Eastern Peach Pest Management Strategies for Adapting to Changing Management Options

Dan Horton, Bob Bellinger and Larry Elworth, Editors

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Bob Bellinger, Clemson University, Entomology, 864-656-5042, bbllngr@clemson.edu

Phil Brannen, University of Georgia, Plant Pathology, 706-542-2685, pbrannen@uga.edu

Wilfred Burr, USDA, OPMP, 202-720-8647, wburr@ars.usda.gov

Chalmers Carr, South Carolina Peach Council

Larry Elworth, Center for Agricultural Partnerships, Asheville, NC, 828-285-9340, lelworth@agcenter.org

Clyde Gorsuch, Clemson University, Entomology, 864-656-5043, cgrsch@clemson.edu

Paul Guillebeau, University of Georgia, Entomology, 706-542-1765, pguillebeau@bugs.ent.uga.edu

Larry Gut, Michigan State University, Entomology, 517-353-8648, gut@msu.edu

John Halbrendt, Pennsylvania State University, Nematology, 717-677-6116, jmh23@psu.edu

Dan Horton, University of Georgia, Entomology, 706-542-1765, dlhorton@uga.edu

Lynnae Jess, Michigan State University, 517-355-3459, jess@msue.msu.edu

Greg Krawczyk, Pennsylvania State University, Entomology, 717-677-6116, gxk13@psu.edu

Wayne Mitchem, NCSU/Clemson/UGA, Weed Science, 704-810-0819, wayne_mitchem@ncsu.edu

Norm Nesheim, University of Florida, Director Southern Region Pest Management Center, 352-392-4721, onn@gnv.ifas.ufl.edu

Bill Shane, Michigan State University, Cooperative Extension Service, 616-944-1477, shane@msue.msu.edu

Harald Scherm, University of Georgia, Plant Pathology, 706-542-1258, scherm@uga.edu

Pete Shearer, Rutgers University, Entomology, 856-455-3100, shearer@aesop.rutgers.edu

Guido Schnabel, Clemson University, Plant Pathology, 864-656-6705, schnabe@clemson.edu

Lora Lee Schroeder, U.S. EPA, Region 4, 404-562-9015, schroeder.lora@epa.gov

Katherine Taylor, University of Georgia, Horticulture, 912-956-6417, kctaylor@uga.edu

Dave Ritchie, NC State University, Plant Pathology, 919-515-6809, david_ritchie@ncsu.edu

EXECUTIVE SUMMARY

PEST MANAGEMENT NEEDS IN EASTERN PEACH CULTURE

BACKGROUND

- Peach production in the eastern U.S. encompasses ca. 82,000 bearing acres, 52% of the national total (fresh & processing). The 1999 eastern peach crop was valued at $191 million. Eastern peach production is centered in three main areas: the upper mid-West (MI), the mid-Atlantic (NJ, PA) and the Southeast (GA, NC, SC).

- In 1999 GA, MI, NJ, PA and SC produced 34% of the nation's peach crop.

- Peaches are a perennial crop requiring at least 6 years to recoup investment costs. Average tree life expectancy is 12-14 years.

CRITICAL ISSUES

Key pests

- The importance of particular pests varies by region. Plum curculio has been the key pest on peaches in the southeast. Oriental fruit moth has become the key pest in the Midwest and Northeast. Both pests have typically been controlled with organophosphate (OP) applications.

- The pests that damage and destroy trees, scale insects, greater and lesser peachtree borers are common throughout eastern peach production.
  - ❖ Severe scale infestations are difficult and expensive to control and can easily shorten an orchard's productive life by 2 years. Scale insects suck sap from foliage, twigs and branches.
  - ❖ Borer infestations weaken trees, make them more susceptible to disease and can dramatically shorten tree productivity and longevity.

❖ Plant bugs, stink bugs are important pests that damage fruit and can be mechanical vectors of brown rot. These insects, in combination with other insect pests such as aphids and Japanese beetles, present a complex insect management challenge for peach growers

Key pest management issues

- ❖ With the loss of methyl parathion and changes in the availability of other OPs, IPM in peaches needs to be reinvented. In doing so, certain realities will need to be considered:

- ❖ Current peach insecticide alternatives include OPs, carbamates and pyrethroids. OPs and carbamates are all under EPA scrutiny, hence they are questionable long-term options.

- Pyrethroids are entirely unacceptable as mainstay insecticides in eastern peach culture because they induce secondary pests. Primary in season insecticides must not exacerbate scale as the pyrethroids do.

- Plant bugs, stink bugs and assorted opportunists are sporadic pests in OP-based insect management systems. If OPs are retained as early season options-- to take advantage of their broad spectrum and provide a resistance management option - alternative control tactics become more feasible. These fruit pests are difficult to monitor and gaps in the understanding of biology and behavior limit control tactics to cultural controls that only modestly diminish stink bug pressure. Low risk insecticides that do not promote scale problems are badly needed for stink bugs and opportunistic fruit pests.

- Essentially 100% of eastern peaches receive a single, handgun directed, post harvest spray with the OP chlorpyrifos for borers. This treatment also suppresses scale. There is a 7+ month interval between this application and fruit set; as such, this important IPM practice presents no risk of fruit contamination. It is analogous to similar treatments in nursery production.

- Although cultural practices and biocontrol play important roles in management of both diseases and insects, thorough spray coverage with effective pesticides is essential to sustain commercially competitive production in the Southeast.

- ❖ **Mating disruption for control of borers and oriental fruit moth has demonstrated that effective control is possible but a significant amount of additional field implementation is necessary before use is widespread.**

CRITICAL NEEDS

Research needs

- Re-inventing eastern peach IPM must first focus on pest biology for peach pests: insects, mites, diseases, nematodes and weeds, along with their complements of natural enemies, to develop a currently lacking, prerequisite knowledge base. Improved understanding of biology is needed to form the foundation for creating biologically-refined monitoring and predictive tools for key peach pests.

- Plum curculio (PC) in the Southeast and Oriental fruit moth (OFM) in the mid-Atlantic and upper mid-West are the key fruit insect pests. Even the modest reduction in organophosphate achieved to date, have facilitated observable elevations in the pest status of both PC and OFM in those areas where they are presently subordinate pests**. Pest biology and behavior studies for PC and OFM are key prerequisites to development of more evolved IPM options.**

- **Low risk insecticides that do not promote scale problems are badly needed for stink bugs and opportunistic fruit pests**. Stink bugs and tarnished plant bugs in particular are a concern. These pests damage fruit and they can be important mechanical vectors of brown rot.

- Scale, primarily San Jose and white peach, have become damaging primary pests. This elevation in pest status is attributable to changes in pesticide availability. **Research should focus on scale biology and model development to improve timing of insecticide applications.**

- Beetles (Japanese, green June, rose chafers & white fringed) are occasionally very difficult to control. **Research needs need to include these occasional but highly problematic pests.**

- Efficacy trials of lower-risk insecticides and biorational controls must be conducted. Impacts on key, secondary and induced pests; beneficials; and "new" pests must be carefully studied. Promising options must be incorporated into existing commercial practice.

- Brown rot is the East's key fruit rot of peach. De-methylation inhibitor (DMI)-based control programs are excellent, but the brown rot organism readily develops fungicide resistance**. A fuller understanding of the pathogen's biology and epidemiology is needed to improve timing of sprays and develop prudent resistance management strategies.**

- At present, some 20% of the bearing peach acreage is planted to cultivars susceptible to bacterial spot. Chemical control is solely dependent on materials that face regulatory scrutiny. Pesticide resistance is a major concern. Host plant resistance is important and is being used. However, all but the most resistant cultivars need supplemental chemical control when pest pressure is high**. A better understanding of pest biology and examination of lower-risk control options are essential.**

- Research is needed to determine optimal weed-free intervals for early-, mid- and late-season peaches. In-row cover crops must be evaluated as a potential means of reducing herbicide use and controlling weeds during at least part of the annual production cycle. **New herbicides must be evaluated as potential replacements, especially for simazine and 2,4-D.**

- Research on nematode control must focus on pest biology, resistant rootstocks and cultural controls. **More environmentally favorable alternatives to methyl bromide are badly needed, especially in the tree nurseries.**

Regulatory Needs for Eastern Peach Pest Management.

- Peaches are highly dependent on hand labor. Step-wise, acute and cumulative, in-orchard quantification of worker exposure to key pesticides is needed for all key activities.

- Regulatory decisions on re-entry intervals (REIs) need to recognize the need to conduct field essential activities and such decisions should take into effect cost/benefits considerations.

- Regulatory decisions on OPs have extended preharvest intervals (PHIs). However the need to for late season insect control and the effects on IPM programs with longer PHIs needs to be fully considered in regulatory decisions and in the evaluation of mitigation options.

- American produce growers, including peach growers, should receive assurance that foreign producers will be held to U.S. standards for pesticide labels. **Tolerances should not allow foreign competitors unfair advantages.**

- Resistance management is a key concern with orchard pests. Rotating pesticides to expose pests to varied modes-of-action is the most feasible management option. **Regulatory decisions should thoroughly consider resistance management concerns. It is imperative to maintain multiple modes-of-action for use against key pests.**

- Critical point analysis (HACCP) for both microbial and pesticide residue risks is badly needed to model risks from harvest through shipment.

- Region-wide virus and phytoplasma tree-health programs are needed to mitigate potential spread of plum pox virus (PPV) and reduce the incidence on less catastrophic, endemic viruses. Nursery certification and elimination of non-certified stocks is an industry priority.

Educational needs

- Integrated Orchard Management (IOM and its pest management components) carry considerable management costs that are seldom given due weight for high-value commodities such as peaches. Growers, especially processing growers, need orchard consultants to successfully implement increasingly complex pest management options. The economics of pest management must be re-examined in light of its non-farm benefits to society in order to sustain a badly need cadre of pest management consultants. **Integrated Orchard Management is a key element of both worker safety and environmental stewardship.**

- Best management practices for mitigating in-orchard spread of virus and other systemic tree diseases has become an industry priority.

