PEST MANAGEMENT STRATEGIC PLAN
FOR
EASTERN PEACHES

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General Peach Production Information and Economic Impact

- Peaches are a perennial crop. Peach orchards have a typical life expectancy of 12 to 14 years. Orchards should pay for their own establishment costs and be 'free and clear' by the seventh or eighth year. Orchard profitability is inextricably tied to maintaining and prolonging an orchard's productive life. The imperative to plant on sites offering some protection from spring frosts forces growers to favor planting to replant sites, which typically experience shorter orchard longevity.
- Fruit quality must be uniformly high to compete successfully in the marketplace, thereby requiring intensive pest management throughout the production period.
- Worker safety is especially imperative in peaches, which are highly dependent on hand labor.
- Eastern peach growers need at least one low-risk material with the overall efficacy of encapsulated methyl parathion or azinphos methyl. Without such a material, tree pests will force pest managers to utilize a primitive, prophylactic system to gain a minimal level of tree pest suppression. Development of more evolved as-needed management options for fruit pests will have little real impact until an in-season insecticide capable of suppressing tree pests while simultaneously controlling fruit pests becomes available.
- Insecticides with sufficient efficacy to simultaneously manage tree and fruit insects are not a luxury, they are a genuine need. At present we lack the tools to reliably and affordably address fruit and tree pests without inducing secondary pests. Regulatory decisions have unintentionally, but severely, compromised the eastern peach industry's ability to manage tree pests which are compromising vital orchard productivity and longevity.
- The eastern peach industry needs low-risk insecticides that are cost-effective and able to provide excellent control of fruit pests and vastly improved management of tree pests that are stable over a period of years. The eastern peach industry's economic viability may hang on improving management of borer species.
- Azinphos methyl, which will not be available after the 2006 season, is the best available active ingredient for in-season suppression of lesser peachtree borer. Azinphos methyl is also the peach pest management practitioner's only effective clean-up material for fruit pests. Pest management systems are far more functional when reliable salvage materials are available. None of the low-risk materials projected to gain peach labels in the near future fulfill this role.
- Resistance management is an increasingly vital role for the organophosphate phosmet. Chemical control is the only option for plum curculio management. Plum curculio continues to be quite susceptible to phosmet despite almost 50 years of organophosphate use. At present, most of the candidate low-risk materials are nicotinoids, a class that has demonstrated resistance problems with a variety of pest taxa in other cropping systems.
- 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.
- Pesticide tolerances should not allow foreign competitors unfair advantages.
- Management of peach insect pests has declined demonstratively since the loss of encapsulated methyl parathion. Lesser peachtree borer has become an uncontrolled tree-killing pest. The most obvious entomological need is registration of a low-risk broad spectrum insecticide with efficacy comparable to encapsulated methyl parathion.

- Peach production in the eastern United States encompasses ca. 71,250 bearing acres, 62% of the U.S. national total (fresh production), with a value of $179 million.
- Eastern peach production has epicenters in: the Southeast [GA (12,000 acres), SC (14,500 acres)]; the Mid-Atlantic [NJ (7,600 acres), PA (4,500 acres)]; and the upper Mid-West [MI (5,200 acres)].
- GA, SC, NJ, PA and MI rank second through sixth in value of fresh peach production nationally.

Overall Research and Regulatory Priorities

Research

- In-orchard research to assess and quantify acute and chronic worker safety risks needs to be conducted for key pesticides used in temporal proximity to hand-labor intensive activities such as thinning and picking.
- Basic biology of all of the major pests of peach should be further elucidated, along with potential bio-control options.
- Hazard Analysis and Critical Control Point Analysis (HACCP) for microbial contaminants, with companion development of management protocols to mitigate pesticide residue risks, should be a research priority.

Regulatory

- *Pesticide policy deliberation for edible crops should be re-structured so meaningful, commodity-based dialogues among key IPM professionals become central to the process of risk mitigation.* U.S. EPA and USDA-OPMP should be charged with developing and implementing changes that assure IPM professionals are fully utilized to address crop-specific risk mitigation without the current, too often, spastic reductions in overall IPM performance. Policy should not be limited by compound-specific regulatory processes for new compounds or materials under consideration for re-registration.
- In the short-term, insecticide registration and re-registration goals for eastern peaches should focus on mitigating the chronic exposure risks of phosmet and retaining use of chlorpyrifos as a tool for managing borers and scale.
- Lesser peachtree borer infestations are presently at crisis levels in southeastern orchards. Short-term regulatory relief on use of OPs to facilitate suppression of lesser peachtree borer is needed.
- Peach labels should be expedited for efficacious, low-risk insecticide materials that would diminish reliance on OP chemistries while improving control of sporadic, but sometimes damaging, pests such as plant bugs, stink bugs (fenpropathrin), grasshoppers (diflubenzuron) and scarab beetles (acetamiprid or thiacloprid with 3- to 7-day PHIs).
- Phosmet uses should be retained to complement broader labeling of efficacious, low-risk insecticides, sufficient to manage the full complement of fruit and tree pests.
- Chronic worker exposure concerns of phosmet and other foliar applied pesticides could be substantially mitigated if peach growers had an effective post-bloom fruit thinner to diminish their need for ca. 4-weeks of hand thinning to achieve competitive fruit size.
- U.S. EPA's regulatory role should give due consideration of the farmer's need for effective pesticides that have re-entry intervals (REIs) and pre-harvest intervals (PHI) which permit adequate crop protection while allowing workers to conduct field essential activities. *Peach growers need insecticides with pre-harvest intervals (PHI) shorter than 14-days to prevent occasional late surges in pest abundance from ruining crops.*
- Regulatory decisions should thoroughly consider resistance management concerns. It is imperative to maintain multiple modes of action for use against key pests.
- Region-wide virus and phytoplasma tree-health programs are necessary to mitigate potential spread of plum pox virus and reduce the incidence of less catastrophic, endemic viruses. Nursery certification and elimination of non-certified stocks is an industry priority.

Eastern Peach Pest Overview

(Importance of particular pests varies by sub-region)

Insect General Overview

Arthropod pests of both fruit and trees must be assiduously managed or fruit quality, yield and long-term tree health will be compromised. Prophylactic insecticide use is expensive and fraught with problems. However, until improved IPM tools for as-needed management of fruit pests and major improvements in management of tree pests come together, eastern peaches will remain dependent on scheduled, preventative insecticides.

Current in-season peach insecticide programs are heavily dependent on the organophosphate (OP) phosmet. Limited, but essential, pyrethroid and carbamate use is also common. Phosmet is crucial for management of fruit-attacking pests. It presents minimal acute risk to workers and has a favorable food safety profile.

Chronic worker exposure to phosmet residues is an important concern because the peach system requires extensive hand labor for fruit thinning and harvest. Phosmet does not have dietary or environmental concerns. The thinning period, typically 30 days, is problematic, because pest pressures from plum curculio, scale, stink bugs and Oriental fruit moth are typically high during the time when thinning must take place.

Mitigation of phosmet's chronic worker exposure risk could theoretically be achieved by several means. Labor is almost universally a limiting factor for peach growers. Additional workers are not reliably available to hire more workers to shorten the exposure period for any one individual. Chemical fruit thinners for peaches should be aggressively researched. These plant growth regulator materials are available in most other deciduous fruits, where their use greatly diminishes the amount of hand labor required for thinning. Reliable chemical fruit thinners for peaches should be a key priority for reducing chronic worker exposure to all foliar applied pesticides. Sulfcarbamide (Wilthin) is available as a bloom thinner, but inconsistent performance has severely limited use in peach. Research and labeling of efficacious thinners to thin a crop after the risk of spring-time cold injury has diminished would demonstratively reduce worker exposure during the thinning period.

Growers need quality OP replacement insecticides for use during thinning and pre-harvest. Efficacy against both fruit insect pests and tree pests, re-entry interval (REI), cost and inclination to promote outbreaks of secondary pests such as scale or mites, are all important use considerations. Currently labeled OP alternatives available for mitigation of phosmet's chronic exposure concerns during thinning and pre-harvest are the carbamate carbaryl (Sevin), several pyrethroids and the nicotinoid thiamethoxam (Actara). Carbaryl has poor plum curculio efficacy. The pyrethroids and thiamethoxam provide fair to good plum curculio control, and, so far as is known, similar levels of control of other fruit pests. Each of these insecticides is inclined to promote secondary pest outbreaks in orchards. Given this less than stellar efficacy from potential low-risk, OP-replacement options, growers will opt for the cheapest option. Esfenvalerate, an older pyrethroid ($4-6/acre) is far more affordable than carbaryl ($13.50/acre) or thiamethoxam ($28/acre).

Chlorpyrifos (Lorsban), an OP, is applied to 98% of eastern peaches as a handgun-directed, post-harvest spray for control of peachtree borer. Chlorpyrifos also provides some degree of scale suppression. In the southeastern states, the bulk of peachtree borer's oviposition period falls after harvest, allowing this important pest management practice to be made with no risk of fruit contamination. Unfortunately, observations in 2004 and early in 2005 indicate that current in-season phosmet cover sprays followed by post-harvest chlorpyrifos may be showing early signs of control failure. Decline in what had traditionally been stellar control of peachtree borer is most likely due to moths which emerge and lay eggs before chlorpyrifos is applied. As with lesser peachtree borer, loss of encapsulated methyl parathion seems to have catalyzed this erosion of control.

Insufficient availability of efficacious, affordable, low-risk insecticidal options is a substantial management constraint. The cost and restrictive label of thiamethoxam (Actara) (1 post-bloom application and 14-day PHI) renders the risk mitigation impacts of this OP replacement insignificant. Truly efficacious, broad-spectrum, low-risk OP replacement insecticides are needed.

Acceptable control of both fruit and tree pests similar to that of encapsulated methyl parathion is needed. Materials currently projected as OP-replacement materials appear to be serviceable for key fruit pests, but they are lacking as clean-up materials and they do not project to improve management options for borers or scale.

