue culture plants	• Less effective against perennial weeds	• Good efficacy and less expensive when combined with simazine • WSSA* Group: 3
Established 4.8% growers 14.5% acres	Established 17% Exc. 66% Good 17% Poor			
sethoxydim (Poast) Established <1% growers <1% acres	Established none reported			• Targets Post-emergent grasses • WSSA* Group: 1
simazine (Princep 4L) Transplant 10% growers 27% acres Established 21% growers 32% acres	Transplant 33% Exc. 50% Good 17% Poor Established 15% Exc. 73% Good 12% Poor	• Relatively inexpensive • Targets broadleaf weeds • Some efficacy against post-emergent weeds	• Resistance development possible for certain broadleaf weeds • Must be applied prior to crop bud break	• WSSA* Group: 5
terbacil (Sinbar 80WP) Established 10% growers 17% acres	Established 38% Exc. 62% Good	• Good option to rotate with simazine when resistance possible • Some efficacy against post-emergent small weeds	• Injury possible when plants are growing • More damage likely with lighter soils	• WSSA* Group: 5

**Herbicide Resistance Action Committee (HRAC) Classification of Herbicides by Mode of Action List (includes Weed Science Society of America (WSSA) groups). http://www.hracglobal.com/Publications/ClassificationofHerbicideModeofAction/tabid/222/Default.aspx*

Currently Registered Pesticides for Post-emergent Weed Control

Transplant Year and/or Established Plantings

Pesticide alphabetically by a.i.	**Survey Data Rating**	**Pros**	**Cons**	**Comments**
2,4-D (Formula 40) Established <1% growers 1.7% acres	 Established 50% Good			• Not labeled for raspberry
clopyralid (Stinger)		• Good efficacy against vetch	• Permanent injury possible to raspberry (interveinal whitening, leaf curling) • Timing of application critical	• Not labeled for raspberry
fluazifop (Fusilade DX) Transplant 2.4% growers 2.3% acres	 Transplant 67% Exc. 33% Poor	• Targets grasses only	• Weather conditions can affect efficacy • Phytotoxicity possible when applied at same time as oil during hot weather	• WSSA* Group: 1
glyphosate (Roundup Ultra, Touchdown) Transplant 1.6% growers 3% acres Established 21% growers 17% acres	 Transplant 100% Exc. Established 30% Exc. 60% Good 10% Poor	• Very effective against perennial weeds	• Injury very possible to raspberry • Direct contact not necessary to cause injury to raspberry • Must apply when raspberry dormant • Timing of application narrow in fall – raspberry dormant, weeds active	• Some formulations not for use on raspberry • WSSA* Group: 9
paraquat (Gramoxone Max) Established 6% growers 8% acres	 Established 12% Exc. 62% Good 26% Poor	• Effective burn down of all weeds • Slight injury to raspberry does not affect yield	• Restricted Use Material • High oral toxicity	• WSSA* Group: 22

pelargonic acid (Scythe) <u>Established</u> 1.6% growers 1.9% acres	 <u>Established</u> 50% Good 50% Poor	• Strictly for burn down	• Expensive • Offensive odor	• WSSA* Group: 27
sethoxydim (Poast) <u>Transplant</u> 10% growers 27% acres <u>Established</u> 17% growers 23% acres	 <u>Transplant</u> 33% Exc. 50% Good 17% Poor <u>Established</u> 25% Exc. 55% Good 20% Poor	• Targets quackgrass, crabgrass	• Poor efficacy against some other grasses • Phytotoxicity possible when applied at same time as oil during hot weather	• More effective than fluazifop on many same weeds • WSSA* Group: 1
terbacil (Sinbar 80WP) <u>Established</u> <1% growers 1.7% acres	 <u>Established</u> 100% Exc.	• Some efficacy against Post-emergent small weeds	• Injury possible when plants growing • More damage likely with lighter soils	• WSSA* Group: 5

**Herbicide Resistance Action Committee (HRAC) Classification of Herbicides by Mode of Action List (includes Weed Science Society of America (WSSA) groups). http://www.hracglobal.com/Publications/ClassificationofHerbicideModeofAction/tabid/222/Default.aspx*