BACKGROUND

Peach production in the eastern U.S. encompasses ca. 82,000 bearing acres, 52% of the national total. The 1999 eastern peach crop was valued at $191 million. Eastern peach production has three epicenters, the upper mid-West (MI), the mid-Atlantic (NJ, PA), and the Southeast (GA, SC).

Market expectations are high. Growers, especially wholesale marketers, must strive for fruit with a nearly flawless appearance to meet market demands. **Currently even our most evolved programs require multiple pesticide applications to manage fruit and tree pests. For growers, the potential loss associated with pest injury mandates development of affordable, highly reliable, low-risk IPM options.**

Vandeman et al. (1994) observed that pest management in peaches was less evolved than in the other major tree fruits. Peach pest management is making exciting progress; however, eastern peach growers still lack the comprehensive IPM tools needed to move beyond scheduled prophylactic spray programs. In eastern peaches the biologically-refined management tools required for as-needed pest management responses are lacking for most key pests. Eastern peach pest complexes are complex; pest pressure is often heavy and may be season-long. Pest species across the eastern U.S. are surprisingly similar. Most key pests are common to the entire region, although their severity varies considerably from region to region.

Research must focus first on developing biologically-refined monitoring and predictive tools to direct more evolved pest management systems. Transition strategies must simultaneously address short- and long-term needs. The immediate grower need is reliable, affordable, low-risk alternatives to augment diminishing availability of standard materials. Ultimately, transition strategies must develop practical, affordable IPM systems that employ lower-risk pesticides. **Growers want eastern peach IPM re-invented in a fashion that merits praise from economic, social and environmental perspectives. Stable IPM funding is essential if we are to reach that goal.**

In the 1990s most of the eastern peach producers' most damaging pests, plum curculio, Oriental fruit moth, borers, scab and brown rot, have been well controlled. Options for scale and bacterial spot are more problematic.

Regional Pest Management Goals.

Eastern peach pest management scientists, aided by this USDA/EPA sanctioned planning process, are committed to prioritizing research and extension goals. Leadership status in addressing particular goals will be based on key pest status within sub-region; facilitating complementary work and avoiding potential duplication.

Eastern Peach Pest Overview

Insect & Mite Pests

Plum curculio (PC) in the Southeast and Oriental fruit moth (OFM) in the mid-Atlantic and upper mid-West are the key fruit attacking insects. They must be very thoroughly controlled or eastern peach production is imperiled. Both species are present in all eastern production areas. A fuller understanding of OFM and PC biology, along with efficacy assessments for developing pest management options, alone and as components of existing programs, are essential for both pests.

Current insect IPM systems rely heavily on the organophosphates (OPs) phosmet (Imidan) and azinphos-methyl (Guthion, Sniper). Organophosphates are reliable, they do not require extreme precision in time of application, they are largely untroubled by resistance and they do not induce outbreaks of secondary pests such as scale or mites. Organophosphate uses should be retained for early- and, at least, mid-season applications. Eastern peach producers also make limited, but predictable, use of the carbamates carbaryl (Sevin) and methomyl (Lannate), and the pyrethroids permethrin (Ambush/Pounce) and esfenvalerate (Asana). The long-term availability of OPs and carbamates is in question. Pyrethroids are entirely unacceptable as mainstay insecticides in eastern peach culture, as their use induces outbreak levels of scale and mites. The cost of scheduled insecticide sprays in year 2000 rose ca 60%. Peach insecticide costs in the East have risen some 700% since the mid-1980s.

Tree pests—**San Jose scale, white peach scale, peachtree borer and lesser peachtree borer** must be carefully managed or orchard productivity and longevity suffer, with disastrous financial impacts. Peach growers have ca $2,400/a invested before trees begin to bear. Typical orchard longevity is 12-14 years. In many orchards, scale and other tree pests are lengthening the planned-for 6-8 year recovery period to recoup orchard establishment costs.

Scale infestations in the Southeast and mid-Atlantic regions have increased dramatically during the 1990s. This is a **classic example of pesticide-induced crisis**. Scale populations increased after regulatory actions encouraged pyrethroid use while forcing season-long reliance on phosmet, a material with modest scale efficacy. Azinphos methyl (Guthion, Sniper) has better scale efficacy than phosmet, but its 14 day re-entry interval (REI) essentially precludes azinphos-methyl's use while peaches are being thinned, the key period of scale crawler activity. Use restrictions and then loss of encapsulated methyl parathion altered the balance of an eastern peach IPM system that was remarkably free of scale and mite problems. **Severe scale infestations can easily shorten an orchard's productive life by 2 years. Sacrificing 2 years of production easily projects to a 20+% loss of profit potential** [14 yrs- 6 yrs to recoup costs = 8 yrs production, less 2 yrs production lost to scale-induced orchard decline]. **Low-risk scale insecticides and better tools to time sprays are needed to improve scale control. Primary in-season insecticides must not exacerbate scale as the pyrethroids do.**

Peachtree borer and lesser peachtree borer are also key tree pests. Borer infestations weaken trees, make them more susceptible to disease and can kill young trees. Borer treatment thresholds are presently a long-term research challenge. **Well over 90% of eastern peaches receive a single, hand-gun directed spray with the OP chlorpyrifos (Lorsban) for borers. In the Southeast, the timing of borer flights allows growers to delay this spray until after harvest. This provides a 6-month+ interval between application and fruit set. The chlorpyrifos borer spray also suppresses scale.**

Diseases

Current disease control systems are also quite effective, although there are key research and extension needs here too. **Brown rot is the key fruit rot organism**. It is very effectively controlled by de-methylation (DMI) fungicides, often with minimal need for control of the blossom blight and green fruit rot stages of the disease. **There is a need for more detailed understanding of the organism's biology and for non-DMI control options to support better resistance management programs.**

Scab control is typically good. A number of scab sprays are required because multiple, often very brief, infection periods necessitate protection of fruit from early-season until 30 days before harvest. Reduced input sprays are becoming common when disease pressure from scab and other diseases allow. Two important scab fungicides, sulfur and azoxystrobin, are low-risk materials.

Minor fruit rots, anthracnose, peach red spot, sooty peach, rhizopus and gilbertella rots are occasional, but when severe, damaging diseases that are only controllable with older fungicides such as captan, Ziram or Ferbam. Low-risk materials for these diseases are a long-term need.

Bacterial spot is a damaging and problematic key pest on susceptible varieties. Under heavy bacterial spot pressure even resistant varieties need some protective sprays. Bacterial spot pressure varies within the region. Resistant varieties are being planted as commercially competitive selections become available. In major southeastern production areas ca 20% of the bearing acreage must be sprayed for bacterial spot. Control programs for bacterial spot are based on coppers, the fungicide Ziram which boosts the efficacy of coppers, and the key in-season antibiotic oxytetracycline (Mycoshield). **Resistance management options are very limited and regulatory scrutiny is expected, making low-risk, alternative bacterial spot chemistries an important priority.**

Nematodes

Nematodes are extremely important to peach production, since nematodes cause direct damage and play a major role in peach tree short life. Nematodes are also important vectors of certain peach viruses, such as peach rosette mosaic virus and tomato ringspot virus. On replant sites, nematodes are key risk factors influencing orchard health and productivity. Root knot (*Meloidogyne* spp.), ring (Criconemella xenoplax), lesion (*Pratylenchus vulnus*), and dagger (*Xiphinema* spp.) nematodes are the major nematodes of concern to peach production. Cultural practices for control are mainly limited to crop rotation strategies. Root stock selection is also a very important control measure. However, use of chemical nematicides and fumigants continues to play a crucial role in control strategies for peach nematodes. Pre-planting fumigation or applications of nematicides are commonly used practices. Post-plant nematicide application is often a site-specific response to "hot" nematode sites, hence its use is more selective.

Orchard Floor Management

Weeds compete readily with trees for water, nutrients, and sometimes light. Weed competition reduces fruit yield, tree growth and, therefore, the development of young orchards. Delaying orchard development reduces early productivity and return. In established orchards, weed competition reduces total yield and fruit size, resulting in decreased crop value. In tree fruit such as peach, weeds must be managed within a holistic **orchard floor management (OFM)** program. The OFM program of choice uses herbicides to maintain bare-ground in the tree row with an adjoining grass sod between rows. The herbicide strip minimizes competition, while the perennial grass sod reduces erosion and provides an adequate surface for equipment movement through the orchard even during periods of wet weather.

Weed control is critical to the integrated management of other orchard pests. Weeds serve as hosts to cat-facing insects. Eliminating winter annual weeds from the entire orchard floor reduces cat-facing insect populations, aiding in their management with insecticides. Broadleaf weeds are hosts to nematodes that vector tomato ring-spot virus. It is critical that broadleaf weeds be controlled to prevent population increases of Dagger nematodes, which vector viruses, following preplant nematicide application. Vegetation around trees makes orchards attractive to voles. Weeds provide cover for protection from predators and are a source of water, as well as food. Maintaining a clean herbicide strip in the tree row is part of an integrated approach for vole management.

Maintaining a bare soil surface under trees provides a radiant heat benefit in the spring during frost freeze events. Bare soils absorb heat from the sun and release the heat at night. The potential benefit is the slight elevation of orchard temperatures. Although the temperature elevation may be only a few degrees, it may be enough to prevent or reduce fruit losses during spring freeze events. Soil surfaces covered with plant residues or living winter annual weeds are considerably cooler than bare-soil surfaces.

OUTLINE OF PLAN

Pest-by-Pest Profiles. Pest status, damage and biology, along with current and potential control options, are outlined in the pest-by-pest profiles that follow, with particular attention to currently used organophosphate and carbamate insecticides and B1-B2 carcinogens. Also noted are other control options, chemical and non-chemical, new, non-registered pesticide chemistries in development, and a "TO DO" list of research, regulatory and educational needs.

Insects & Mites

1) Oriental fruit moth (OFM)

- **OFM is the key fruit insect pest of the mid-Atlantic and upper mid-West sub-regions.**
- 1st generation larvae attack terminals causing dieback and flagging.
- Larvae of subsequent generations are the most common internal feeding caterpillars in peach.
- Azinphos-methyl, phosmet, and pyrethroids provide excellent control.
- Zero tolerance for wormy fruit.
- Entire loads have been rejected when wormy fruit was detected, a loss of ca $20,000.