There are some promising biorational control options for eastern peaches. Mating disruption may become a key element in abating the escalating impact of lesser peachtree borer. Field evaluations in the Southeast suggest that pheromone rates three- to four-fold those used in the upper Mid-West are necessary in heavily infested blocks. Pheromone mating disruption of Oriental fruit moth has performed well in Southeastern and Mid-Atlantic orchards. However, current use of mating disruption for Oriental fruit moth or borers is cost prohibitive. High costs relative to broad-spectrum insecticides that control multiple pests currently preclude this low-risk IPM option in all eastern peach regions. Most eastern peach growers who use mating disruption, ~1% of acreage, are processing growers who receive cost-share subsidies from companies that favor aggressive IPM utilization.

Entomogenous nematodes have shown promise against plum curculio. In similar fashion, entomogenous nematodes have demonstrated control efficacy against several clearwing moth species, suggesting the potential for meaningful, non-chemical alternatives for peachtree borer and lesser peachtree borer. More research is needed as a precursor to recommending nematode-based controls commercially.

Inadequate understanding of pest and beneficial arthropod biology dramatically limits management practices. In-depth biological studies are needed to provide a foundation for more evolved pest management options. Existing arthropod pest management options for eastern peach production must be refined into practical, affordable, stable systems that, where possible, replace our current prophylactic system with pest-specific and as-needed IPM responses.

Insect Research, Regulatory and Education Priorities

Research

- A more comprehensive biological and ecological understanding of all peach arthropod pests and beneficials is needed to form the foundation of more biologically refined peach pest management options. Detailed biological studies need to include: host plant selection, host preference and fidelity, characterization of attractive host plant volatiles, pest mobility to and within orchards, and rate of pest movement under various temperature regimes.
- Sound sampling tools, predictive models and action thresholds, the decision-making tools for cost effective pest management, are lacking. These tools must be developed, evaluated and incorporated into commercial peach production in the eastern U.S.
- Biological control agents should be studied and examined as potential components of comprehensive management strategies for plum curculio, Oriental fruit moth, scale and borer species.
- Better sampling options for scale and an improved understanding of scale predators and parasites are needed.
- Research is needed on host plant succession, chemical ecology and basic biology of thrips, plant bugs and stink bugs, grasshoppers, Japanese beetles, green June beetles, rose chafers and white fringed beetles.
- Development, evaluation and incorporation of low-risk pesticides into commercial management schemes is important.
    - Impacts on key, secondary and induced pests, beneficials, and emerging pest problems must be carefully studied.
    - Sub-lethal insecticidal effects, though difficult to investigate, should be examined because they may prove important in providing stable, cost-effective pest management options.

Regulatory

- Eastern peach producers must have efficacious pesticides that control fruit and tree pests, with labels permitting application numbers sufficient to fully address pest pressures.

Education

- Growers must be informed of emerging pest management options to replace lost chemical usage and to address emerging pest issues.

Pest Name: Oriental fruit moth (OFM)

Distribution, damage and importance:

- OFM is the key fruit insect pest of the Mid-Atlantic and upper Mid-West sub-regions. It has similar potential in the Southeast and may become more problematic as plum curculio spraying becomes more targeted.
- Wholesale fruit has a zero tolerance for wormy fruit; entire loads have been rejected when infested by OFM.

Chronology:

- 1st generation larvae attack terminals, causing dieback and flagging.
- Larvae of subsequent generations are a common internal feeding caterpillar pest of peach.

Control measures used and recommended:

Cultural/mechanical

- OFM phenology models (degree-day, egg hatch, etc.) are certain to become more important as OFM control becomes more independent of plum curculio control.

Biological

- Pheromone-based mating disruption (MD) of OFM is species specific and very effective, but MD is not cost effective and is little used. Control measures must still be applied for other pests, effectively increasing the cost of mating disruption. MD for OFM can be used effectively in combination with reduced-rate application of conventional insecticides. MD must be used with a scouting program.

Chemical

- OFM is controlled by scheduled, prophylactic applications of organophosphate (OP) insecticides. Until 1999, OP's also provided substantial suppression of tree-attacking scales and borers.
- Azinphos methyl, phosmet, and pyrethroids provide excellent OFM control. AZM peach uses will be terminated in the fall of 2006. Additional pyrethroids will be labeled for use in peaches.

Chemicals used:

Organophosphates

- azinphos methyl (Guthion, Sniper, Azinphos Methyl)
  - Azinphos methyl is effective for control of OFM; it provides up to 2 weeks of residual activity.
  - *Azinphos methyl may be used through the 2006 season.* AZM is the best available salvage material for problematic infestations of Oriental fruit moth plus plum curculio or stink bugs. AZM is also the best available in-season material for combating lesser peachtree borer, which has become a tree-killing pest in the Southeast. AZM is also quite useful for fighting scale.
  - Despite AZM's high mammalian toxicity concerns, it has low residue on harvest fruit, making it the OP of choice for some baby food processors. Some processors favor use of AZM over phosmet or carbaryl because its residual on harvested fruit dissipates rapidly.
  - Field failures due to OFM resistance have been reported in some Mid-Atlantic and upper Mid-West orchards.
  - AZM's 14-day re-entry interval and 21-day pre-harvest interval limit its use in peach.
- phosmet (Imidan)
  - Phosmet provides effective OFM control, but in areas with high OFM pressure phosmet requires more applications and higher rates than azinphos methyl.
  - Phosmet is the dominant peach insecticide in eastern production areas. Phosmet is particularly important to eastern peach growers pre-thinning and pre-harvest, because its 1-day REI and 14-day PHI are less restrictive than AZM's.
  - Phosmet has chronic worker exposure concerns during thinning and picking. Current low-risk options include pyrethroids, the insect growth regulator methoxyfenozide, and pheromone mating disruption (MD). Pheromone mating disruption provides reliable, low-risk OFM control, but provides no control for plum curculio and other pests which are abundant during the thinning season. Similarly, methoxyfenozide (Intrepid) is a reliable OFM material, though application(s) must be carefully timed to be effective. Neither mating disruption nor methoxyfenozide are cost competitive with AZM or phosmet. Pyrethroids (Ambush, Asana, Warrior, Proaxis) provide very good OFM control, but most pyrethroids are weak plum curculio materials, and regular pyrethroid use promotes outbreaks of scale or mites.
  - Phosmet is easier on beneficials than pyrethroids or thiamethoxam, the other broad spectrum insecticide options.
  - Field failures due to phosmet resistant OFM have been reported in some Mid-Atlantic and upper Mid-West orchards.
  - Processors utilize only a small percentage of the eastern peach crop (ca. 1.5% in MI and 1.5% in SC), but one prominent baby food producer prohibits use of phosmet, while allowing as-need applications of AZM.

Carbamates

- carbaryl (Sevin)
  - Effective OFM material if used at high rates.
  - Short residual (less than 7 days) control of OFM makes carbaryl impractical for season-long control.
  - Carbaryl is toxic to beneficial insects and mites; disruption of biocontrol sometimes promotes secondary pest outbreaks.
  - Some processors prohibit use of carbaryl and other carbamates.
- methomyl (Lannate)
  - Short residual.
  - Methomyl is very effective against OFM, but only at high rates.
  - Very short residual (3 days) make it impractical for regular use.
  - Methomyl is disruptive to biocontrol; its use often encourages outbreaks of mites.
  - Some processors prohibit use of methomyl and other carbamates.
  - Methomyl application via airblast sprayer presents applicator safety concern; in the Southeast, where OFM is less problematic, methomyl is little used.

Pyrethroids

- esfenvalerate (Asana)
  - Esfenvalerate's activity against OFM is limited, it requires many applications.
  - Post-bloom use of esfenvalerate, or other pyrethroids, typically upsets IPM programs by destroying beneficial mites and insects. Pyrethroids seriously exacerbate scale and mite problems.
  - Pests readily develop resistance to pyrethroids in systems where they are used repeatedly.
  - Esfenvalerate is very economical, but use is limited due to concerns about disrupting IPM programs, potential resistance problems and short residual.
  - Esfenvalerate's 14-day pre-harvest interval is too long for use as a pre-harvest salvage material.
- permethrin (Ambush, Pounce)
  - Permethrin's activity against OFM is short, requires many applications.
  - As with esfenvalerate, permethrin is difficult to use in an IPM context. Post-bloom use of pyrethroids typically upsets IPM programs by destroying beneficial mites and insects. Permethrin use is limited because pyrethroids seriously exacerbate scale and mite problems.
  - Pests rapidly develop resistance to pyrethroids.
  - Permethrin's 14-day PHI is too long for use as a pre-harvest salvage material.
- gamma cyhalothrin (Proaxis)
  - Gamma cyhalothrin's peach label is recent, and it has been little tested in peach, but its performance against OFM is expected to be similar to that of esfenvalerate or permethrin.
  - Post-bloom use of pyrethroids, including gamma cyhalothrin, can be expected to increase the frequency of scale or mite outbreaks.
  - Gamma cyhalothrin's 14-day PHI is too long for use as a pre-harvest salvage material.

- lambda cyhalothrin (Warrior)
    - Lambda cyhalothrin's peach label is also newly acquired; until tested, its performance against OFM will be assumed to be similar to that of esfenvalerate or permethrin.
    - Post-bloom use of pyrethroids, including lambda cyhalothrin, is likely to encourage outbreaks of scale or mites.

Ecdysone Mimic, Insect Growth Regulators

- methoxyfenozide (Intrepid) [Diacylhydrazine]
    - Methoxyfenozide use in peach has been limited. It is a low-risk material with activity against lepidopterans; its performance in apples suggests it should provide good OFM control. Application will need to be timed to initiation of larval hatch, imposing an additional management requirement with no clear benefit to the grower. At present OFM control with methoxyfenozide is a niche use in peaches. Its high cost and narrow range of activity will limit its use in peach unless it becomes a key component for management of lesser peachtree borer.

Juvenile Hormone Mimic, Insect Growth Regulators

- pyriproxyfen (Esteem) [Pyridine]
    - Fair OFM efficacy when applied in early-season; timing is critical; must be on foliage prior to OFM egg lay.
    - Pyriproxyfen is an effective, as-need, clean-up scale control material in peach. It is expensive and because of timing issues most often used pre-bloom. High cost, narrow range of activity (scale crawlers and early-instar caterpillars) and moderate OFM efficacy make extensive use of pyriproxyfen for OFM control unlikely.
- novaluron (Rimon) [Benzoylurea]
    - Novaluron is an insect growth regulator. It is expected to provide good, fairly long residual control of OFM when applied early in the pest's life cycle. OFM control will necessitate proper timing of applications. Little tested in peach; activity in other crops suggests possible activity against some beetles and other lepidopterans.