Cultural and Biological Alternatives

Practices Reported	Survey Data Efficacy Rating	Pros	Cons	Comments
Mulching (see below) 39% growers	42% Exc. 48% Good 10% Poor	• Can be supplemented with chemical options • Organically acceptable	• Vole habitat	• Provides other benefits (soil moisture retention, etc)
Hand weeding 74% growers	33% Exc. 55% Good 12% Poor	• The best option for persistent and noxious weeds	• Labor intensive	• Common during establishment year • Early in season
Hoeing 32% growers	20% Exc. 62% Good 18% Poor	• The best mechanical option for persistent and noxious weeds	• Labor intensive	• Not common practice
Flaming 1% growers	100% Poor		• Risk of fire	
Weed whacker 1% growers	100% Good			
Mowing 5% growers	33% Exc. 50% Good 17% Poor	• Very effective in row middles • The most effective option for between crop rows	• Requires multiple treatments • Can encourage weed seed dispersal	
Mechanical cultivation 37% growers	29% Exc. 62% Good 9% Poor	• Fairly effective on emerged annual weeds	• Can be challenging when mulch present • Perennial weed growth quick to recover • Not effective on wet soil • Can damage crop roots	• Cultivation generally occurs between crop rows • More effective in sandier soils
No-till or zone-till 2% growers	67% Good 33% Poor	• Provides benefits towards improving soils • Zone-till allows soil to warm in narrow bands	• Lowers overall soil temp	

Mulch Material	Survey Data Efficacy Rating	Pros	Cons	Comments
Wood chips 24% growers	56% Exc. 33% Good 11% Poor	• Can be supplemented with chemical options • Organically acceptable	• Vole habitat	• Provides other benefits (soil moisture retention, etc)
Sawdust 16% growers	16% Exc. 67% Good 18% Poor	• Can be supplemented with chemical options • Organically acceptable	• Vole habitat	• Provides other benefits (soil moisture retention, etc.)
Compost manure 13% growers	20% Exc. 80% Good	• Can be supplemented with chemical options • Organically acceptable	• Introduction of weed seeds possible	• Provides other benefits (soil moisture retention, etc)
Straw/Barley straw 11% growers	20% Exc. 50% Good 25% Poor	• Can be supplemented with chemical options • Organically acceptable	• Vole habitat	• Provides other benefits (soil moisture retention, etc)
Hay 11% growers	100% Exc.	• Can be supplemented with chemical options • Organically acceptable	• Vole habitat	• Provides other benefits (soil moisture retention, etc)
Leaves/chopped leaves 5% growers	50% Exc. 50% Good	• Can be supplemented with chemical options • Organically acceptable	• Vole habitat	• Provides other benefits (soil moisture retention, etc.)
Bark 5% growers	50% Exc. 50% Good	• Can be supplemented with chemical options • Organically acceptable	• Vole habitat	• Provides other benefits (soil moisture retention, etc)

Plastic 5% growers	100% Exc.	• Very effective • Can be supplemented with chemical options • Organically acceptable if plastic not left on ground over winter • Recommended in tunnel systems • Increases production with black raspberries, blackberries	• Expensive initial investment • Holes can allow weed growth • Can provide pine vole habitat when plastic left on ground over winter	• Provides other benefits (soil moisture retention, etc) • Becoming common with crown-suckering species • Common in tunnel systems

Research Needs:

- Develop and test new chemistries and management options for milkweed, bindweed, and other hard-to-control perennials.

Regulatory Needs:

- Expand labeling for clethodim (Select), clopyralid (Stinger), and isoxaben (Gallery) for use on raspberries to provide more options to growers.
- Expand labeling for diuron (Karmex) for use on raspberries in New England.

Education Needs:

- Educate growers of the proper timing and methods of application for different herbicide chemistries.
- Raise awareness of resistance development possibilities to triazine (atrazine, simazine, etc.) family of herbicides.
- Foster understanding among growers of watershed location and potential for herbicide leaching.

Key Vertebrates

Birds (various species)

% Acres Affected: Unknown
Yield Losses: Unknown

- Robins, mockingbirds, catbirds, and grackles are common
- Late summer massing-flocks are problematic
- Bird pressure varies greatly with location
- A method for predicting high pressure locations, aside from field history, is not available.
- More of a problem for homeowners than commercial operations
- Birds prefer black raspberry over red raspberry
- Most methods don't work once birds are aware of crop
- All methods must be moved/rotated regularly to disrupt pest
- Pickers in the field discourage birds temporarily
- Larger plantings more can absorb more bird damage