Currently Used Organophosphate (OP) insecticides

❖ **azinphos-methyl (Guthion, Sniper)**

- Azinphos-methyl is effective for control of OFM, provides up to 2 weeks of residual activity, depending on weather.
- Field failures due to resistance reported in some mid-Atlantic and upper mid-West orchards.
- Some processors prohibit use of azinphos-methyl and other Ops.
- Recent increase in re-entry intervals to 14-days limits azinphos-methyl's utility.

❖ **phosmet (Imidan)**

- Phosmet provides effective control, but in areas with high OFM pressure phosmet requires more applications and higher rates than azinphos-methyl because of its shorter residual.
- Phosmet is the dominant peach insecticide in the Southeast. It is the primary insecticide in the East during thinning and pre-harvest, because its REI and PHI are shorter than those of azinphos-methyl.
- Phosmet is easier on beneficials than other OPs.
- Field failures due to resistance reported in some mid-Atlantic and upper mid-West orchards.
- Some processors prohibit use of phosmet and other OPs.

Carbamate insecticides

❖ **carbaryl (Sevin)**

- Effective insecticide if used at high rates.
- Short residual (less than 7 days) make it impractical for season-long control.
- Toxic to beneficial insects and mites and disruptive to established IPM programs.
- Some processors prohibit use of carbaryl and other carbamates.

❖ **methomyl (Lannate)**

- Short residual.
- Effective insecticide if used at high rates.
- Very short residual (less than 7 days) make it impractical for season-long control, too expensive and too disruptive to biocontrol of mites to spray at 3-4 day intervals.
- Toxic to beneficial insects and mites and disruptive to established IPM programs.
- Some processors prohibit use of methomyl and other carbamates.
- Applicator safety is a concern; very little methomyl is used in the Southeast.

Pyrethroid insecticides

❖ **esfenvalerate (Asana)**

- Esfenvalerate is a short-residual material, requires many applications.
- Post-bloom use of pyrethroids typically upsets IPM programs by destroying beneficial mites and insects, which seriously exacerbates scale and mite problems.
- Pests readily develop resistance to pyrethroids in systems where they are used repeatedly.
- Esfenvalerate is very economical, but use limited due to concerns about disrupting IPM programs, potential resistance problems and short residual.

❖ **permethrin (Ambush, Pounce)**

- Permethrin is a short-residual material, requires many applications.
- As with esfenvalerate, permethrin is difficult to use in an IPM context. It is detrimental to beneficial mites and insects, which exacerbates scale and mite problems.
- Pests rapidly develop resistance to pyrethroids.
- Permethrin (7-day PHI) has a shorter pre-harvest interval than esfenvalerate (14-day PHI), which is useful when salvage treatments are needed near harvest.

Alternative management options

❖ **Pheromone-based mating disruption (MD) of OFM**

- MD is species specific, it only controls OFM, control measures must still be applied for other pests.
- MD provides effective OFM control, when used in combination with an as-needed, typically reduced, OFM insecticide spray program.
- MD must be used with a scouting program.

Unregistered insecticides

❖ **indoxacarb (Avaunt)** [Indeno-Oxadiazines]

- Effectiveness unknown, short residual.
- Small plot trials suggest moderate effectiveness.

❖ **methoxyfenozide (Intrepid)** [IGR-ecdysone receptor antagonist]

- Likely replacement product for sister-compound, tebufenozide (Confirm), thought to have better OFM activity.

❖ **thiacloprid (Calypso)** [Chloronicotinyl]
  - Effectiveness unknown.
  - Plum curculio activity in apples suggests a potential role in peaches. Small plot trials suggest moderate OFM effectiveness.

❖ **thiamethoxam (Actara)** [Chloronicotinyl]
  - Effectiveness unknown.
  - Plum curculio activity in apples suggests potential role in peaches. OFM efficacy is unknown.

❖ **pyriproxyfen (Esteem) [IGR-pyridene selective juvenile hormone mimic]**
  - Only moderately effective on OFM, timing is critical (must be on foliage prior to OFM egg lay).
  - Projects limited use for OFM because of its modest efficacy and anticipated long PHI (reference 45-day apple PHI).
  - Cost prohibitive.

Pest management aids

❖ Pheromone trapping to determine timing of control actions.

❖ Insect phenology models (degree-day, egg hatch, etc.) to time applications. Owing to OFM's lower pest status, its DD-model has not been evaluated in the Southeast.

Strategies for future control ("To Do" list for OFM)

Regulatory needs

❖ Expedite registration of new insecticides and other control tactics as they become available.

❖ Develop and implement a program that will allow researchers to test new chemistries on up to 250 acres prior to full registration (different than the EUP program which doesn't work).

❖ Develop protocol whereby needed pesticides remain available if residue analysis indicates insignificant risk.

Research needs

- OFM's ecology is inadequately understood. In the upper mid-West and mid-Atlantic areas there is a major knowledge gap regarding OFM movement from adjacent orchard and non-orchard habitats. In the Southeast understanding of OFM is rudimentary.
- Develop treatment thresholds.
- Determine effectiveness of new insecticides.
- Evaluate new mating disruption delivery systems and assess the usefulness and economics of MD alone and in conjunction with the full array of insecticidal options.
- Make on-farm research monies available.
- Evaluate resistance, especially cross-resistance of OPs and new chemistries.
- Conduct residue and post-harvest interval studies.

Education needs

- Inform growers on new methods, timing and techniques as they become available.
- Train consultants and scouts for on-farm implementation of new technologies as they evolve.
- Increase consumer knowledge about IPM programs.

2) Plum curculio (PC)

- Plum curculio adults feed on and lay their eggs in fruit. Larval injury, wormy fruit, is most often encountered in the second or field generation.
- Plum curculio overwinter successfully in orchards, but many PC also migrate to orchards from nearby woods where they thrive on native hosts. In the Southeast the spring migration/oviposition period begins with petal-fall and extends up to 8 weeks.
- In the Southeast and some mid-Atlantic orchards the second or field generation must be anticipated and rigorously controlled or wormy fruit will result.
- Plum curculio control must be flawless, a zero tolerance exists for wormy fruit.
- OP insecticides are far more effective than other materials; at present OPs are the only materials that do not induce scale or mite outbreaks. OPs are exceptional orchard IPM tools and should be retained, even if availability is reduced.
- Alternative insecticides must be evaluated to determine efficacy and weave lower-risk materials into management programs to mitigate chronic worker exposure during thinning and harvest operations, and to avoid residue concerns when pre-harvest applications are needed.
- Modeling efforts are targeting initiation of the second or field generation. No reliable, seasonally adjusted method exists for anticipating the onset of this key control window.

- ❖ A reliable monitoring technique is needed to detect PC after petal fall. This is especially critical for PC's second or field generation, as an effective model will indicate when to expect second generation PC. Models alone will not shed light on the presence or absence of PC.

Organophosphate (OP) insecticides Currently used for PC Control

- ❖ **phosmet (Imidan)**
  - Phosmet provides excellent PC control.
  - Phosmet is the dominant peach insecticide in the Southeast. Phosmet is the primary insecticide in the East during thinning and pre-harvest, because its REI and PHI are shorter than those of azinphos-methyl.
  - Phosmet is easier on beneficials than other OPs.
  - Some processors prohibit use of phosmet and other OPs.

- ❖ **azinphos-methyl (Guthion, Sniper)**
  - Azinphos-methyl provides excellent PC control, it has better residual efficacy than phosmet.
  - Some processors prohibit use of azinphos-methyl and other Ops.
  - Azinphos-methyl's 14-day re-entry interval (REI) limits its utility.

- ❖ **diazinon**
  - **Diazinon use is almost exclusively post-harvest, because it has shown fruit finish problems (phytotoxicity) when used in conjunction with sulfur-containing compounds.** Elemental sulfur and captan (sulfur-containing) are the standard scab fungicides, effectively eliminating diazinon from in-season use.
  - Trials in apples have shown diazinon to be a mediocre PC insecticide.

Carbamate insecticides

- ❖ **carbaryl (Sevin)**
  - A marginally effective PC insecticide.
  - Carbaryl is used in peach primarily for June beetles, rose chafers. Its short pre-harvest interval (1-day PHI) make it useful for as-needed salvage treatments just before harvest.
  - Toxic to beneficial insects and mites and disruptive to established IPM programs.
  - Some processors prohibit use of carbaryl and other carbamates.

❖ **methomyl (Lannate)**

- Methomyl is seldom used for PC.
- Methomyl is a short residual material that is highly toxic to applicators and its PC efficacy is mediocre. Methomyl is also detrimental to beneficial complexes, its use has induced mite problems.
- Some processors prohibit use of methomyl and other carbamates.
- Applicator safety is a concern, very little methomyl is used in the Southeast.

❖ **formetanate HCl (Carzol)**

- Formetanate HCL's PC efficacy is poor.
- Formetanate HCL can only be used once at petal fall.

Pyrethroid insecticides

❖ **esfenvalerate (Asana)**

- Esfenvalerate is a short residual material, with mediocre PC activity.
- Post-bloom use of pyrethroids disrupt IPM programs by destroying beneficial mites and insects, which seriously exacerbates scale and mite problems.
- Pests readily develop resistance to pyrethroids in systems where they are used repeatedly.
- Esfenvalerate's long pre-harvest interval (14-day PHI) diminishes its potential as a pre-harvest material. As-needed pre-harvest sprays are the only recommended pyrethroid uses in the Southeast; accordingly Asana is no longer recommended to southeastern growers.
- The resistance problems that prevail with regular pyrethroid use should also be kept in mind.

❖ **permethrin (Ambush, Pounce)**

- Permethrin is a mediocre PC material.
- As with esfenvalerate, permethrin use is associated with scale and mite problems.
- Pests rapidly develop resistance to pyrethroids.
- Permethrin (7-day PHI) has a shorter pre-harvest interval than esfenvalerate (14-day PHI), which is useful when salvage treatments are needed near harvest.