Chloronicotinyls

- thiamethoxam (Actara)
    - Thiamethoxam has poor OFM efficacy. It has competitive plum curculio activity, but its peach label allows one post-bloom application. Thiamethoxam use as an OFM material will be insignificant.

Unregistered insecticides which may have potential for OFM management

- indoxacarb (Avaunt) [Oxadiazine]
    - Indoxacarb is only moderately effective against OFM, short residual.
- thiacloprid (Calypso) [Nicotinoid]
    - Thiacloprid has only moderate OFM activity; the need for high use rates will dramatically limit use against OFM.
    - Thiacloprid has a potential role in management of plum curculio, though cost, allowable number of applications, and PHI will be determinants of its peach market share.

- acetamiprid (Assail) [Nicotinoid]
    - Probably has adequate OFM efficacy, but only at higher rates.
    - Acetamiprid has shown fair, though short residual, plum curculio activity, with possible scarab beetle activity, suggesting a potential short-PHI use niche. If the compound's OFM efficacy is adequate, it could see use as a pre-harvest material that would augment primary OFM control strategies.
- dinotefuran (Venom) [Nicotinoid]
    - Probably has adequate OFM efficacy, but likely to require higher rates.
    - Dinotefuran has shown good preliminary performance against plum curculio. Until tested against OFM in peach, dinotefuran's potential should be considered similar to other chloronicotinyls, which is fair to adequate.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- OFM's ecology is inadequately understood. There is a major knowledge gap regarding OFM movement from adjacent orchard and non-orchard habitats. Research leadership for OFM in eastern peaches should come from the Mid-Atlantic and upper Mid-West, with complementary OFM work from the Southeast.
- Owing to OFM's lower pest status in the Southeast, OFM's DD-model has not been adequately evaluated in southeastern peaches. Regional OFM model evaluation must be conducted in the Southeast.
- Pheromone-based treatment thresholds to facilitate as-needed management of OFM would be a boon to the evolution of peach insect IPM in the eastern U.S. Solid, pheromone-based thresholds are needed.
- Determine effectiveness of new insecticides.
- Evaluate efficacy, utility and cost-effectiveness of mating disruption delivery systems alone, and in conjunction with the full array of insecticidal options.
- Regionally validated baseline OFM susceptibilities should be established for OPs and new chemistries to aid in resistance management.
- Conduct residue and post-harvest interval studies.

Regulatory

- Expedite registration of new insecticides and other control tactics as they become available.
- EUP programs should encourage meaningful, on-farm evaluation of new management options. This is especially critical for pheromone mating disruption where large orchard requirements typically preclude evaluation in research orchards.

Education

- Train growers and IPM professionals as new research improves our understanding of OFM biology and management.

Pest Name: Plum curculio (PC)

Distribution, damage and importance:

- PC is the key fruit-attacking peach insect pest in the Southeast, where two generations routinely impact fruit. Though PC is secondary to OFM in the Mid-Atlantic and upper Mid-Western regions, where one generation is the rule, PC is still a prominent pest which has very high injury potential.
- PC overwinter successfully in orchards, but many PC also migrate to orchards from nearby woods where they thrive on native hosts.
- PC control must be absolute for fruit sold to wholesale markets, which have a zero tolerance for wormy fruit.

Chronology:

- PC adults feed on and lay eggs in fruit.
- Larval injury, which results in wormy fruit, is most often encountered during the second or field generation in the Southeast, and to some extent in the Mid-Atlantic region.
- In the Southeast, the spring migration/oviposition period begins with petal-fall and extends up to 10 weeks.

Control measures used and recommended:

Cultural/mechanical

- Commercially feasible sampling techniques and thresholds are lacking. Models are limited and still undergoing field validation. Until all three are developed and combined into a commercially reliable system, growers will have no choice but to over-apply insecticide to assure control of this key pest.

Biological

- Entomopathogenic nematodes show good to excellent efficacy controlling the in-ground stages of PC. This should provide highly beneficial PC suppression, though control of adults continues to be elusive. IPM components of organic peach production systems are being researched in the Southeast and entomopathogenic nematodes are being examined as components of PC control within these systems.

Chemical

- Phosmet (Imidan) [OP] is the key in-season insecticide for eastern peaches. It provides very reliable control of PC, and OFM, without encouraging outbreaks of scale or mites. While clearly less effective than encapsulated methyl parathion or azinphos methyl, phosmet is the standard against which other potential plum curculio insecticides must be judged.
    - Phosmet's weaknesses are its limited and short-residual efficacy against stink bugs; its inability to suppress scale at rates that allow the needed number of applications per season; and its inability to suppress lesser peachtree borer.
    - *Even with its critical shortcomings, phosmet remains the key in-season insecticide, because of its overall control of key pests, its ability to control a broad spectrum of pests, and its obviously low resistance risk against PC.*

- **Pyrethroids**
    - Pyrethroid use in peaches is attractive because of low material cost. *However, effective use of pyrethroids in peaches will, in the long-term, require use of more efficacious broad-spectrum materials (OPs) to bolster the performance of the inexpensive but marginally effective pyrethroids.* With currently labeled insecticides, and those being considered for peach labels, phosmet applications during periods of peach plum curculio pressure will remain extremely important to ensure the thorough PC suppression necessary to successfully use pyrethroids and other emerging options that are weaker against PC.
        - Estimated 2005 prices may help illustrate the grower incentive to use pyrethroids during use windows when they likely perform well. Esfenvalerate, the most commonly used pyrethroid, is generally $4-5/acre vs. $20/acre for phosmet. Labeling of two very effective curative scale materials [pyriproxyfen (Esteem/Knack) or buprofezin (Centaur)] and an excellent miticide [bifenazate (Acramite)] allows growers to more safely apply pyrethroids several times a season. These low-risk curative materials are expensive, but effective enough to support selective pyrethroid use, because growers can confidently re-establish control of scale and mites.

Chemicals used:

Organophosphates

- phosmet (Imidan)
    - Phosmet provides excellent PC control.
    - Phosmet is the primary insecticide in the East because it provides good PC efficacy, it does not induce secondary pest outbreaks, and phosmet's REI and PHI are short enough to allow adequate opportunity for hand thinning and harvest.
    - Phosmet is far less effective than ethyl parathion, encapsulated methyl parathion and azinphos methyl in suppressing tree pests.
    - Lesser peachtree borer (LPTB) and scale became yield-reducing, tree-killing pests since phosmet replaced encapsulated methyl parathion as the standard in-season peach insecticide. In the Southeast, LPTB, which was formerly a minor pest, is now a widespread tree-killer.
    - Phosmet is easier on beneficials than alternative in-season insecticides.
    - Processing markets account for less than perhaps 1% of overall fruit volume in the Southeast and Mid-Atlantic regions; some processors prohibit use of phosmet, while allowing use of azinphos methyl.

- azinphos methyl (Guthion, Sniper)
  - AZM use in peach will end after the 2006 season.
  - AZM is the long-time gold standard for control of PC. It is easily the most efficacious peach insecticide, providing excellent control of PC and other fruit pests and the best available control of tree pests. AZM appears to be the only in-season insecticide that suppresses LPTB infestations, and it does not increase scale problems. AZM is also the only true salvage material for orchard blocks that develop problematic infestations of fruit pests.
  - AZM's 14-day re-entry interval (REI) limits its utility.
  - AZM is acceptable to key baby food processors because it declines to undetectable residue levels more dependably than other OPs and carbamates.
  - AZM use provides the best available in-season suppression of LPTB.
  - Tree pest infestations have reached tree-killing levels in southeastern peaches. AZM's time-limited, through 2006, peach label extension is an important and well conceived compromise.

Carbamates

- carbaryl (Sevin)
  - Carbaryl is a weak, short residual PC insecticide.
  - Carbaryl has a short (3-day) pre-harvest interval (PHI) and a broad spectrum of activity. Carbaryl is the material of choice for combating late, just before harvest, intrusions by mixed complexes of fruit feeders which may include PC, stink bugs, white fringed beetle and scarab beetle pests (June beetles and rose chafers).
  - Carbaryl is toxic to beneficial insects and mites. Frequent use increases the risk of mite or scale outbreaks.
  - Some processors prohibit use of carbaryl and other carbamates.

Pyrethroids

- esfenvalerate (Asana)
  - Esfenvalerate is a short residual material with decent PC activity. It is suitable for careful use within a management scheme which carefully relies on phosmet to assure good control during periods of peak PC activity.
  - Post-bloom use of esfenvalerate, or other pyrethroids, is disruptive to beneficial complexes which very often provide valuable suppression of scale and mites.
  - Pests readily develop resistance to pyrethroids in systems where they are used repeatedly.
  - Esfenvalerate's long pre-harvest interval (14-day PHI) severely limits pre-harvest use.

- permethrin (Ambush, Pounce)
  - Permethrin is a short residual material with very mediocre PC activity.
  - As with esfenvalerate, permethrin use is associated with scale and mite problems.
  - Pests rapidly develop resistance to pyrethroids.
  - Permethrin's 14-day PHI dramatically diminishes its value as a pre-harvest material.
  - As with esfenvalerate, use of permethrin is dependent on the superior PC control provided by phosmet and is further dependent on reliable curative scale materials [pyriproxyfen (Esteem/Knack) or buprofezin (Centaur)] and bifenazate (Acramite) for mites.
- gamma cyhalothrin (Proaxis) and lambda cyhalothrin (Warrior)
  - Cyhalothrin's peach labels are new, circa 2005. Pre-label testing in peach was superficial. In preliminary testing, Cyhalothrin, Proaxis and Warrior appear to be similar to esfenvalerate.
  - In 2005 trials, cyhalothrin showed uninspiring PC activity, falling between esfenvalerate and permethrin in PC control.

Nicotinoids

- thiamethoxam (Actara)
  - Thiamethoxam has good PC efficacy, being similar to phosmet (Imidan), but clearly less effective than AZM.
  - Thiamethoxam's peach label allows only one post-bloom application. If phosmet's pending review results in a longer REI, other materials will have to be considered for sprays during fruit thinning. Thiamethoxam's 12-hr REI does position it as one viable alternative for this use window.
  - Thiamethoxam's PC efficacy is consistently comparable with low to moderate rates of phosmet; its per acre cost is ca. 1/3 more than comparable dosages of phosmet.
  - Thiamethoxam's lengthy 14-day pre-harvest interval (PHI) will minimize its use in the pre-harvest spray window.