Cultural and Biological Alternatives

Practices Reported		Pros	Cons	Comments
Scare-eyed balloons 32% growers	7% Exc. 50% Good 43% Poor		• Limited efficacy • Variable results	
Nylon flash tape 7% growers	50% Good 50% Poor		• Limited effectiveness • Variable results • Limited species efficacy • Not practical on large scale	• Some tapes also have sound components as deterrents
Balloons 2% growers	100% Good			
Owls 2% growers	100% Poor		• Must be moved daily to be effective	• More realistic is better • Some incorporate moving head
Recorded distress call devices 18% growers	75% Good 25% Poor	• Attract actual live predators	• Equipment failure possible • Annoyance to neighbors and customers	• Some models can vary calls to reduce chances of pest acclimation

Cannons 18% growers	25% Exc. 50% Good 25% Poor	• Effective for short periods	• Annoyance to neighbors and customers	
Shell crackers 9% growers	25% Exc. 75% Good	• Effective at key feeding times	• Annoyance to neighbors and customers • Safety issues • Very short term effectiveness	• Effective in conjunction with people picking • Products are legal for use in agriculture
Shoot 7% growers	33% Exc. 67% Good		• Neighbor relations • Safety issues • Legality issues • Short term effect	
Avitrol bait 2% growers	100% Good		• Restricted Use Material	
Plant extra raspberry 2% growers	100% Good			
Cats 1% growers	100% Exc.			
Heli-Kite		• Effective for short periods • Attracts predator hawks		

Research Needs:

- Develop and test new chemistries (e.g. antifeedants) for bird management.
- Develop and test new management options (robotic hawks, sound devices that attract predators) against birds.

Regulatory Needs:

- None identified

Education Needs:

- Encourage placement of perches and houses to encourage predatory birds to nest and hunt near raspberry fields.
- Create awareness among growers of availability of captive predatory birds that may be exercised in raspberry fields.

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

% Acres Affected: Unknown
Yield Losses: Unknown

- Prefer long grass, field habitat
- More of a problem where mulch is used, providing favorable habitat
- Prefer blackberries
- Girdle canes, gnaw on roots
- Gnaw on drip irrigation lines

Cultural and Biological Alternatives

Practices Reported		Pros	Cons	Comments
Mouse baits 30% growers	38% Exc. 62% Good	• Easy to broadcast or place under shingles	• Non-target effects possible	
Mow grass 12% growers	100% Good			• Necessary practice
Weed management 3% growers	100% Good			• Necessary practice
No sod 3% growers	100% Good	• Provides no refuge for pest		
Owls 3% growers	100% Exc.			
Cats 3% growers	100% Exc.			
Dogs 3% growers	100% Good		• Digging damage to field	• Included red fox and coyotes
Fill in holes 3% growers				

Research Needs:

- None identified

Regulatory Needs:

- None identified

Education Needs:

- Encourage placement of perches and houses to encourage predatory birds to nest and hunt near raspberry fields.
- Create awareness among growers of availability of captive predatory birds that may be exercised in raspberry fields.

Selected Comments on Other Vertebrates

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

Whitetail Deer (*Odocoileus virginianus*)

- Can damage tips on new canes early spring
- Limits on number can shoot
- Seem to prefer blackberry
- Hoofs punch holes in fabric, plastic groundcovers
- Usually something nearby they prefer to eat before raspberry

Turkey

- Becoming more of a pest in New England
- Damage fruit but not significantly
- Relatively easy to dissuade from raspberry

Skunks

- Occasionally dig after grubs and cause damage to field
- Easily trapped

Porcupines

- May cause damage gnawing on canes in winter

Raccoons

- May disrupt bee hives

Bear

- May disrupt bee hives

IV. Appendices

Raspberry Crop, Worker, Pest and Pesticide Timing

H = High Tunnel Production System only

	Apr.				May				June				July				Aug.				Sep.				Oct.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Crop Stage																												
Pre-Harvest	X	X	X	X	X	X	X	X	X	X	X																	
Harvest												X	X	X	X	X	X	X	X	X	X	X	X	X	H	H	H	H
Post-Harvest																			X	X	X	X	X	X	X	X	X	X
Worker activities																												
Soil Fumigation (Year Prior to Planting)																							X	X	X	X	X	X
Land preparation and cultivation (Year Prior to Planting)										X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Land preparation and cultivation (Planting Year)			X	X	X	X																						
Planting			X	X	X	X																						
Fertilization										X	X	X	X	X														
Harvest												X	X	X	X	X	X	X	X	X	X	X	X	X	H	H	H	H
Field Scouting for Integrated Pest Management (IPM)				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	H	H	H	H