Other insecticides

❖ **endosulfan (Thiodan)** [chlorinated hydrocarbon]

- Endosulfan may have PC activity.

- Endosulfan is insecticidally active at relatively cool temperatures, which is useful, especially at petal fall.
- Processor restricts use of this product.
- Endosulfan's regulatory future is questionable.

Unregistered insecticides

❖ **indoxacarb (Avaunt)** [Indeno-Oadiaaines]

- Initial testing in apples shows some PC efficacy, but not as effective as azinphos-methyl or phosmet.
- May help with re-entry (REI) considerations during thinning and picking.

❖ **thiacloprid (Calypso)** [chloronicotinyl]

- Initial testing shows good PC efficacy, but not as effective as azinphos-methyl or phosmet.
- May help with re-entry (REI) considerations during thinning and picking.
- Chloronicotinyls are typically persistent and systemic.
- Thiacloprid may offer improved aphid control.
- Persistent, systemic compounds are often prone to resistance development.

❖ **thiamethoxam (Actara)** [chloronicotinyl]

- Initial testing shows good efficacy, but not as effective as azinphos-methyl or phosmet.
- May help with re-entry (REI) considerations during thinning and picking.
- Chloronicotinyls are typically persistent and systemic.
- Thiametoxam may offer improved aphid control.
- Persistent, systemic compounds are often prone to resistance development.

❖ **diflubenzuron (Dimilin)** [IGR-benzoyl phenyl urea]

- Diflubenzeron has some activity against weevils and may suppress egg production. Should be investigated as an early-season or post-harvest PC material.

Alternative management options

❖ Where applicable, row cropping and annual tillage of adjacent cropland suppresses PC by compromising overwintering habitat.

Pest management aids

- Pheromone trapping to determine timing of control actions.
- Insect phenology models (degree-day, egg hatch, etc.) to time applications. Owing to OFM's lower pest status its DD-model has not been evaluated in the Southeast.

Strategies for future control ('To Do' list)

Regulatory needs

- Expedite registration of new insecticides and other control tactics as they become available.

Research needs

- Develop and validate PC degree-day models as tools for predicting the onset and duration of overwintered and field generations.
- Develop PC population monitoring tools, particularly traps using pheromones and/or plant volatiles to determine PC presence in orchards season-long. Current options lose effectiveness shortly after fruit set.
- Identify PC pheromone and/or host plant volatiles for enhancing trap performance.
- Determine effectiveness of new PC insecticides.
- Develop a site-specific PC risk assessment protocol to characterize individual orchards and the surrounding habitat as PC harborage. Host succession on native hosts and PC's inclination to migrate to orchards must also be examined.

Education needs

- New tools and tactics are sorely needed before education can occur.

3) Aphids (Green peach & other potential plum pox virus vectors)

Green peach aphid (GPA)

- GPA is a common pest in the mid-Atlantic and upper mid-West. It is not presently a problem in the Southeast. GPA sucks plant juices from leaves and blossoms; heavy infestations can slow tree growth and reduce fruit set.
- GPA is a known vector of the plum pox virus.
- Trees should be monitored weekly from bloom until 4-6 weeks after shuck fall.
- Larger trees can tolerate higher levels of infestation.

- Resurgence of GPA following sprays of broad-spectrum foliar insecticides is attributed to the destruction of natural predators and to insect resistance.

Organophosphate insecticides

- OPs do not provide control of GPA.

Carbamates in use for GPA Control

- **methomyl (Lannate)**
  - Methomyl resistant GPA populations exist in many orchards.

Chlorinated Hydrocarbons

- **endosulfan (Thiodan, Phaser)**
  - Endosulfan resistant GPA populations exist in many orchards.
  - Some processors prohibit use.

Other insecticides

- **Imidacloprid (Provado)** Section 18 in NJ, NY, PA, WV
  - Very effective, Section 3 registration needed.

Non-chemical options

- Parasitoids and predators often help suppress GPA populations. However, aphids are the prime in-orchard vectors of plum pox virus (PPV). Biocontrol is unlikely to be effective enough to be of use in areas seeking to mitigate potential spread of PPV.

Unregistered chemicals or other control materials

- **Triazamate**
  - Selective for aphids.

- **Pirimicarb**
  - Selective for aphids.

- **thiomethoxam (Actara)**
  - Small plot trials suggest good efficacy.

- **thiacloprid (Calypso)**
  - Aphid efficacy unknown.

Pest management aids

- Orchard scouting programs.
- Need treatment thresholds to prevent tree and fruit damage.

Strategies for future control ('To Do' list)

Regulatory needs

- Register new insecticides. Alternate modes of toxic action are needed to provide growers with a workable resistance management strategy.

Research needs

- Fund and conduct research on the effects of new insecticides on predators and parasitoids of GPA, and the potential for biological control of this pest.
- Develop monitoring programs and treatment thresholds.

- **Migratory Aphid Species (potential plum pox virus vectors)** are common visitors in peach. Most species are not damaging to peach, hence they have received little study and are poorly understood. In Europe a number of aphids, primarily the transient or migratory species have been shown to be the primary in-orchard vectors of plum pox virus (PPV). With the arrival of PPV in North America, there are obvious research needs, including characterization of the aphid fauna in eastern peaches, and to determine, in-quarantine, if insecticidal control of aphids is a plausible precautionary step to impede spread of the virus.

Education needs

- Explain monitoring techniques and use of treatment thresholds to the industry.
- Provide training in the identification and management of key aphid species and beneficial insects.

4) Plant Bugs & Stink Bugs

Comprises a complex: tarnished plant bug, leaf footed bug, brown, dusky, green, & southern green stinkbugs.

- Early feeding results in cat-facing deformation of fruit. Feeding closer to harvest results in corky and/or water soaked lesions.
- Damage occurs first and is most severe on the edges of orchards and in weedy orchards.
- Preventing injury depends largely on well-timed insecticide applications.
- Orchard-floor-management programs that minimize the abundance of broadleaf plants in the orchard floor reduce the abundance of plant bugs and stink bugs. This seldom lessens the need for insecticide applications, but it does improve the performance of sprays by lowering pest density.
- Very difficult to monitor activity of these pests in the canopy.

Organophosphate insecticides currently used for plant bugs or stink bugs

- **azinphosmethyl (Guthion)**
    - Good control and broad spectrum.
- **phosmet (Imidan)**
    - Acceptable control and broad spectrum.

Pyrethroids insecticides

- **esfenvalerate (Asana)**
    - Short residual, many applications required.
    - Post-bloom use of pyrethroids frequently upsets IPM programs by destroying beneficial mites and insects, and seriously exacerbates scale and mite problems
    - Pests readily develop resistance to pyrethroids; if they are used repeatedly, resistance should be expected.
    - Economical, but use limited due to concerns about disrupting IPM programs.

- **permethrin (Ambush or Pounce)**
    - Permethrin is slightly less efficacious than esfenvalerate.
    - Permethrin has a shorter pre-harvest interval than esfenvalerate, which makes it more useful in as-needed pre-harvest sprays.
    - Permethrin shares all of the IPM concerns noted for Asana.

Chlorinated hydrocarbon

- **endosulfan (Thiodan)**
    - Moderate control.
    - Some processors prohibit use.

Carbamates

❖ **methomyl (Lannate)**
  - Poor-fair control.
  - Some processors prohibit use.

Non-chemical options

❖ Suppression of broadleaf weeds on the orchard floor will help minimize abundance and damage of plant bugs and stink bugs. When done pre-bloom, broadleaf suppression also minimizes exposure of bees to insecticides.

Unregistered chemicals or other control materials

❖ **indoxacarb (Avaunt)**
  - Effectiveness is unknown, needs more research.

❖ **thiomethomax (Actara)**
  - Effectiveness is unknown, needs more research.
  - Moderate toxicity to plant bugs and stink bugs.
  - Significant feeding deterrent to plant bugs and stink bugs.

❖ **thiocloprid (Calypso)**
  - Needs more research.
  - Moderate toxicity.
  - Significant feeding deterrence.

❖ **azadirachtin (Neemix, Ecozin)**
  - Significant feeding deterrence.
  - Short residual.

Pest management aids

❖ No reliable monitoring options are available for plant bugs or stink bugs.

Strategies for future control ('TO DO' list) for plant bugs and stink bugs

Regulatory needs

- ❖ Expedite registration of new insecticides and other control tactics as they become available.
- ❖ Need registrations of effective broadleaf herbicides to reduce alternate hosts of these pests.

Research needs

- ❖ Develop and implement a reliable monitoring system.
- ❖ Work with pheromones for monitoring and possible control.
- ❖ Develop treatment thresholds.
- ❖ Screening and development of new compounds.

Education needs

- ❖ Increase grower awareness of the significance of orchard floor management as an IPM tactic.

5) Scale Insects

- ❖ **San Jose, Forbes Scale, Terrapin, and White Peach Scale are problems in some regions.**
- ❖ Scale feeding on woody tissue results in a decline in tree vigor, growth and productivity. If left unchecked, scale will kill fruiting wood, scaffold limbs and eventually trees.
- ❖ Scale problems have increased rapidly following the loss of encapsulated methyl parathion (Penncap-M). Phosmet, one of the replacement materials, has only fair efficacy against scale. Sprays made with the inexpensive pyrethroids induce scale outbreaks.
- ❖ Scale infestations of the fruit causes a distinctive reddish-purple spotting that results in unmarketable fruit.
- ❖ Once established, scale insects are difficult to control and require additional targeted sprays.
- ❖ Thorough coverage is the key to control.
- ❖ Insecticides added to dormant oil enhance control.
- ❖ If infestations are heavy, an additional insecticide may be applied at petal fall to control males before they mate.

Organophosphate insecticides

- ❖ **chlorpyrifos (Lorsban)**
  - Widely used during the dormant season; oil enhances efficacy.

- ❖ **methidathion (Supracide)**
  - Effective during the dormant season; oil enhances efficacy.