Unregistered insecticides with potential for PC management:

Pyrethroids

- fenpropathrin (Danitol)
  - In preliminary testing, fenpropathrin has shown very encouraging, broad spectrum activity on PC and other fruit pests (similar to OP standards).
  - Use in apples suggests some miticidal efficacy, although activity may be greater for European red mite than for two spotted spider mite (primarily peach mite).
  - Fenpropathrin has shown good stink bug efficacy in other crops.

Nicotinoids

- thiacloprid (Calypso)
  - Thiacloprid has fair to good PC efficacy; certainly not as effective as azinphos methyl or phosmet.
  - Nicotinoids are typically persistent and systemic.
  - Thiacloprid may offer improved aphid control, which would be of greater value to growers in the upper Mid-West and Mid-Atlantic regions.
  - Persistent, systemic compounds are often prone to resistance development.
  - As with other nicotinoids, thiacloprid appears inclined to scale and mite problems.
- acetamiprid (Assail)
  - Acetamiprid testing in peach suggests the attributes and shortcomings of other nicotinoids. Acetamiprid may be a shorter residual material. If labeled with a short PHI, 3-days or less, acetamiprid might serve as a resistance management tool to protect carbaryl.
- dinotefuran (Venom)
  - Dinotefuran testing in peach suggests the attributes and shortcomings of other nicotinoids. If labeled with a short PHI, 3-days or less, acetamiprid might serve as a resistance management tool to protect carbaryl.

Oxadiazines

- indoxacarb (Avaunt)
  - Indoxacarb has good to excellent PC efficacy, though not as effective as azinphos methyl.
  - An indoxacarb label should be expedited for peach to mitigate OP risks during thinning and picking without overuse of pyrethroids or nicotinoids (both resistance prone).
  - Testing in scale prone orchards suggests indoxacarb will not provide suppression of scale.
  - Indoxacarb's efficacy against lesser peachtree borer has not been determined.

Insect Growth Regulators, Chitin Synthesis Inhibitors

- novaluron (Rimon)
  - Efficacy against citrus root weevil suggests that novaluron should be investigated for possible reproductive inhibition or even some direct toxicity to adult PC.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- PC modeling, sampling and threshold research should be a high priority.
- Thorough field validation of the PC degree-day model is needed so this IPM tool for predicting PC life cycle events can be utilized commercially.
- Examine PC's native hosts, determining host preference, fidelity and succession.
- Examine PC's migration patterns and its rate of migration from and within various wild and cultivated hosts. Temperature and other environmental parameters should be studied for possible impacts on PC behavior and movement.
- Develop a site-specific PC risk assessment protocol to characterize PC risk for individual orchards and their surroundings.
- Isolate and test potential pheromones and/or plant volatile attractants for PC trapping.
- Develop PC traps to facilitate development of thresholds. Current traps are inadequate for use as IPM tools for growers who produce fresh peaches to wholesale venues.
- Entomopathogenic nematodes and fungi should be comprehensively evaluated for potential implementation as PC controls for home and small-scale organic orchards.
- Evaluate low-risk insecticides for PC efficacy and incorporate them into management plans to mitigate risks associated with present OP use patterns, particularly during thinning and harvest.

Regulatory

- *Eastern peach growers need a broad spectrum, low-risk insecticide with efficacy similar to that of encapsulated methyl parathion.* It is understood that foliar application labels for fipronil on fruit will not be considered, but to date fipronil is the only new insecticide that appears to offer that level of insecticidal activity. Experimental evaluation of related pyrazole chemistries in peaches should be encouraged in hope of isolating materials to help fill this crucial void.
- Low-risk, organophosphate (OP) replacement materials evaluated to date appear to provide adequate protection from fruit-attacking pests. However, neither phosmet (OP standard) nor the low-risk materials being widely considered for fruit labels have given indication they would substantially suppress or control tree-attacking pests, specifically lesser peachtree borer. Since the loss of encapsulated ethyl parathion in ca. 1999, lesser peachtree borer has evolved from a minor pest to a major, tree-killing pest across the Southeast. Early indications suggest the Mid-Atlantic region may be experiencing the onset of the same phenomena, albeit at a slower rate.
- Aggressive registration of new, low-risk chemistries, with an eye for strengthening resistance management options, should be a priority.

Education

- Successful implementation of more evolved IPM tools will require higher levels of extension support for farmers and IPM practitioners.
- Regional web-based support technology should be developed to efficiently share current information on pest life cycles, abundance, and to offer critiques of IPM options as research generates new IPM tools.

Pest Name: **Green peach aphid (GPA) and black peach aphid (BPA)**

Distribution, damage and importance:

- GPA and BPA are common pests in the Mid-Atlantic and upper Mid-West. Both are commonly present in southeastern peaches, though seldom at injurious levels.
- GPA and BPA suck plant juices from leaves and blossoms; heavy infestations can slow tree growth and reduce fruit set.
- BPA infestations can be particularly injurious to young trees. Damage to young trees is common in the Mid-Atlantic and upper Mid-West regions, but is seen only occasionally in the Southeast, primarily in the cooler production areas.
- GPA and BPA are plum pox virus (PPV) vectors. Young, vigorously growing trees are more prone to PPV infection.
- Resurgence of GPA may be experienced following sprays of broad-spectrum foliar insecticides such as pyrethroids. These outbreaks have been attributed to the destruction of natural predators and to insect resistance.

Chronology:

- GPA and BPA are normally early-season pests. Trees should be monitored weekly from bloom until 4-6 weeks after shuck fall.

Control measures used and recommended:

Cultural/mechanical

- Since young trees are more susceptible to PPV infection, monitoring should focus on young orchards.
- The frequency and severity of aphid infestations should be monitored carefully.

Biological

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

Chemical

- Pyrethroid use will increase as OP-risk mitigation proceeds. The affordability of pyrethroids clearly favors use of these materials to supplant OP standards for control of OFM and to some extent PC. Increased incidence of aphid, scale and mite outbreaks should be expected as pyrethroid use increases.
- Nicotinoids
    - Imidacloprid (Provado) is an excellent aphid material; it also has leafhopper efficacy. Imidacloprid's most important use in peach is pre-harvest control of scarab beetles.
- Thiamethoxam (Actara) is labeled with one pre-bloom application and post-bloom. Its key use in peach will be as an OP-replacement material for control of PC. Thiamethoxam provides excellent aphid control.

- There are some unregistered chemicals that may provide aphid control:
  - Nicotinoids
    - Unlabeled nicotinoids under consideration for peach labels include thiacloprid (Calypso), acetamiprid (Assail), dinotefuran (Venom), clothianidin (Clutch) and flonicamid. They are all excellent aphicides. Nicotinoid use should emphasize OP risk mitigation, with very judicious use for aphids.
    - Aphid efficacy is important, but the first and most important use consideration for nicotinoids in peach should be mitigation of phosmet's chronic worker exposure risks to thinners and harvesters.
    - Where aphids are injurious, prudent resistance management should limit nicotinoid use to as-needed responses, primarily in young orchards.
- Other potential peach aphicides
  - triazamate (unclassified); selective for aphids.
  - pirimicarb (dimethylcarbamate); selective for aphids.

Chemicals used:

Organophosphates
- None, OPs do not provide control of GPA in the Mid-Atlantic or upper Mid-West.

Carbamates
- methomyl (Lannate); methomyl-resistant GPA populations exist in many Mid-Atlantic and upper Mid-West orchards.

Chlorinated Hydrocarbons
- endosulfan (Thiodan, Phaser)
  - Endosulfan-resistant GPA populations exist in many Mid-Atlantic and upper Mid-West orchards. Endosulfan typically works well as a BPA cleanup material in the Southeast.
  - Some processors prohibit use of endosulfan.

Nicotinoids
- imidacloprid (Provado)
  - Provado is an excellent aphid material, but it does not control other common peach pests.
  - Provado use has increased mite outbreaks in ornamentals.
- thiamethoxam (Actara)
  - Thiamethoxam is an excellent aphid material, but it does not control other common peach pests.
  - Thiamethoxam increases the risk of mite outbreaks in ornamentals.
  - Thiamethoxam's one post-bloom application in peaches would most logically be used for mitigation of phosmet's chronic worker exposure risks for thinners and harvesters.

State/local pesticide restrictions or limitations, export issues, etc.:
- None

Critical issues:

Research

- Evaluate effects of new and old insecticides on predators and parasitoids of GPA and BPA to facilitate development of integrated control options for these occasional pests.
- Develop monitoring programs and treatment thresholds for tree and fruit injury from both GPA and BPA.
- Migratory aphid species are common visitors to peach. Most species are not damaging, hence they have received little study and are poorly understood. However, migratory aphids are thought to be the prime potential vectors for PPV. With the arrival of plum pox virus 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.

Regulatory

- Register new insecticides. Management of aphids would benefit by registration of new chemistries, particularly non-nicotinoids.

Education

- Provide training on ID, monitoring, and management of key aphid species and beneficial insects.
- Grower education on the anticipated merit or lack thereof of aphid suppression as a means of managing PPV.

Pest Name: **Tree Pests [scale species, lesser peachtree borer (LPTB) and peachtree borer (PTB)]**

Distribution, damage and importance:

- Since the mid-1950s cover sprays, first with ethyl parathion which was replaced by encapsulated methyl parathion, substantial suppression of both scale and borer species provided enhanced productivity and tree longevity. Beginning in 2000, when phosmet became the standard peach cover spray material, we saw first scale and, then even more significantly, lesser peachtree borer evolve from minor pests to key pest status. Borers and scale are ubiquitous tree pests in eastern peach production.
- Diligent annual suppression of borers and scales is necessary for sustainable production.

Scale

Distribution, damage and importance:

- Armored scale species are the primary scale pests of peach. San Jose, Forbes, Terrapin and White Peach Scale are potentially debilitating tree pests. White peach scale and San Jose scale have become key pests in the Southeast.
- 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.
- Severe scale problems are generally pesticide-induced, in the case of southeastern peaches, having been brought about by replacing encapsulated methyl parathion (Penncap-M) with phosmet, which is far less effective.
- Pyrethroids, carbamates and thiamethoxam (Actara), the one nicotinoid labeled in peaches, all exacerbate scale problems.
- Scale infestations of fruit cause a distinctive reddish-purple spotting that results in unmarketable fruit.
- Scale are ubiquitous, difficult to monitor. Scale require scale-specific treatments in order to maintain orchard productivity. Thorough spray coverage is imperative, regardless of material.