JB = Japanese Beetle
TPB = Tarnished Plant Bug
PLH = Potato Leafhopper

Bot = *Botrytis*
PM = Powdery Mildew
Cane = Cane diseases: Cane Blight, Spur Blight, Anthracnose
Phyt = Phytophthora

	Apr.				May				June				July				Aug.				Sep.				Oct.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Insect & Disease Pest Key Activity & Monitoring Periods																												
JB														X	X	X	X	X										
TPB			X	X	X	X																						
PLH														X	X	X	X	X										
Bot												X	X	X	X	X	X	X	X	X	X	X	X	X				
PM										X	X	X	X	X	X	X	X	X	X	X	X	X						
Cane			X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X						
Phyt			X	X	X	X																						
Insecticide & Disease Application Timing																												
JB								X	X					X	X	X	X	X	X	X	X	X						
TPB				X	X	X	X	X	X	X																		
PLH															X	X	X	X	X	X								
Bot								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
PM								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Cane	X	X	X	X	X	X	X	X	X																			
Phyt	X	X	X	X																			X	X	X	X	X	X
Weed Key Activity & Monitoring Periods																												
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Herbicide Application Timing																												
					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
Vertebrate Pest Control Timing																												
Birds												X	X	X	X	X	X	X	X	X	X	X	X	X				
Mice and Voles*	X	X	X	X	X	X	X	X																				

* Mice and vole damage can happen anytime, but may be more prevalent and damaging in the spring.

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

Method	Source	Status	Pests Affected
abamectin	IR4	Pending (Insecticide)	Broad spectrum acaricide with activity on leafminers, Colorado potato beetle, and pear psylla. Weak against sucking insects and thrips. Good IPM tool with short re-entry interval. Translaminar activity providing long residual activity.
Bacillus thuringiensis	IR4	Registered (Insecticide)	New strains of Bt are being discovered that have activity against numerous pests.
bifenazate	IR4	Potential (Insecticide)	Controls spider and European red mites, including eggs and motiles. Provides quick knockdown. Safe on predator mites.
canola oil	Pipeline	Biopesticide (insecticide) Registration Approved (insecticide) Tolerance Accepted (insecticide)	Mites, Plant Bugs, Scales, Whiteflies, Aphids, Leafhoppers, Phylloxerans, Mealybugs, Psyllids, Adelgids, Sawflies
hexythiazox	IR4	Registered (Insecticide)	Mites
indoxacarb	IR4	Potential (Insecticide)	Controls most major Lepidopteran pest species. Possibly controls plant bugs. Soft on beneficials so it is a good fit with IPM.
iron phosphate	IR4	Registered (Insecticide)	Slugs and snails.
kaolin (raspberry)	Pipeline	Biopesticide (insecticide) (plant growth regulator) (miticide) Registration Approved (miticide) (plant growth regulator) (insecticide) Tolerance Accepted (insecticide) (plant growth regulator) (miticide)	mites, blackberry psyllid, European raspberry aphid, Japanese beetle, leafhoppers, thrips
kaolin (caneberry)	IR4	Registered (Insecticide)	Various insect and mite pests.
novaluron	IR4	Potential (Insecticide)	Effective against Lepidoptera, mealy bugs, silver leaf whitefly, Western flower thrips, leaf miner, and some mites. Strictly a contact material, no systemic activity.
pyridaben	IR4	Potential (Insecticide)	Activity on mite, whiteflies, aphids, mealybugs, leafhoppers, and thrips. A new class of insecticide offering long term residual control. Good for IPM/resistance management programs.
spinosad	IR4	Registered (Insecticide)	Controls Coleoptera, Diptera, Hymenoptera, Isoptera, Lepidoptera, Thysanoptera, Siphonaptera, and mites. Has low environmental impact, good

			residual activity, and is safe to many beneficial insects making it ideal for use in IPM programs.
spinosad	IR4	Pending (Insecticide)	Controls Coleoptera, Diptera, Hymenoptera, Isoptera, Lepidoptera, Thysanoptera, Siphonaptera, and mites. Has low environmental impact, good residual activity, and is safe to many beneficial insects making it ideal for use in IPM programs.
tebufenozide (raspberry)	Pipeline	Reduced-Risk Pesticide (insecticide) Registration Approved (insecticide) Tolerance Accepted (insecticide)	Variegated Leafhopper, Gypsy Moth, Redbanded Leafroller, Obliquebanded Leafroller
tebufenozide (caneberry)	IR4	Registered (Insecticide)	Controls only Lepidoptera larvae. Safe to beneficial insects with low environmental impact. Excellent for IPM programs.
cinnamaldehyde	IR4	Registered (Insecticide) (Fungicide)	Aphids, Mites, and the diseases Downy mildew, Powdery mildew, Botrytis, and Brown rots.