- ❖ **azinphos-methyl (Guthion)**
  - Cover sprays provide good control of crawlers if properly timed.
  - Some processors prohibit use of this product.

- ❖ **phosmet (Imidan)**
  - Cover sprays moderately effective controlling crawlers.
  - Some processors prohibit use of this product.

- ❖ **diazinon**
  - Effective for control of crawlers.
  - Used post-harvest only, as growers fear fruit finish problems with diazinon.
  - Some processors prohibit use of this product.

Other insecticides currently registered

- ❖ **Oil**
  - Effective when used correctly.
  - Most efficacious when used in combination with an OP pre-bloom.

Non-chemical options

- ❖ Several parasitoids attack scale and can provide some population suppression.
- ❖ Pruning of infested branches can help reduce populations.
- ❖ Remove alternate host plants adjacent to orchards.

Unregistered chemicals or other control materials

- ❖ **pyriproxifen (Esteem)**
  - An insect growth regulator.
  - Very effective against scale in CA, but needs testing in eastern peaches.

- ❖ **imidacloprid (Provado)**
  - Efficacy research is needed. In ornamentals imidacloprid is effective against soft scale, most peach scale are armored scale and hence unlikely to be controlled by imidacloprid.
  - Small plot trials suggest moderate efficacy.

- **thiomethoxam (Actara)**
  - Initial testing shows good efficacy; further research needed.

- **thiacloprid (Calypso)**
  - Initial testing shows good efficacy; further research needed.

Pest management aids

- Pheromone traps to determine start of male flight have limited use; males are weak fliers.
- Black sticky tape can be used for monitoring crawlers.
- Degree-day models are used in other tree fruit cropping systems.

Strategies for future control of scale(s) ('To Do' list)

Regulatory needs

- Expedite registration of pyriproxifen and one or more of the newer neonicotinoids.

Research needs

- Screening and development of new compounds.
- Better tools needed to target the timing of sprays.
- Validation of degree-day models.
- Examine strategies that would optimize biological control.
- Determine impact of "new" insecticides on biological control.

Education needs

- Train growers and scouts to identify and monitor the crawler stage for timing sprays.
- Reinforce benefits of oil and high volume sprays to control scale.
- Post-harvest monitoring can identify localized infestations, which can be spot-treated.

6) Thrips (primarily western flower thrips)

- The adult and larval stages of this insect feed on protected sites on the fruit surface such as stem end, suture and under leaves.
- Early-season injury results in coarse, brown russetting. Injury pre-harvest results in silver stippling, that is less damaging to grade or pack-out.

Organophosphate insecticides

- ❖ None.

Carbamates

- ❖ **methomyl (Lannate)**
  - Methomyl does not have a federal labeled on peach or nectarine, methomyl has a nectarine label in CA and AZ, methomyl has peach labels in NJ, WV and PA.

- ❖ **formetanate HCL (Carzol)**
  - Carzol is not labeled on plums.
  - Standard thrips material on peaches and nectarines, also controls plant bugs and stink bugs.
  - Not labeled for use after petal fall.

Other insecticides currently registered

- ❖ **spinosad (Spintor)**
  - Small-plot trials indicate that spinosad provides good control of thrips.
  - A newly registered, 'reduced risk' material.

Non-chemical options

- ❖ None.

Unregistered chemicals or other control materials

- ❖ None.

Pest management aids

- ❖ Flailing blooms over a cigar box provides some indication of relative thrips abundance.

Strategies for future thrips control ('To Do' list)

Regulatory needs

- ❖ Thrips materials should be labeled on peaches, nectarines and plums.

Research needs

- ❖ A better understanding of thrips host succession and host preferences might afford cultural options to ameliorate thrips pressure.

Education needs

- ❖ Improve grower understanding of thrips biology and the greater risk associated with dry winters and springs.

7) Scarab beetle pests. Rose chafer (RC) and green June beetle (GJB) are fruit feeders; Japanese beetle is primarily a foliage feeder.

Rose Chafer

- ❖ Larvae feed on the roots of grasses and prefer sandy soils.
- ❖ This pest is especially abundant where peaches are grown adjacent to grassy fields. They are often especially abundant in pastures fertilized with manures.
- ❖ Beetles emerge in the spring and migrate to peach orchards to feed and mate.
- ❖ The beetles are voracious feeders, rendering the peaches they feed on unmarketable.
- ❖ Encapsulated methyl parathion was the only truly effective material for rose chafer control.
- ❖ The most effective materials currently used provide about 60% control and have very short residual activities (<1 week).
- ❖ More than one application of insecticide is generally made because beetles occur in large numbers and continue to move in from surrounding areas for 4-5 weeks.

Organophosphate insecticides

- ❖ Azinphos-methyl and phosmet are at best marginally effective for control of rose chafer.

Carbamates

- ❖ **carbaryl (Sevin)**
  - Carbaryl provides about 60% control and has very short residual.
  - Carbaryl is highly toxic to beneficial insects.

Pyrethroids

- ❖ **esfenvalerate (Asana)**

- Least expensive, but use of pyrethroids destroys beneficial mites and insect complexes and often leads to mite or scale outbreaks.
- Provides about 60% control and has very short residual.

Non-chemical options

❖ Mass trapping provides some suppression.

Unregistered chemicals or other control materials

❖ **Kaolin**

- May have efficacy, although persistent white residue adhering to fruit at harvest could easily prevent its use in fresh peach production; more research is needed.

❖ **azadirachtin (Neemix, Ecozin)**

- Repellency effect.
- Short lived.

❖ **thiomethoxam (Actara)**

- Moderate lethal effect.
- Good feeding deterrence.

Pest management aids

❖ Traps for population monitoring.

Strategies for future control ('To Do' list)

Regulatory needs

❖ Expedite registration of new insecticides and other control tactics as they become available.

Research needs

❖ Screening/developing new products.

❖ Potential of various attractants and repellents.

❖ Effectiveness of kaolin and azadirachtin, alone, or in combination with mass trapping.

Education needs

❖ Programs will be needed as new options become available.

8) Japanese Beetle (JAB)

- Adult feeding results in skeletonizing of foliage, in high numbers they reduce the tree's photosynthetic capacity.

Organophosphate insecticides

- **azinphos-methyl (Guthion, Sniper)**
  - Azinphos-methyl has good JB efficacy.
  - Processor restricts use of this product.

- **phosmet (Imidan)**
  - Phosmet is a standard material in many areas, as it is easier on beneficials than azinphos-methyl and has adequate efficacy.
  - Processor restricts use of this product.

Carbamates

- **carbaryl (Sevin)**
  - Effective, but has short residual.
  - Highly toxic to beneficial insects.
  - Processor restricts use of this product.

Pyrethroids

- **esfenvalerate (Asana)**
  - Least expensive, but use of pyrethroids often induce secondary pests because they are detrimental to beneficial mites and insects.
  - Short residual.

Non-chemical options

- None identified.

Unregistered chemicals or other control materials

- **Kaolin**
  - May be efficacious, persistent white residues adhering to fruit at harvest are a problem, more research is needed.

- **azadirachtin (Neemix, Ecozin)**
  - Repellency effect.
  - Short lived.

- **thiomethoxam (Actara)**
  - Moderate lethal effect.
  - Good feeding deterrence.

Pest management aids

- Traps for population monitoring.

Strategies for future control ('To do' list)

Regulatory needs

- Expedite registration of new insecticides and other control tactics as they become available.

Research needs

- A better understanding of host preferences and succession might improve management.
- Screening/developing new products.
- Potential of various attractants and repellents.
- Effectiveness of kaolin.

Education needs

- Programs will be needed as new options become available.

9) Borers

Lesser peachtree borer (LPTB) and Peachtree borer (PTB)

- Borers feed within the trunk of trees, causing loss of vigor and eventual tree death.
- Incidence of *Cytospora* canker is closely related to LPTB and further exacerbates injury to the tree and to shothole borer.
- Preventative insecticide application via high volume hand-gun sprays to trunk and scaffold limbs is the only established control option.

Organophosphate insecticides

- **chlorpyrifos (Lorsban)**
  - Applied once/season with a hydraulic gun to the trunk in early to mid-June.
  - Not applied directly to fruit to control this pest. In the Southeast timing of PTB and LPTB generations facilitates good control with a post-harvest Lorsban application.

Chlorinated Hydrocarbons

- **endosulfan (Thiodan)**
  - Not as effective as chlorpyrifos; must be applied two times per season to get control.
  - Processor restrictions do not allow use.
  - Growers prefer to avoid reliance on endosulfan, a chlorinated hydrocarbon, which is expected to face regulatory scrutiny.

Pyrethroids

- **esfenvalerate (Asana)**
  - Not used for borer – short residual, thus requires multiple applications.
  - Pyrethroids disrupt natural control and induce secondary pest outbreaks.

Non-chemical options

- Mating disruption shows promise for borer control, especially for LPTB.
- More research on efficacy is needed.

Unregistered chemicals or other control materials

- None identified.

Pest management aids

- Pheromone traps for monitoring.

Strategies for future borer controls ('To Do' list)

Regulatory needs

- Provide incentives for research of new products.

Research needs

- Treatment thresholds for borers, accommodating varying tree age, are badly needed to minimize unneeded borer applications.
- Rootstock breeding should include selection for borer resistance.
- Mating disruption research needs to examine the impact of area-wide control. Also needs to examine the impact of newer insecticides vs current OP standards in terms of in-season suppression.
- Borer ecology is poorly understood. Borer site characterization would allow targeting of currently rudimentary monitoring options.
- Screening/developing new products.

Education needs

- Educate and train industry as new control tactics and management strategies become available.
- Increase consumer knowledge about IPM programs.

10) Leafrollers

Obliquebanded leafroller (OBLR)

Tufted apple budmoth (TABM)

- A complex of species, however, OBLR is the key leafroller pest in the mid-Atlantic and upper mid-Western production areas.
- Leafroller feeding often causes shallow injury that scarifies the fruit surface, but feeding to the pit can develop, especially in cultivars prone to split-pit fissures at the stem end of the fruit. Leafroller damaged peaches are culled.
- OBLR and TABM resistance to OP's in many peach production regions where apples are also grown.
- Since leafroller species overwinter as larvae in the litter underneath peach trees, a Section 2(ee) registration has been granted for the use of Asana as a ground spray in the mid-Atlantic and upper mid-Western production areas.
- Potential for biological control.