Chronology:

- Scale are year-around pests. Critical control windows include dormant season applications of superior oil(s), pink to early bloom application of IGR insecticides and cover sprays that are carefully adjusted to target the initial, early-season crawler generation.

Control measures used and recommended for scale:

Cultural/mechanical

- Selective pruning of infested branches can help reduce scale and/or lesser peachtree borer populations.
- Black sticky tape can be used for monitoring scale crawlers.
- Remove of scale-infested alternate host plants adjacent to orchards may be practical for some orchards, and appears to reduce scale pressure.

Biological & Biorational:

- Natural enemies sometimes provide impressive scale control, but our understanding of scale and their natural enemies is insufficient to allow for constructive manipulation of scale populations. Detailed biological studies of scale and their enemies should be conducted in each major production area, with complementary studies to determine the pesticide susceptibilities.
- Scale monitoring with pheromone traps is of limited use because male scales are weak fliers.

Chemical

- Phosmet, the in-season insecticide standard (OP), nor the anticipated OP-replacement products can be expected to provide meaningful in-season suppression of scale.
- Scale control programs are based primarily on one, often two, dormant oil applications.
- The low-risk, OP-replacement materials pyriproxyfen (Esteem or Knack) and buprofezin (Centaur) provide very good clean-up of problematic scale infestations. The high cost of these IGR products is supportive of resistance management. Cost limits use of both pyriproxyfen and buprofezin to as-need triage for problem blocks.

Chemicals used:

Organophosphates

- chlorpyrifos (Lorsban)
  - Chlorpyrifos provides a helpful level of scale suppression when applied for PTB control once/season with a hydraulic gun to the butt and lower trunk.
  - PTB application time varies with region, from mid-June in northern production areas to post-harvest in the Southeast, where the PTB adult flight facilitates good control with a post-harvest Lorsban application.
  - 24C chlorpyrifos labels in GA and SC now allow additional post-harvest applications to aid in suppression of scale and lesser peachtree borer.
- methidathion (Supracide)
  - Effective during the dormant season for scale; oil enhances efficacy.
- phosmet (Imidan)
  - Phosmet rates traditionally used in cover sprays provide no observable suppression of scale or lesser peachtree borer.
  - Some processors prohibit use of this product.
- diazinon
  - Effective post-harvest treatment for control of scale crawlers may also provide some suppression of LPTB.
  - Used only post-harvest for scale control, as growers fear fruit finish problems with diazinon.
  - Some processors prohibit use of this product.

Insect Growth Regulators

- **pyridines**
  - pyriproxyfen (Esteem/Knack) [Juvenile hormone mimic IGR]
    - Very effective and consistent when applied pre-bloom against San Jose or white peach scale.
  - buprofezin (Centaur) [Juvenile hormone mimic IGR]
    - Very effective and consistent when applied pre-bloom against San Jose or white peach scale.

Pyrethroids

- esfenvalerate (Asana), permethrin (Ambush or Pounce), gamma cyhalothrin (Proaxis), lambda cyhalothrin (Warrior)
  - Pyrethroids disrupt natural control and induce secondary pest outbreaks, particularly scale.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- Screening/developing new products, to include biopesticides and biorationals.
- Regional validation of scale degree-day models to target the timing of sprays.
- Examine strategies that would optimize biological control.
- Determine impact of standard and "new" insecticides on scale biological control.

Regulatory

- Provide incentives for research of new products.

Education

- Train growers and scouts to identify and monitor the crawler stage of scales for timing of sprays.
- Reinforce benefits of oil and high volume sprays to control scale.
- Post-harvest monitoring can identify localized infestations, which can be spot-treated.
- Educate and train industry as new control tactics and management strategies become available.

Borers (Lesser peachtree borer and Peachtree borer)

Distribution, damage and importance:

- LPTB, a pest inadvertently 'created' by pesticide policy decisions, has become the key tree pest of southeastern peaches; it presently threatens the economic viability of the southeastern peach industry.
- In the Southeast, widespread LPTB infestations now cause extreme reductions in fruit size and orchard longevity. Its pest impact has increased progressively since 2000, but does not appear to have peaked.

- LPTB was long regarded as a minor pest that was confined to older orchards in the last years of production. Loss of encapsulated methyl parathion in 1999 and dramatic use restrictions on azinphos methyl effectively eliminated some 60 years of substantial in-season suppression. A series of highly efficacious insecticides that were regularly applied to control fruit pests apparently provided extremely important suppression of LPTB and PTB.
- Mid-Atlantic peach producers are experiencing scale problems, and LPTB numbers have more recently begun to escalate. Increasing abundance of these previously suppressed tree pests appear to be mirroring those experienced in the Southeast, though populations in the cooler Mid-Atlantic region have been slower to develop.
- LPTB and PTB feed on the inner bark, destroying vascular tissue, causing loss of vigor and eventual tree death.
- LPTB has surpassed scale as the most significant cause of entomologically-induced premature tree decline and mortality.
- Incidence of *Cytospora* canker is closely related to LPTB and further exacerbates injury to the tree and to shothole borer.

Chronology:

- Lesser peachtree borer and peachtree borer are year-around pests of *Prunus* spp. In the warmer southeastern production areas, lesser peachtree borer is on the wing and laying eggs in substantial numbers from April well into October. Peachtree borer ovipositional periods are shorter, making them much more amenable to control via directed, barrier insecticide applications.

Control measures used and recommended for borers:

Peachtree Borer. Chlorpyrifos (OP) applied as a barrier treatment provides good to excellent control of PTB. Chlorpyrifos is an essential use in peaches. In the Southeast, PTB phenology allows for effective post-harvest application.

Lesser Peachtree Borer. Residual, barrier insecticides are not available for lesser peachtree borer. Pheromone mating disruption may become a major tool for control of lesser peachtree borer, which would simultaneously provide control of peachtree borer. Peachtree borer is typically well controlled by residual, barrier insecticide.

Cultural/mechanical:

- Healthy bark is less susceptible to attack by either borer species. Cultural practices which protect bark from sunburn, mechanical injury, limb breakage and other wounding processes provide some mitigation of borer pressure.
- Research to examine the impact of tree training on susceptibility is needed to see if this approach has merit.

Biological & Biorational:

- Mating disruption shows important promise to perhaps offer control of both PTB and LPTB. LPTB pheromone can be used to disrupt mating of both species.
- Entomogenous nematodes have demonstrated promising efficacy against both borer species.
- Use of pheromone traps for monitoring borers can document when adult flights have begin to rise and fall.
- In the Southeast where LPTB is severe, pheromone mating disruption at recommended rates is not effective. In heavily infested southern orchards, pheromone rates that are 3-4 times those used in northern production areas appear necessary to gain control of LPTB.

Chemical:

- Peachtree borer (PTB) is well controlled by preventative chlorpyrifos (OP) insecticide applications via coarse, high volume, directed hand-gun sprays to the tree butt and lower trunk. Handgun sprays for PTB are presently the only form of borer control utilized by commercial producers in most of the eastern U.S.
- There are no conventional insecticides that provide control of lesser peachtree borer (LPTB).

Chemicals used:

Organophosphates

- chlorpyrifos (Lorsban)
  - Chlorpyrifos provides a helpful level of scale suppression when applied for PTB control once/season with a hydraulic gun to the butt and lower trunk.
  - PTB application time varies with region, from mid-June in northern production areas to post-harvest in the Southeast, where the PTB adult flight facilitates good control with a post-harvest Lorsban application.
  - 24C chlorpyrifos labels in GA and SC now allow additional post-harvest applications to aid in suppression of scale and lesser peachtree borer.
- phosmet (Imidan)
  - Phosmet rates traditionally used in cover sprays provide no observable suppression of scale or lesser peachtree borer.
  - Some processors prohibit use of this product.
- diazinon
  - Effective post-harvest treatment for control of scale crawlers may also provide some suppression of LPTB.
  - Used only post-harvest for scale control, as growers fear fruit finish problems with diazinon.
  - Some processors prohibit use of this product.

Chlorinated Hydrocarbons

- endosulfan (Thiodan)
  - PTB control with endosulfan is not as effective as with chlorpyrifos; endosulfan must be applied two times per season to achieve 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), permethrin (Ambush or Pounce), gamma cyhalothrin (Proaxis), lambda cyhalothrin (Warrior)
  - Little to no use for PTB control because its short residual requires multiple applications.

Critical issues:

Research

- Treatment thresholds for borer species, accommodating varying tree age, are badly needed to minimize unneeded borer applications.
- Borer pupal counts, which document successful larval development, are too labor intensive for pest monitoring on a commercial scale, therefore development of pheromone-based thresholds for PTB and LPTB should be investigated.
- LPTB infestation levels may be influenced by training system, evaluation of LPTB in training system trials and grower orchards should examine the potential of this possible cultural control.
- Germplasm (rootstocks and scions) should be evaluated. Hopefully, breeding programs can eventually offer helpful degrees of host plant resistance in commercial cultivars.
- Transgenic incorporation of *Bacillus thuringiensis* into peach may be a reasonable short-term response to increasing borer problems, particularly for rootstocks.
- Borer ecology is poorly understood. Site-specific risk assessments should be explored as a means of potentially characterizing risk on a block-to-block basis.
- Mating disruption research needs to examine the impact of area-wide control. Research also needs to examine the impact of newer insecticides vs. current OP standards in terms of in-season suppression.
- Chemical of host trees likely plays a major role in selection of oviposition sites. Detailed understanding of all aspects of borer ecology will be needed if we are to minimize utilization of broad spectrum, residual pesticides.

Miscellaneous insect pests

- Thrips, grasshoppers, aphids, scarab beetles (Japanese beetles, green June beetles and May beetles) are occasional, but damaging, pests that are included in the peach insect pest complex. Often these pests are particularly problematic during bloom (thrips), or immediately before or during harvest (thrips and scarab beetles).
- Insufficient knowledge of pest biology hampers our ability to effectively manage these occasional insect pests.
- *Peach labels are needed* for low-risk insecticides such as *diflubenzuron (Dimilin) for in-season grasshopper control*, and nicotinoids, possibly *acetamiprid (Assail) or thiacloprid (Calypso) with short pre-harvest intervals, for scarab pests*. These tools would diminish the need for additional OPs or carbamates.