New Pest Management Technologies for Diseases of Raspberry

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

Method	Source	Status	Pests Affected
Agrobacterium radiobacter	IR4	Registered (Fungicide)	Control of hairy root and root mat, crown gall.
Agrobacterium radiobacter (strain K1026)	Pipeline	Biopesticide (bactericide) Registration Approved (bactericide)	Crown gall
Ampelomyces quisqualis isolate M-10	IR4	Pending (Fungicide)	Hyperparasite of Powdery mildew.
BAS 516	IR4	Pending (Fungicide)	Broad spectrum activity on Anthracnose, Alternaria, downy mildew, powdery mildew, Botrytis, Sclerotinia, and Monilinia.
cinnamaldehyde	IR4	Registered (Insecticide) (Fungicide)	Aphids, mites and the diseases Downy mildew, Powdery mildew, Botrytis, and Brown rots.
famoxadone	IR4	Potential (Fungicide)	Broad spectrum fungicide, including Early blight, Downy mildews, and other ascomycetes. Can be combined with Cymoxanil (marketed as Tanos) to pick up Late blight.
glutamic acid	IR4	Pending (Fungicide)	Controls brown rot and suppresses shot hole.
mocobifen-BAS 510	IR4	Pending (Fungicide)	Manages Powdery mildew, Alternaria, Botrytis, Sclerotinia and Monillia
phosphoric acid	IR4	Potential	Downy mildew, scab, and root rot.

		(Fungicide)	
propiconazole	IR4	Pending (Fungicide)	Powdery mildew, rusts, smuts, Pyrenophora, Septoria, Cercospora, Cercosporidium, Ascochyta, Pseudocercosporela, Mycosphaerella, Fusicladium, Gaeumannomyces, Monilinia, Clasterosporium, Helminthosporium and related genera, Kabatiella, Ceratocystis, Sclero
pyrimethanil	IR4	Potential (Fungicide)	Active against Botrytis spp., Venturia spp., Alternaria solani, Alternaria mali, Sphaerotheca macularis and Monilinia spp.
quinoxyfen/DE795	IR4	Potential (Fungicide)	Has shown activity against powdery mildew in a wide range of crops.
Streptomyces lydicus WYEC 108	IR4	Pending (Fungicide)	Controls soil borne plant root rots and damping off fungi.
zoxamide	IR4	Potential (Fungicide)	Control of foliar phycomycetes and albugo. Also protectant against Oomycete fungi. Will be mixed with mancozeb for broader activity.

New Pest Management Technologies for Weeds of Raspberry

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

Method	Source	Status	Pests Affected
carfentrazone-ethyl (raspberry, black & red)	IR4	Pending (Herbicide)	Numerous broadleaf weeds, including cocklebur and water hemp.
carfentrazone-ethyl (caneberry)	IR4	Pending (Herbicide) Registered (Herbicide)	Numerous broadleaf weeds, including cocklebur and water hemp.
clethodim	IR4	Pending (Herbicide)	Strictly a grass herbicide.
Colletotrichum gloeosporioides f. sp *malvae*	IR4	Pending (Herbicide)	It is pathogenic to round-leaved mallow, small flowered mallow, common mallow, and velvetleaf.
S-metolachlor	IR4	Potential (Herbicide)	Same spectrum as metolachlor (Dual).
thiazopyr	IR4	Potential (Herbicide)	Annual and perennial broadleaf weeds, including crabgrass and nutsedge.

Pesticide Efficacy for Weeds

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

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

Active ingredient or Method	Brand name(s)	Annual Grasses	Annual Broadleaf	Perennials
glyphosate	Roundup	E	E	G-E
napropamide	Devrinol	G-E	P-E	P
paraquat	Gramoxone	E	G-E	P-G
pelargonic acid	Scythe	E	G-E	P-G
sethoxydim	Poast	E	N	N-E

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