Organophosphate insecticides

- **azinphos-methyl (Guthion, Sniper)**
  - Leafroller resistance to OPs is present in apple/peach production areas as far south as north GA.
  - Processor restricts use of this product.

- **phosmet (Imidan)**
  - OP resistance minimizes the effectiveness of phosmet in apple/peach production areas.
  - Processor restricts use of this product.

Carbamates

- **methomyl (Lannate)**
  - Short residual, not very effective.
  - Isolated field failures reported, resistance suspected.

Pyrethroids

- **esfenvalerate (Asana)**
  - Short residual, many applications required for season-long control.
  - Isolated field failures reported, resistance suspected.
  - Post-bloom use may upset mite management programs by destroying beneficial mites and insects.
  - Useful and non-disruptive when ground applied pre-bloom.

Other labeled insecticide options

- **spinosad (Spintor)**
  - Good efficacy at high rate.
  - Cost is prohibitive (Expensive).
  - Short residual, frequent applications needed.

- **pyriproxifen (Esteem)**
  - Only moderately effective.
  - Small plot trials suggest suppression of feeding, but not lethality.

Non-chemical options

- **Pheromone-based mating disruption**
  - Not effective as a stand-alone control, supplemental insecticide sprays are needed.

- ***Bacillus thuringiensis* (Dipel, Javelin, etc.)**
  - Temperature sensitive, often too cool in Michigan to allow for good efficacy.
  - Short residual, multiple applications required.

Unregistered chemicals or other control options

- **tebufenozide (Confirm)** [IGR-ecdysone receptor antagonist]
  - Excellent control of TABM, but must be timed with a phenological model to be practical.
  - Does not control OFM, the key caterpillar pest of peach.

- **methoxyfenozide (Intrepid)** [IGR-ecdysone receptor antagonist]
  - Next generation Confirm analogue said to offer excellent control of leafroller species and OFM.

- **indoxacarb (Avaunt)**
  - Effectiveness is questionable.

- **emamectin benzoate (Proclaim)**
  - Research is needed.

Pest management aids

- Pheromone trapping and phenology models for timing of control actions.

Strategies for future control ('To Do' list)

Regulatory needs

- Expedite registration of new insecticides and other control tactics as they become available.
- Develop and implement a program that will allow researchers to test new chemistries on up to 250 acres prior to full registration (different than the EUP program as this doesn't work).

Research needs

- On-farm evaluation of new insecticides.
- Potential for biological control.
- Evaluate new mating disruption delivery systems and multi-species formulations.

Education needs

- Demonstration.
- Educate and train industry as new techniques become available.

Pest management aids

- ❖ Traps for population monitoring.

11) Mites: Two-spotted spider mite (TSSM), European red mite (ERM)

- ❖ Mite feeding damages foliage, which may reduce tree vigor, fruit yield and winter hardiness.
- ❖ Tree vigor and the following year's crop may be reduced.
- ❖ Hot weather is conducive to rapid increases in mite populations.
- ❖ Pyrethroid use for other insects exacerbates mite problems.
- ❖ Dormant oil can be used alone or combined with insecticides for ERM control; oil does not suppress TSSM which overwinter in the ground litter.

Organophosphate insecticides used for peach mite control

- ❖ None

Miticides currently registered

- ❖ **Oils**
  - Dormant oils are effective against ERM eggs only, not TSSM.
  - Summer oils would likely be efficacious, but they are not practical in peach because they can not be used within two weeks of application of sulfur-containing compounds. Elemental sulfur and captan (sulfur-containing) are the key scab control materials in peach.

- ❖ **clofentezine (Apollo)**
  - Safe on beneficials.
  - Primarily an ovicide.

- ❖ **formetanate HCL (Carzol)** [Carbamate]
  - Will also provide control of stink bugs.
  - Can't be used after petalfall.

- ❖ **fenbutatin oxide (Vendex)** [Organotin]
  - Slow acting, moderately effective.
  - Safe on beneficials.

- ❖ **hexiothiozox (Savey)** [Organotin]

- Safe on beneficials.
- Primarily an ovicide.

❖ **pyridaben (Pyramite)** [Pyridiainone]
  - Fast acting.
  - Need higher rates for TSSM.
  - Moderate toxicity to beneficials.

Non-chemical options

❖ Several generalist and specific predators and predaceous mites are important in the management of mites.

❖ Selection and timing of insecticide applications can directly impact mites.

Unregistered chemicals or other control materials

❖ **abamectin (Agrimek)**

❖ **milbamectin**

Pest management aids

❖ Orchard scouting programs.

Strategies for future control ('To Do' list)

Regulatory needs

❖ Register new miticides to provide needed rotation options for resistance management.

Research needs

❖ Develop treatment thresholds.

❖ Screening and development of new compounds.

❖ Better tools to help target the timing of sprays.

❖ Potential for biological control.

Education needs

❖ Train growers and scouts to identify hot-spots so targeted use of sprays can be relied on.

Nematodes

Nematodes are extremely important to peach production, since nematodes cause direct damage and play a major role in peach tree short life. Nematodes are also important vectors of certain peach viruses, such as peach rosette mosaic virus and tomato ringspot virus. On replant sites, nematodes are key risk factors influencing orchard health and productivity. Root knot (*Meloidogyne* spp.), ring (Criconemella xenoplax), lesion (*Pratylenchus vulnus*), and dagger (*Xiphinema* spp.) nematodes are the major nematodes of concern to peach production. Cultural practices for control are mainly limited to crop rotation strategies. Root stock selection is also a very important control measure. However, use of chemical nematicides and fumigants continues to play a crucial role in control strategies for peach nematodes. Pre-planting fumigation or applications of nematicides are commonly used practices. Post-plant nematicide application is often a site-specific response to “hot” nematode sites, hence its use is more selective.

Labeled Nematicides:

- **Methyl-bromide (Brom-O-Gas, Meth-O-Gas, and other names)** is generally sold as a combination of methyl bromide and chloropicrin. Though methyl bromide gives excellent control of nematodes, it will be completely phased out by 2005, in accordance with the Montreal Protocol. Methyl bromide is soil-injected as a pre-plant application; plastic tarp is applied to seal the gas as it is applied.

- **1,3-Dichloropropene (Telone)** is often utilized for pre-plant nematode control. It is deep-shank injected and sealed with a water or soil seal. While possibly not as efficacious as methyl bromide, this material is an integral part of nematode control in peach orchards. When combined with good root stocks, control can be excellent.

- **Metam-sodium (Vapam)** is also applied preplant. It is generally roto-tilled into the soil. It is probably the least efficacious of the three pre-plant materials, but when applied in combination with 1,3-dichloropropene, it can broaden and increase nematode control.

- **Fenamiphos (Nemacur)** is applied post-plant in the fall for suppression of major peach nematodes.

Regulatory Needs:

- Maintain current nematicides, especially in light of the schedule loss of methyl bromide.

- Expedited registration of safer, effective nematicides.

Research Needs:

- Development of safe alternatives to current nematicides.

- ❖ Continued development of nematode-resistant rootstocks.

- ❖ Development of cultural and biological alternatives to chemical nematicides.

Brown Rot

Brown rot is the single most important disease of peaches in the southeastern U.S. The causal organism, *Monilinia fructicola*, can actually cause several stages of disease in peach, to include blossom blight, green fruit rot, and pre- and post-harvest brown rot. Blossom blight occurs sporadically, but it is often observed when sufficient inoculum is available during wet bloom periods. Though blossom blight alone does not generally impact yield, it provides substantial inoculum for late-season brown rot. Therefore, it is important that fungicides are available to provide blossom protection. Late-season brown rot is generally controlled by fungicides which are applied at 14 and 7 days prior to harvest. Post-harvest brown rot is controlled by application of fungicides during the packing process.

Cultural practices for control of brown rot mainly revolve around reduction of inoculum sources, such as mummy destruction. Removal of wild plums adjacent to a peach orchard is an important sanitation procedure which is also aimed at breaking the disease cycle.

1) Brown rot *Monilinia fructicola* (disease manifests as blossom blight, green fruit rot, pre-harvest brown rot and post-harvest brown rot)

- ❖ Brown rot is the key fruit rot in eastern peach production. It must be successfully controlled.
- ❖ Fungicidal control of pre-harvest brown rot focuses on applications typically made 14- and 7-days before harvest.
- ❖ De-methylation inhibitor (DMI) fungicides provide excellent control. They are key materials. Research and extension efforts should focus on steps to minimize the risk of brown rot developing resistance to this key class of compounds.
- ❖ Blossom blight is sporadic in occurrence, often observed when inoculum is available during wet periods. Blossom blight alone is normally insufficient to reduce yield. It is however a concern as it increased inoculum levels early in the season which may increase fruit rot.
- ❖ Fungicides are an important tool for managing blossom blight. It is preferably to use non-DMI fungicide when blossom blight is treated to minimize selective pressure in an organism with a history of resistance problems.
- ❖ Green fruit rot is not common, but when present green fruit rot, can be a more serious source of inoculum for pre-harvest brown rot than blossom blight.
- ❖ Post-harvest brown rot is mitigated by sanitation and rapidly lowering fruit temperature in the packing process. Post-harvest fungicides can be extremely important when brown rot pressure is high.

Labeled Brown rot fungicides:

De-methylation Inhibitors (DMIs)

- **Resistance management is a primary concern with this essential class of brown rot fungicides.**

- **propiconazole (Orbit)**
  One of the standard materials, quite heavily relied on for pre-harvest brown rot control.

- **fenbuconazole (Indar)**
  Indar is often relied on when disease pressure is greatest.

- **tebuconazole (Elite)**
  Elite is often used in the last pre-harvest application as it may provide longer lasting brown rot control on the harvested fruit.