Pest Name: **Thrips (primarily western flower thrips)**

Distribution, damage and importance:

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

Control measures used and recommended:

Cultural/mechanical

- None.
- Flailing blooms over a cigar box provides some indication of relative thrips abundance.

Biological

- None.

Chemical

- Methomyl (Lannate) and formetanate chloride (Carzol) are carbamates that may not fare well in re-registration, accordingly they should not be regarded as long-term management options for thrips in peaches.

Chemicals used:

Organophosphates

- None

Carbamates

- methomyl (Lannate)
    - Good thrips efficacy. Inhalation toxicity risks to applicators are a concern.
    - Has a Section 3 label for peach; it is not labeled on nectarine or plum.
    - Methomyl has a nectarine label in CA and AZ.
- formetanate HCL (Carzol)
    - Carzol is the standard thrips material on peaches and nectarines; it is not labeled on plums. Also controls plant bugs and stink bugs.
    - Not labeled for use after petal fall.

Spinosyn

- spinosad (SpinTor)
  - Spinosad provides good control of thrips.
  - A 'reduced risk' material that offers an excellent worker safety margin for growers who bloom thin.
  - Spinosad's lengthy pre-harvest intervals (peach 14-days, plum and nectarine 7-days) are problematic. Its stone fruit label should be amended to allow use 1 to 3 days pre-harvest, as growers have no control options for managing thrips that move to peaches as the fruit break color.
  - Spinosad's risk of resistance development is high, new alternative materials are needed.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

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

Regulatory

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

Education

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

Pest Name: Plant bugs and stink bugs: tarnished plant bug, leaf footed bug, brown, dusky, green, and southern green stink bugs

Distribution, damage and importance:

- Plant bugs and stink bugs are occasional pests that, when abundant, can be quite damaging. Plant bug and stink bug injury is associated with disfigurement of the fruit. Cells are killed at the feeding site while adjacent cells continue to grow, progressively damaging the fruit.
- Stink bug feeding that coincides with wet weather often exacerbates brown rot infections. Stink bug feeding carries fungal spores past (beneath) the fruit's protective fungicide barrier.
- Plant bugs and stink bugs are difficult to manage. Residual insecticidal control is poor. Inadequate sampling options and the mobility of these pests, which facilitates ready movement from host to host, further complicates management attempts.
- Early-season feeding results in cat-facing deformation of fruit. Feeding closer to harvest results in corky and/or water soaked lesions.

Control measures used and recommended:

Cultural/mechanical

- Orchard floor management is a seminal consideration in management of plant bugs and stink bugs in the peach system. Damage occurs first, and is most severe, on the edges of orchards and in weedy orchards. Floor-management programs selectively control broadleaf plants on the orchard floor, which makes orchards less attractive to plant bugs and stink bugs. Floor management suppresses pest abundance, thereby improving insecticide performance. When done pre-bloom, broadleaf suppression also minimizes exposure of bees to insecticides.

Biological

- None

Chemical

- Effective insecticide options which do not induce other pests are needed for stink bugs. Azinphos methyl is the most effective remaining material. AZM use in peach will cease after the 2006 season.
- Fenpropathrin (Danitol) is a good stink bug material, but like other pyrethroids, it is expected to aggravate scale and mite problems.
- Well-timed insecticides are a key complement to floor management in good management systems for plant bugs and stink bugs.

- There are some currently unregistered chemicals that may offer plant bug control:
    - thiamethoxam (Actara)
        - Moderate toxicity to plant bugs and stink bugs.
        - Thiamethoxam's peach label allows only one post-bloom application. Its use should remain on mitigation of phosmet's chronic worker safety concerns. Accordingly, its value as a stink bug control will be limited.
    - thiacloprid (Calypso)
        - Moderate toxicity to plant bugs and stink bugs.

Chemicals used:

Organophosphates

- azinphos methyl (Guthion or Sniper)
    - The best broad spectrum, in-season peach insecticide.
    - Use of AZM for PC, OFM, scale crawlers or suppression of lesser peachtree borer provides good control of plant bugs and stink bugs.
    - AZM use in peaches will cease after the 2006 season.
- phosmet (Imidan)
    - Phosmet is the key in-season peach insecticide. It provides a moderate level of short-term plant bug and/or stink bug control.

Pyrethroids

- esfenvalerate (Asana)
    - Provides short-term control, similar to that of phosmet.
    - Post-bloom use of pyrethroids frequently upsets IPM programs by decimating beneficial mites and insects, and it 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)
    - Slightly less efficacious than esfenvalerate.
    - Permethrin shares all of the IPM concerns noted for Asana.
- Gamma cyhalothrin (Proaxis) efficacy against plant bugs and stink bugs in the peach systems is not known. Experience in cotton suggests good potential.
- Lambda cyhalothrin (Warrior) efficacy against plant bugs and stink bugs in the peach systems is not known. Experience in cotton suggests good potential.

Chlorinated hydrocarbons

- endosulfan (Thiodan)
    - Moderate control.
    - Long pre-harvest interval limits use.
    - Some processors prohibit use.

Carbamates

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

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- Develop and implement a reliable monitoring system for plant bugs and stink bugs to include monitoring these pests in the canopy.
- Work with pheromones for monitoring and possible control.
- Develop treatment thresholds which would reduce reliance on preventative insecticide use on these pests.
- Screening and development of new compounds, to include biopesticides.

Regulatory

- Expedite registration of new insecticides.
- Register additional broadleaf herbicides to reduce alternate hosts of these pests.

Education

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

Pest Name: Scarab beetles: rose chafer (RC), green June beetle (GJB) and Japanese beetle (JB)

Distribution, damage and importance:

- RC and GJB are fruit feeders; JB is typically a foliage pest but may attack fruit, particularly in orchards where bacterial spot has created open wounds.
- Rose chafer is a serious pest in the upper Mid-West and an occasional pest in the Mid-Atlantic states; it is seldom a pest in the Southeast.
- GJB is a serious fruit-feeding pest of late-season peaches in the Southeast.
- Larvae of rose chafer, green June beetle and Japanese beetle feed on the roots of grasses and prefer sandy soils.
- Fruit-feeding adults of RC and GJB are especially abundant where peaches are grown adjacent to grassy fields or pastures fertilized with manures.
- Rose chafers and green June beetles are voracious feeders, rendering the peaches they feed on unmarketable.
- Chemical control options for at-harvest scarab beetles are quite limited. Effective, non-nicotinoid insecticides with $\leq$ 7-d pre-harvest intervals are needed to provide meaningful resistance management options.

Chronology:

- RC adults emerge in the spring and migrate to peach orchards to feed and mate.

Control measures used and recommended:

Cultural/mechanical

- Mass trapping provides some suppression, it may be feasible for small pick-your-own orchards that sell fruit for higher prices.

Biological

- None

Chemical

- Imidacloprid (Provado) is the material of choice for either RC or GJB. Its short pre-harvest interval is especially useful for controlling GJB at harvest.
- Azinphos methyl and phosmet are, at best, marginally effective for control of RC. They are moderately effective in controlling green June beetle.
- Multiple applications may be required, as beetles tend to aggregate and may move into orchards in inundative numbers for periods of up to 4-5 weeks.

- There are some unregistered materials that may provide RC or GJB control:
    - kaolin
        - Decent efficacy, however persistent white residue adhering to fruit at harvest precludes use on fresh market peaches.
    - azadirachtin (Azatin XL Plus, Neemix)
        - Repellency effect.
        - Very short lived.
    - thiamethoxam (Actara)
        - Moderate lethal effect.
        - Good feeding deterrence, but 14-day PHI and single post-bloom use greatly diminish Actara's use for scarab beetle control.

Chemicals used:

Organophosphates

- azinphos methyl (Guthion, Sniper)
- phosmet (Imidan)
- Azinphos methyl and phosmet are, at best, marginally effective for control of rose chafer; they are moderately effective in controlling green June beetle.
- Azinphos methyl use in peach ends following the 2006 season.

Carbamates

- carbaryl (Sevin)
    - *Carbaryl is quite important. It is the sole available broad spectrum insecticide with a short (3-day) pre-harvest interval.*
    - Carbaryl performance varies, generally in a range of 60-80%.
    - Carbaryl is highly toxic to beneficial insects.

Pyrethroids

- esfenvalerate (Asana)
    - Inexpensive, but pyrethroid use decimates beneficial mites and insect complexes and often leads to mite or scale outbreaks.
    - Provides about 60% control, residual control is very short.
    - Esfenvalerate's 14-day PHI greatly limits its value for control of scarab beetles pre-harvest.

Chlornicotinyls

- imidacloprid (Provado)
    - Provado is the material of choice for pre-harvest scarabs. However, it offers nothing for control of other pre-harvest pests.
    - Provado is a low-risk material with a short pre-harvest interval, making it easily compatible with hand labor operations such as thinning and harvesting.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- Screening/developing new products.
- Potential of various attractants and repellents.
- Effectiveness of kaolin and azadirachtin alone or in combination with mass trapping.
- Traps for population monitoring.

Regulatory

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

Education

- Programs will be needed as new options become available.

Pest Name: **Leafrollers, and other fruit and foliage feeding lepidopterous pests: Obliquebanded leafroller (OBLR), Tufted apple bud moth (TABM)**

Distribution, damage and importance:

- Leafrollers are a complex of fruit pests; OBLR is the key leafroller pest of peaches in the Mid-Atlantic and upper Mid-Western production areas. Tufted apple bud moth is an occasional peach pest in cooler southeastern production areas if apples are also grown nearby.
- 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 must be culled.

Control measures used and recommended:

Biological

- Potential for biological control.
- Pheromone-based mating disruption is not effective as a stand-alone control, supplemental insecticide sprays are needed.
- *Bacillus thuringiensis* (Dipel, Javelin, etc.) is temperature sensitive. The weather is often too cool in Michigan to allow for good efficacy. Additionally, B.t. has a very short residual and multiple applications are required.

Chemical

- In areas where apples are also grown, primarily the Mid-West and Mid-Atlantic regions, OBLR and TABM are frequently resistant to OPs.
- 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.

Chemicals used:

Organophosphates

- azinphos methyl (Guthion, Sniper)
  - Leafroller resistance to OPs is present in apple/peach production areas as far south as the north Georgia mountains, where peaches are grown in association with apple production.
  - AZM's use on peaches will cease after the 2006 season.
- phosmet (Imidan)
  - OP resistance minimizes the effectiveness of phosmet in apple/peach production areas.
  - Processors, small markets in MI and SC, restrict 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.
- spinosad (SpinTor)
  - Good efficacy at high rate, but is only moderately effective against leafrollers.
  - Very costly and its short residual necessitates multiple applications.
- pyriproxyfen (Esteem)
  - Limited potential. Small plot trials suggest suppression of feeding, but not lethality.
- methoxyfenozide (Intrepid)
  - Testing against leafrollers in peaches has been limited, but methoxyfenozide offers long residual and good efficacy against these pests in apple, hence would probably work in peaches.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

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

Regulatory

- 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).

Education

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

Pest Name: **Two-spotted spider mite (TSSM), European red mite (ERM)**

Distribution, damage and importance:

- Mites are typically less problematic in peaches than other tree fruit; infestations have become more common and in some blocks require occasional use of curative miticides. A few growers make use of preventative miticides.
- 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.
- Mites have historically been very minor pests of peaches. However, changing pesticide use patterns seem to have stimulated greater mite abundance. Peaches are more tolerant of mites than most deciduous fruits, but scattered problematic infestations that require treatment have become a yearly occurrence. Peach-specific mite thresholds, identification of mite bio-control agents in peach, and determination of how various pesticides influence the abundance of mites and their natural enemies are long-term research needs.

Chronology:

- TSSM overwinters on the ground.

Control measures used and recommended:

Cultural/mechanical

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

Biological

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

Chemical

- Pyrethroid use exacerbates mite problems.
- Dormant oil(s) for scale provide ERM control; oil does not suppress TSSM which overwinters in the ground litter.
- Unregistered miticides:
  - abamectin (Agrimek) [Macrocylic lactone]
  - milbamectin (Koromite & Mesa)
- Though it has not been documented in-orchard, thiamethoxam and other nicotinoids are viewed as mite-builders in ornamental crops.

Chemicals used:

Organophosphates

- None

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.

Organotins

- fenbutatin oxide (Vendex)
  - Slow acting curative miticide, moderately effective.
  - Safe on beneficials.

Carbazates

- bifenazate (Acramite)
  - Fast acting.
  - Excellent curative miticide for TSSM, typically the key mite of peach; requires higher rate for ERM.

Pyridazinone

- pyridaben (Pyramite)
  - Fast acting.
  - Excellent curative material for ERM, requires higher rates for TSSM.
  - Moderate toxicity to beneficials.

Tetrazines

- clofentezine (Apollo)
  - Primarily an ovicide.
  - A preventative material, which limits its use in peaches.

Carboxamides

- hexythiazox (Savey)
  - Primarily an ovicide.
  - A preventative material, which limits its use in peaches.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- Develop treatment thresholds.
- Screening and development of new compounds.
- Better tools to help target the timing of sprays.
- Potential for biological control.
- Mite scouting protocols for peaches.

Regulatory

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

Education

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

Diseases and Nematodes General Overview

The primary fruit diseases of eastern peaches are brown rot, bacterial spot and peach scab. Anthracnose and powdery mildew, rusty spot and phomopsis rot are also important pests, though their severity varies by season, location and environmental conditions. Tree diseases are too often under-estimated, but, over time, they severely impact orchard productivity, longevity and replant success. Armillaria root rot, nematodes, phytophthora root and crown rot, constriction canker and other below- and above-ground pathogens affect tree health, replant success, orchard establishment and longevity.

High pest pressure and diversity, coupled with an obvious need for effective resistance management, make availability of varied efficacious fungicides, bactericides and nematicides imperative. Stable, profitable systems require on-going access to pesticides of varied modes-of-action to provide valuable, affordable alternatives for use in rotations and tank mixes. Availability of disease control materials with sufficient range of activity to successfully manage disease in moist, disease-prone eastern peach-producing areas is a key priority.

Resistance management is a major, on-going need that must be aggressively addressed. *Older protectant fungicides are invaluable resistance management tools.* It is also significant that several presently minor diseases can only be controlled with some of the older, broad-spectrum fungicides. Several materials expected to undergo regulatory scrutiny are important management tools: the protective fungicides (such as captan, chlorothalonil and ziram), the antibiotic oxytetracycline, and the nematicide dichlropropene. Each of these materials is the sole control, the material of choice, or a valuable resistance management tool for one or more important diseases of eastern peaches.

Azoxystrobin (Abound) is a primary tool for managing DMI resistance. Azoxystrobin is a member of the quinone outside inhibitor class [QoI (also known as strobilurins)]. QoIs are low-risk fungicides with their own unique modes of action. Unfortunately, both DMI and QoI classes of chemistry have potential for resistance development, and a shift toward DMI-resistant *Monilinia fructicola* strains has already been documented. QoIs (strobilurins) are felt to be even more resistance prone than the DMIs. Accordingly, it is strongly recommended that the new, low-risk fungicide Pristine, a prepackaged mix of boscalid plus the QoI pyraclostrobin, be utilized as the last pre-harvest brown rot application. In wet, high disease pressure circumstances, a rotation of pre-harvest brown rot fungicides would often utilize captan or azoxystrobin (Abound), followed by a DMI (fenbuconazole, propiconazole or tebuconazole), followed by the boscalid plus pyraclostrobin mix (Pristine). Post-harvest control of brown rot is limited to one very valuable material, fludioxonil (Scholar).

Several of the protectant materials are the only fungicide options for diseases that are presently secondary pests. It can also be persuasively argued that, without these materials, current secondary fungal diseases might assert themselves as key pests. Pathologists should consider lesser peachtree borer's elevation to key pest status when efficacious insecticides were lost.

Resistant varieties have much to offer when they are competitive, but often this is not the case. Peach seasons are progressions of cultivars which ripen sequentially from early- to late-season. Each period of ripening, typically around 10 days, is defined by its dominant cultivar. In the Southeast there are no highly resistant cultivars capable of competing successfully in the marketplace against the dominant standards, which are often quite susceptible to bacterial spot. Growers utilize the cultivars which sell well; regrettably, many of the more disease resistant cultivars are not competitive. 1,3-dichloropropene (Telone II) is an extremely valuable tool for maintenance of orchard longevity. 1,3-dichloropropene, in combination with Guardian rootstock, is consistently the most productive, long-lived management program for short life sites. Any combination of cultural control and/or host plant resistance is dramatically enhanced by addition of the nematicide.

Disease and Nematode Research and Regulatory Priorities

Research

- A fuller understanding of the brown rot pathogen's biology and epidemiology is needed to improve timing of sprays and to develop more insightful resistance management strategies.
- There is an on-going need for additional research to optimize the use of fungicides in the pre- and post-harvest environment.
- Low-risk, cost-effective, fungicide, bactericide and nematicide chemistries are needed for managing virtually all peach diseases and to provide more stable, robust resistance management programs for key diseases such as brown rot and bacterial spot.
- A more detailed understanding of the biology and epidemiology of peach diseases is a compelling need that negatively impacts key and minor pathogens alike.
- Development of more biologically refined, reliable, cost effective controls that emphasize use of low-risk management options to mitigate dietary, worker or environmental concerns is dependent on development of a more comprehensive knowledge base.
- Improved resistance management in high-value, chemical-dependent systems such as peach will continue to be an on-going need.
- Bacterial spot programs need a much improved understanding of pathogen biology, continued availability of coppers and oxytetracycline, labels for any effective, lower risk controls, full development and regional validation of a pest model, and germplasm evaluation for host plant resistance with subsequent incorporation of resistance into the most commercially competitive selections season-long.
- Research on nematode control must focus on pest biology, resistant rootstocks, cultural controls and examination of low-risk materials with nematicidal activity.
- Captan, botran and syllit are older non-DMI chemistries. They are critically important for control of Rhizopus and Gilbertella rots, and they are key resistance management tools for brown rot.
- Research to develop pre-plant sampling technologies to specifically locate Armillaria-infested sites within fields, biological and/or chemical controls and resistant rootstocks are needed.
- Research is badly needed to provide a more in-depth understanding of Armillaria root rot and constriction canker, for evaluation of germplasm for potential host plant resistance, assessment of biocontrol options, pre-plant sampling technology for Armillaria, and identification of effective, preferably low-risk fungicide chemistries.
- No meaningful chemical controls are available for Armillaria root rot or constriction canker. Efficacy screening of new compounds should be a priority.

Regulatory

- Registration of additional low-risk post-harvest fungicides is a priority need that should be expedited.

Pest Name: **Brown Rot**

Distribution, damage and importance:

- Brown rot, *Monilinia fructicola*, is the most consistently injurious fruit disease of eastern peaches.
- *Monilinia fructicola* causes disease during several stages of peach development: blossom blight, green fruit rot, and pre- and post-harvest brown rot.
- Blossom blight occurs sporadically, it is commonly observed when sufficient inoculum is available during wet bloom periods. Blossom blight alone is normally insufficient to reduce yield. It is however a concern, as it increases inoculum levels early in the season which may increase fruit rot.
- Green fruit rot is not common, but when present it can be a very serious source of inoculum for pre-harvest brown rot.
- 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.

Control measures used and recommended:

Cultural/mechanical:

- 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.

Chemical:

- Fungicides are essential tools for managing blossom blight. Rotations of non-DMI fungicides, such as captan, chlorothalonil, cyprodinil and very occasionally thiophanate methyl, are strongly recommended for blossom blight. *M. fructicola,* the blossom blight/green fruit rot/brown rot pathogen, has a history of rapidly developing resistance, use of this fungicide rotation during the blossom blight phase minimizes selective pressure on the key DMI and strobilurin fungicide classes.
- Demethylation inhibitor fungicides (DMIs) are key elements of pre-harvest brown rot control programs. DMI fungicide-resistant strains of *M. fructicola* have been confirmed in several Georgia orchards, serving notice that brown rot programs must maintain rotations of dissimilar modes of action.
- Captan, a multi-site fungicide, is a vital resistance management tool. The advent of brown rot strains resistant to DMI fungicides strongly reinforces the importance of captan. Captan remains an acceptable fungicide for use against any of *M. fructicola*'s stages. It is often the best option against green fruit rot and it is very important as a component of pre-harvest fungicide when high disease pressure requires multiple sprays. Captan's value is further increased by its ability to simultaneously protect the important, but resistance-prone, strobilurin class [azoxystrobin (Abound), trifloxystrobin (Flint) and the strobilurin/anilide tank-mix Pristine]. Captan use against blossom blight and/or green fruit rot normally allows strobilurin use to be focused on pre-harvest management of DMI resistant brown rot strains.