- **myclobutanil (Nova)**

Nova is only modestly effective against brown rot. It is generally not recommended brown rot control.

Methyl benzimidazole carbamates (MBCs)

- **MBCs are resistance prone and should be used judiciously, likely no more than once per season.**
- **MBCs are important as alternative, non-DMI chemistries, to provided brown rot control with an alternative toxic mode of action.**
-
- **benomyl (Benlate)**
- Benlate is recommended mainly for blossom blight.

- **thiophanate-methyl (Topsin-M)**
- Topsin-M is recommended mainly for blossom blight.

Dicarboxamides

Rovral, the remaining dicarboxamide fungicide with stone fruit labels, is important because it provides an alternative, non-DMI toxic mode of action, which is quite important as a resistance management tool.

- **iprodione (Rovral)**
- Rovral is labeled for use before petal fall in both peach and plums.

- ❖ Brown rot resistance to Rovral and other dicarboxamindes exists, so these materials must be used with caution.
- ❖ Rovral has some activity against *Botrytis* and gummosis.

Anilinopyrimidines

- ❖ **anilopyrimidine (Vangard)**
- ❖ Vangard is labeled for control of blossom blight phase only.
- ❖ Vangard has some activity against *Botrytis*.

- ❖ **fenheximid (Elevate)**
- ❖ Newly registered; efficacy data are being developed for stone fruit.
- ❖ May provide a resistance management tool.

Strobilurins

Strobilurin labels in stone fruit and pome fruit typically preclude multiple, redundant applications in an effort to mitigate resistance risk.

- ❖ **azoxystrobin (Abound)**
- ❖ Abound is recommended mainly for green fruit rot in conjunction with scab control in-season and as a pre-harvest brown rot fungicide.
- ❖ Abound is less effective as a brown rot fungicide than the DMIs.
- ❖ Abound offers another resistance management tool.

Multi-Site Fungicides

- ❖ **chlorothalonil (Bravo, Equus)**
- ❖ EPA has some concern that chlorothalonil is a potential carcinogen. It risks in this area are less than those of captan.
- ❖ Chlorothalonil is very efficacious against scab and blossom blight, hence it serves as a key resistance management option for the DMIs.
- ❖ Stone fruit label allows application until shuck split; Section 24C labels in TX, AR, SC and NC allow use of Bravo Weather-Stik one additional time 10 to 14 days after shuck split
- ❖ Multi-site fungicide → low resistance risk.

- ❖ **captan**
- ❖ Captan is under EPA scrutiny as a potential carcinogen.
- ❖ Multi-site fungicide with good scab efficacy. Captan offers less brown rot efficacy than the DMIs.
- ❖ Captan’s primary use for *Monolinia* is control of blossom blight and green fruit rot.
- ❖ Multi-site fungicide → low resistance risk.

fludioxinil (Scholar)

- Scholar's post-harvest use in stone fruit is presently allowed under the auspices of state-to-state Section 18 registrations.
- Scholar is a highly efficacious material.
- Scholar is seen a safe, low risk material.

Unregistered potential stone fruit fungicides:

Strobulurins

- **tifloxystrobin (Flint)**
- Flint is felt to have high potential for cross-resistance with Abound and other soon to be labeled strobulurins.

- **BAS 500 F (Cabrio)**
- Cabrio will likewise pose a high potential for cross-resistance with other strobulurins.

Fungicides classes and active ingredients?

- BAS 516

- Unknown efficacy; under IR4 review.
- Combination of fungicides.

Strategies for future control:

Regulatory Needs

- New, reduced-risk, efficacious brown rot materials are needed to provide differing toxic mode of action for control of this key pest. Efficacious alternative materials are especially important for use against post-harvest brown rot.

Research Needs

- More detailed understanding of disease epidemiology is needed, including an improved grasp of the role of latent infections.
- Further development, testing and validation of the Clemson blossom blight model are needed.
- Pre- and post-harvest brown rot efficacy data for new chemistries

2) Scab (*Cladosporium carpophilum*)

Scab is a major disease in the humid peach production regions east of the Rocky Mountains. Scab requires an almost season-long fungicidal program (from petal fall or shuck split until 4 weeks before harvest). Early applications (until 6 weeks past petal fall) are most important for scab control. Lower disease pressure later in the season frequently allows use of extended spray intervals or alternate-row middle spraying, thereby reducing pesticide input.

There are no alternatives to chemical control. Scab cannot be controlled with cultural practices such as pruning or sanitation, and there is no peach germplasm available with reduced susceptibility to scab.

A. Currently labeled scab fungicides:

- **sulfur**
- Sulfur is a reduced-risk fungicide.
- Sulfur requires more frequent spraying (7- to 10-day intervals are more common with sulfur than 14-day intervals) for satisfactory control.
- Sulfur is very widely used in middle Georgia, where scab potential tends to be lower.
- Sulfur provides insufficient scab control in most other Eastern production areas. Most eastern peach growers rely on a stronger fungicide, at least during the key, early-season infection period.
- Multi-site fungicide → low resistance risk

- **captan**
- Captan is under EPA scrutiny as a potential carcinogen.
- Captan is the long-term standard against which other scab materials are evaluated.
- Captan is very widely used in most eastern peach production areas, especially during the critical early-season period when scab is often most severe.
- Multi-site fungicide → low resistance risk.

- **chlorothalonil (Bravo, Equus)**
- EPA has some concerns that chlorothalonil is a potential carcinogen. Its risk is lower than that of captan.
- Chlorothalonil is the most efficacious scab fungicide.
- Label constraints limit chlorothalonil use to early in the season when scab potential is greatest. It may be applied until shuck split; Section 24C labels in TX, AR, SC, and NC allow use of Bravo Weather Stik one additional time 10 to 14 days after shuck split
- Multi-site fungicide → low resistance risk

Limited Site Fungicides

Strobilurins

- **azoxystrobin (Abound)**
- Abound is a reduced-risk fungicide.
- Abound is more efficacious than sulfur.
- Resistance management is an imperative for the strobilurins. No more than two consecutive applications of strobilurins before rotating with another fungicide class; no more than four applications per season.

Methyl benzimidazole carbamates (MBCs)

- **benomyl (Benlate)**

- Benlate has excellent scab efficacy, against populations that have not developed Benlate resistance.
- MBCs are quite resistance prone; generally unwise to make more than one application per season, around shuck split if applied for scab as opposed to blossom blight.
- Also a valuable option for control of brown rot blossom blight during bloom.

B. Unregistered Fungicides:

- **tifloxystrobin (Flint)**
- Reduced-risk fungicide (strobilurin class).
- Strobilurins have a high potential for cross-resistance.

- **BAS 500 F (Cabrio)**
- Reduced-risk fungicide (strobilurin class)
- Strobilurins have a high potential for cross-resistance.

C. Strategies for Future Control:

Regulatory needs

- Captan or chlorothalonil are quite important for resistance management. There continued availability, even if usage options were narrowed is a priority.
- Effective reduced-risk fungicides other than strobilurin class (resistance concerns) are a key need.

Research needs

- Develop weather-based model to quantify and predict changes in scab potential throughout the season.
- Evaluate alternative chemistries for scab control.

Bacterial Spot

Bacterial spot (*Xanthomonas arboricola* pv. *pruni*, syn. *X. campestris* pv. *pruni*) is a major bacterial disease of susceptible peach cultivars. Though resistant cultivars are available, many of the more profitable cultivars currently in commercial production are moderately to severely susceptible to bacterial spot. This disease effects fruit, leaves, and twigs. Economic loss occurs when fruit are infected. Fruit losses may approach 100% on highly susceptible cultivars if conditions are favorable for disease and controls are not applied. Existing controls are extremely important, but they are not as consistently effective as controls for scab and brown rot. Three to five copper-containing bactericides are used from early bud-swell through late bloom (i.e., early shuck off). Rates of copper are reduced from ca. 2.0 lb metallic copper per acre at the early spray to ca. 0.4 lb metallic copper per acre at the late bloom application. The fungicides Ziram or Ferbam are recommended as a tank-mix with the copper sprays, as it appears to enhance the activity of copper against the bacteria. The antibiotic, oxytetracycline is used after bloom and up to 21 days before harvest on a 7- to 14-day spray interval depending on weather conditions.

A. Currently used bactericides and antibiotics:

- **copper materials** [copper hydroxide (Kocide 101, Kocide DF, Kocide 2000), copper oxychloride sulfate (C-O-C-S), copper linoleate (Tenn Cop 5E), copper ammonium carbonate (Copper-Count-N)]
- Phytotoxicity is a major grower concern when coppers are applied to stone fruit, especially if utilized after shuck split.

- **oxytetracycline (Mycoshield)**
- Utilized on a weekly basis following shuck split.
- Mycoshield is extremely important for in-season control of bacterial spot. Coppers are impractical save for early-season use due to the phytotoxicity. Perhaps 25% of the acreage in many sandy land production areas is moderately to highly susceptible cultivars that could not be grown commercially without Mycoshield.

B. Unregistered materials:

- **zinc sulfate**

- ***Bacillus subtilus*** (Serenade) and other biological control materials.
- **S**erenade's efficacy is unproven. It is unlikely to provide control comparable to Mycoshield.
- Serenade may act through niche exclusion or antibiosis.

C. Strategies for future control:

Regulatory Needs

- Need to maintain registration of oxytetracycline.
- Need additional antibiotics or other bactericides with increased efficacy.
- Existing controls are imperative to maintenance of substantial bearing acreage, but they are only moderately effective, which limits IPM and resistance management options.

Research Needs

- Breeding efforts should target development of highly resistant, commercially competitive cultivars to replace existing acreage of bacterial spot susceptible cultivars such as 'O'Henry.' Replacement cultivars must be regionally adapted and have commercial acceptability.
- A more detailed understanding of the bacterial spot is needed to refine management options such as models to predict the optimal timing of bactericide applications.
- Testing and validation of disease models is needed on a broad basis.

Soil and Root Diseases

Numerous soil fungi attack stone fruit. *Armillaria* spp. and *Phytophthora* spp. Are the most important soil pathogens of peach in the eastern U.S. *Armillaria* spp. is a key cause of premature tree mortality in southeastern production areas. Above-ground fungicide applications are not effective for these pathogens. All commercial peach varieties are susceptible to these pathogens, so most growers suffer tree losses every year. Research is needed to develop commercially acceptable, reduced-risk or cultural controls. Development of *Armillaria*-resistant rootstocks would be of great value.

Minor and Potentially Emerging Diseases.

As fungicide use patterns change to favor reduced-risk materials that, thus far, have a narrower spectrum of activity than the multi-site fungicides they are superseding (captan, chlorothalonil, Ferbam, Ziram), there is concern that diseases rendered minor in existing disease control programs may become more important. Diseases currently of relatively minor import include constriction canker, peach leaf curl, powdery mildew, peach leaf rust, Rhizopus rot, gray mold, sour rot and anthracnose. Many of these diseases are controlled sufficiently by broad-spectrum fungicides such as Ziram, Ferbam, or Captan. However, these diseases may become much more important when low-risk, pathogen-specific fungicides are more generally utilized. Because of the minor importance of these diseases, limited research has been conducted for these. Additional information is needed to address the epidemiology, etiology, and fungicidal sensitivity of the pathogens which cause these diseases.

Constriction canker is not well controlled by current fungicides or cultural controls. Additional examination of disease biology and evaluation of new control options is a clear research need.

Weed Pests

Critical Weed Management Needs

- Studies to identify pre-emergence herbicides from new chemistry with favorable environmental profiles that provide long-term, broad spectrum control and could be an alternative to simazine.
- Woody perennial weed control has been difficult to achieve in peach orchards because of peach's sensitivity to glyphosate in late summer. Studies are needed to identify herbicides for woody perennial weed control.

General Conclusions

- Weed competition directly impacts productivity by delaying orchard development, decreasing fruit size and total fruit yield.
- Weed control is a critical part of integrated approaches for managing cat-facing insects, nematodes and voles.

Seasonal Orchard Floor Management Strategies in Peach

Dormant

- **Broadleaf Weeds** are divided into winter annual weeds and perennial weed species. Common orchard winter annual weeds include common chickweed, pepperweed, cutleaf evening primrose, Carolina geranium, wild radish, field pansy and vetch. Common perennial winter weeds in orchards include common white clover and dandelion. Broadleaf weeds serve as hosts for cat-facing insects and nematodes that vector the tomato ringspot virus.

Herbicides Currently Recommended

- **2,4-D amine** (Various trade names) [Phenoxy]

- **paraquat (Gramoxone Max, Boa)** [Bipyridilium] used in areas where warm-season perennial are planted in row middles.

Notes

- 2,4-D amine or paraquat are applied to row middles. May be applied in herbicide strip if fall preemergence was not used.
- 2,4-D will not adequately control species like white clover.

Non-chemical options:

- **None**
- **Tillage is not a viable management option in peaches.** Tillage destroys perennial ground cover necessary for minimizing erosion and prevents equipment movement through orchard during wet weather. Tillage promotes peach tree short life, a serious complex of mortality factors that can become a major cause of premature orchard decline.

Unregistered Chemicals

- **clopyralid (Stinger)** [Pyridine]
- **halosulfuron (Sempra)** [Sulfonylurea]

Strategies for Future Control

Regulatory

Research

- Screen newer herbicides to identify less problematic materials that are viable OFM options for peaches.

Education

- Reinforce benefits of removing winter annual weeds as part of an integrated approach to managing cat-facing insects.

Late Spring and Summer Peach OFM

- **Grass and Broadleaf Weeds**. Common summer weeds include pigweed (various species), common lambsquarters, morningglory (various species), large crabgrass, goosegrass, fall panicum, foxtails, bermudagrass, Johnsongrass, horsenettle, horseweed, brambles, Virginia creeper, poison-ivy and yellow nutsedge. Summer weeds compete with trees for water and nutrients. In newly planted orchards, weed competition reduces growth and delays tree development, which drastically reduces early yields. In established orchards, competition from summer weeds reduces fruit size and yield.

Notes

- Weeds are primarily a concern in the herbicide strip, within the tree row.
- Late spring pre-emergence herbicides will provide residual control. However, post-emergence herbicides may be needed to control escaped weeds.
- All herbicides applied as directed spray.
- Perennial grass weeds (bermudagrass) must be controlled with Fusilade or Poast.

Currently Recommended Pre-emergence Herbicides

- **simazine** (Princep and various generic formulations) [Triazine] most commonly used peach herbicide
- **diuron** (Karmex) [Urea]– commonly used, often in tank mix with Sinbar
- **terbacil** (Sinbar) [Uracil]- commonly used, often in tank mix with Karmex
- **norflurazon** (Solicam) (Pyridazinone)
- **oryzalin** (Surflan) [Dinitroaniline]
- **pendimethalin** (Prowl) [Dinitroaniline]– non-bearing use only

- **Currently Recommended Peach Post-emergence Herbicides**:

- **paraquat** (Gramoxone) [Bipyridilium] – commonly used
- **glyphosate** (Roundup) [Phosphono Amino Acids] – commonly used
- **fluazifop** (Fusilade) [Aryloxyphenoxy]
- **sethoxydim** (Poast) [Cyclohexenone]

Nonchemical Options

- **None**
- **Tillage is not a reasonable option in peach OFM**. Tillage is a major risk factor promoting peach tree short life. Tillage also destroys the fine, feeder roots of peach, which are responsible for uptake of water and nutrients. Trees can also be lost as a result of equipment contacting the tree trunk.

Potential Alternative Peach Herbicides

- **thiazopyr** (Visor) [Pyridine]
- **halosulfuron** (Sempra) [Sulfonylurea]
- **fluroxypyr** (Starane) [Pyridine]
- **flumioxazin** (Valor) [PPO inhibitor]
- **oxadiargyl** (Topstar) [Oxadiazole]

Strategies for Future Control

Regulatory

- As new chemistries are identified as alternatives, streamline registration.
- Streamline process for obtaining section 18 use, especially when section 3 use is being pursued.

Research

- Herbicide tolerance studies are needed in peach to examine potential new herbicides.
- Once crop tolerance has been determined, in-orchard weed efficacy screening will be needed.
- Research the potential weed control benefit of in-row cover crops.
- Determine the impact post-harvest weed competition has on flower bud development and carbohydrate storage impacting winter hardiness.
- Determine if reduced pre-emergence herbicide rates applied sequentially can reduce overall rate without compromising efficacy.
- Determine the critical weed-free period for peach resulting in optimum fruit quality, maximum yield, and tree growth.

Education

- Educate growers on the multiple benefits of site specific OFM programs.

Post-harvest (Fall) Orchard Floor Management

- **Winter Annual Weeds:** Winter annual weeds under the trees will begin to emerge in the fall. They provide cover for voles, act as over-wintering host to cat-facing insects, prevent utilization of the radiant heat benefit and provide competition in the spring.

Notes

- Post-harvest herbicide applications are in the herbicide strip only.
- In northern climates a well timely non-selective herbicide application will provide winter annual weed control until spring.
- A fall pre-emergence with a non-selective post-emergence herbicide is preferred over a non-selective herbicide alone. This is especially true in southern climates where winter annual weeds emerge throughout the winter.
- The use of fall pre-emergence herbicide can delay the need for a spring pre-emergence herbicide thus extending residual weed control into the summer.

Currently Recommended Peach Pre-emergence Herbicides

- **diuron** (Karmex) (Urea)
- **norflurazon** (Solicam) (Pyridazinone)
- **oxyfluorfen** (Goal) (Diphenylether)
- **pronamide** (Kerb) (Amide)
- **simazine** (Princep and various generic formulations) (Triazine)

Postemergence Herbicides

- **glyphosate** (Roundup) (Phosphono Amino Acids) – dormant application only
- **paraquat** (Gramoxone) (Bipyridilium)

Nonchemical Options

- **None**

- Tillage is not a viable OFM option in peaches. Tillage is a major risk factor encouraging peach tree short life. Tillage destroys the fine, feeder roots of peach, which are responsible for uptake of water and nutrients. Trees can also be lost as a result of equipment contacting the tree trunk.

Unregistered Chemicals
- **thiazopyr** (Visor) (Pyridine)
- **halosulfuron** (Sempra) (Sulfonylurea)
- **fluroxypyr** (Starane) (Pyridine)
- **flumioxazin** (Valor) (PPO inhibitor)
- **oxadiargyl** (Topstar) (Oxadiazole)

Strategy for Future Control

Regulatory

Research
- Screen new herbicides to determine peach's tolerance to potential new peach herbicides.
- Once crop tolerance has been determined, weed efficacy screening in orchards needs to be done.
- Determine the potential weed control benefit of producing dry matter (from a cover crop) in the row middles and moving it under trees for utilization as mulch.
- Determine the impact post-harvest weed competition has on flower bud development and carbohydrate storage, which impacts winter hardiness.
- Consider using reduced pre-emergence herbicide rates applied sequentially as a means of reducing overall herbicide rate without compromising efficacy.

Education
- Controlling winter annual weeds with pre-emergence herbicides reduces cat-facing insects, allows for utilization of radiant heat benefit, and delays the need for pre-emergence herbicides in the spring.

FURTHER RESOURCES:

Southern peach pest management & culture guide. Horton, Gorsuch & Ritchie, Senior Editors. 2000. UGA Extension Bulletin 1171. 32 pp.

OPMP & PIAP crop profiles: crop profile for peaches in NC. Ritchie, Sorensen, Mitchem, Parker & Meyer. 1999. NCSU. 9 pp.

SC Peach pesticide use survey. 1995. CU, Pesticide Impact A97-01, Dec 97. Bellinger, Rowe, Gorsuch, & Newall.

Southeastern peach insect pest management—its evolution and implementation. 1998. Horton. UGA, Extension miscellaneous report. 27 pp.

Peach production handbook. Myers, Editor. 1988. UGA Extension Handbook 1. 221 pp.

Crop profile for peaches in New Jersey. Shearer, Hamilton and Polk. Rutgers University.