- Thiophanate methyl (Top Sin-M) is the sole remaining member of the methyl benzimidazole carbamate (MBC) class of fungicides. Brown rot resistance to MBC fungicides is widespread; accordingly thiophanate methyl's most common use is occasional selective use for scab control. In orchards with a history of MBC resistance, use of thiophanate methyl (Top Sin-M) is sometimes very effective in orchards where it formerly failed. Use against any brown rot stage should be limited to perhaps one application every third year, if, and only if, brown rot mummies from that block have been subjected to lab analysis indicating renewed susceptibility. When used, thiophanate methyl should be tank mixed with captan, which strengthens its performance as a non-DMI rotational option.
- Chlorothalonil (Bravo, Equus) is a broad spectrum, early-season fungicide (early bloom to shuck split) which offers excellent scab efficacy and very good control for blossom blight. Scab control is chlorothalonil's most important use, but use as a bloom spray provides an additional effective mode of action which is dissimilar to both the DMIs and the strobilurins.
- Integration of newer fungicides into management programs is necessary to provide some level of resistance management while maintaining acceptable disease control.
- Strobilurin or QoI fungicides are relatively 'new' materials in peaches, but they are extremely important materials for management of brown rot, scab and anthracnose. The QoI class is itself resistance-prone; multiple pathogens quickly developed resistance to strobilurins in other cropping systems. QoI labels typically preclude or discourage back-to-back applications. While this is doubtless helpful, prudent use of strobilurins is dependent on well planned rotations using fungicides of dissimilar modes of action. Without efficacious rotations, the QoI fungicides can be expected to be short lived in peaches. Stable disease management programs will feature QoI fungicides as brown rot materials, while maximizing captan use against scab and anthracnose as a means of reducing inadvertent selective pressure for brown rot resistance outside of the crucial pre-harvest period.
    - The strobilurin or QoI class fungicides azoxystrobin (Abound), trifloxystrobin (Flint), and pyraclostrobin (strobilurin component of Pristine) share a similar mode of action. They have the same site of action (Target Site Group 11). Pristine is a pre-packaged tank mix of pyraclostrobin (Target Site Group 11) and the anilide fungicide boscalid (Target Site Group 7). While tank mixing of efficacious materials of dissimilar mode of action is an accepted resistance management strategy, pyraclostrobin remains a strobilurin; it should not be rotated with other strobilurins (Abound or Flint). The most reliable means of preserving fungicide efficacy is to rotate it with other fungicide classes which have dissimilar modes of action.
- Azoxystrobin (Abound) is an imperative tool in managing the brown rot pathogen, which has begun developing resistance to the DMI fungicides (Orbit, Indar, Elite). Azoxystrobin is also quite active against scab and anthracnose; however, it is more prudent to control these diseases with captan as a means of limited azoxystrobin use to the more valuable role of serving as pre-harvest brown rot material.

- Pristine [pyraclostrobin (TSG 11) plus boscalid (TSG 7)] has shown itself to be a key component in the post-harvest brown rot fungicide rotation. Often Pristine is the last in a series of two, three, or, in extreme cases, four pre-harvest brown rot fungicide applications. When brown rot pressure is extremely high, a rotation of captan, followed by azoxystrobin, then a DMI [propiconazole (Orbit), fenbuconazole (Indar) or tebuconazole (Elite)], finishing with Pristine (pyraclostrobin and boscalid tank-mix) would be recommended.
- Blossom blight control is recommended to minimize the build-up of *M. fructicola* inoculum, which can result in heavier pre-harvest brown rot pressure. Yield loss from blossom blight is seldom significant. Use of blossom blight materials which do not have a place in pre-harvest brown rot rotations is strongly recommended. Accordingly, use of chlorothalonil, cyprodinil (Vangard), captan, or, where efficacious, thiophanate methyl/captan tank mix is recommended as a means of protecting the brown rot efficacy of both the DMI and strobilurin classes.
- Green fruit rot may result in yield loss, but uncontrolled green fruit rot is all but certain to increase pre-harvest brown rot pressure. Accordingly, use of captan is strongly encouraged as a mechanism for controlling green fruit rot without increasing selective pressure on the DMIs (brown rot) or the strobilurins (scab, brown rot, anthracnose). Captan is also the material of choice for anthracnose. It is important that fungicides are available to provide blossom protection to reduce inoculum. 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.
- Unregistered Fungicides & Potential Stone Fruit Uses
    - Strobilurins

Chemicals used:

Demethylation inhibitors (DMIs)

Resistance management is a primary concern with this essential class of brown rot fungicides. DMI-resistant strains of brown rot have been documented in isolated GA orchards. To this point, even in DMI-resistant blocks, these materials remain important components of pre-harvest brown rot rotations to minimize overuse of the important, but resistance-prone, strobilurin class.

- propiconazole (Orbit)
    - Typically seen as the DMI standard, quite heavily relied on for pre-harvest brown rot control.
- fenbuconazole (Indar)
    - Indar has often been relied on when disease pressure is greatest, though the advent of DMI-resistant strains have prompted a shift to Pristine, an anilide/strobilurin tank-mix, for the crucially important final pre-harvest fungicide application.
- tebuconazole (Elite)
    - Elite has frequently been used in the last pre-harvest application, though as noted above fear of DMI-resistant brown rot has dramatically limited the wisdom of using more than one pre-harvest DMI.

- myclobutanil (Nova)
    - Nova has poor brown rot efficacy. It is generally not recommended for brown rot control. Nova's most often use may be as a mid-season control for rusty spot (powdery mildew).

Methyl benzimidazole carbamates (MBCs)
MBCs are resistance prone and should be used judiciously; likely no more than once every three years. In blocks where testing has confirmed efficacy, thiophanate methyl can be an occasional-use ($\geq$ 3 year rotation) non-DMI alternative for blossom blight.

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

Dicarboximides

- iprodione (Rovral)
    - The sole remaining dicarboxamide fungicide with stone fruit labels.
    - Important because it provides an alternative, non-DMI toxic mode of action, which is quite important as a resistance management tool.
    - Labeled for use as a blossom blight spray only in both peach and plums.
    - Brown rot resistance to iprodione and other dicarboxamides exists, so these materials must be used with caution.
    - Rovral has some activity against *Botrytis* and gummosis.

Anilinopyrimidines

- anilopyrimidine (Vangard)
    - Labeled for control of blossom blight phase only.
    - 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)
    - A key component of brown rot rotations.
    - Offers another resistance management tool.
    - Also effective against scab and anthracnose. DMI-resistant brown rot favors use of captan for these diseases, saving azoxystrobin and Pristine for pre-harvest brown rot.

Multi-Site fungicides

- chlorothalonil (Bravo, Equus)
  - EPA has some concern that chlorothalonil is a potential carcinogen. Its risks in this area are less than those of captan.
  - 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.
- captan
  - 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.
- fludioxinil (Scholar)
  - Post-harvest use in stone fruit is presently allowed under the auspices of state-to-state Section 18 registrations.
  - Highly efficacious material.
  - Deemed a safe, low-risk material.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- Improved brown rot management options can only be achieved as research provides a more detailed understanding of disease epidemiology, 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 and bio-based products.
- Steps to minimize the risk of brown rot developing resistance to the DMIs.

Regulatory

- 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.

Education

- Demonstrate resistance management to minimize the risk of brown rot developing resistance to the DMIs.

Pest Name: **Bacterial spot** (*Xanthomonas arboricola* pv. *pruni*, syn. *X. campestris* pv. *pruni*)

Distribution, damage and importance:

- Bacterial spot can, in years that are favorable to its development, be devastating to all but the most resistant cultivars. Fruit losses may approach 100% on moderately and highly susceptible cultivars if conditions are favorable for disease and controls are not applied.
- In Southeastern and Mid-Atlantic production areas, highly susceptible cultivars (20% to 30% of bearing acreage) are dependent on chemical control of bacterial spot every year.
- Affects fruit, leaves, and twigs.
- Economic loss occurs when fruit are infected.
- Existing controls are extremely important, but they are not as consistently effective as controls for scab and brown rot.

Control measures used and recommended:

Cultural/mechanical:

- Host plant resistance is the optimal management tool for bacterial spot. However, all but the most resistant cultivars require a basic complement of two to four early season chemical applications, with additional applications being needed when weather conducive to high pest pressures persists.
- Though resistant cultivars are available, many of the more profitable cultivars currently in commercial production are moderately to severely susceptible to bacterial spot.

Biological:

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

Chemical:

- In years favorable to bacterial spot, moderately spot susceptible cultivars (40% to 60% of the bearing acres) require at least early season spray regimes for bacterial spot.
- Copper compounds are the basis for early season bacterial spot management programs. 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.
- Early season coppers should be applied to essentially all cultivars when conditions favor disease. Unfortunately, coppers become progressively more phytotoxic as peach development moves past fruit set. Escalating phytotoxicity severely limits in-season use. Additionally, numerous bacterial spot strains have developed resistance to coppers.

- Oxytetracycline (Mycoshield) is vital to the eastern peach industry. It is used after bloom and up to 21 days before harvest on a 7- to 14-day spray interval depending on weather conditions, and is the only available in-season bactericide in peach. Oxytetracycline does not have resistance problems with bacterial spot of peach, despite years of heavy use. Any restriction in its availability would be detrimental to Southeastern and Mid-Atlantic peach production alike.
- Without oxytetracycline, bacterial spot would devastate many currently utilized cultivars in years of either moderate or high bacterial spot pressure.
- Zinc sulfate is a currently unregistered material that may display bacterial spot control.

Chemicals used:

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.
    - Extremely important for in-season control of bacterial spot. Coppers are impractical except for early-season use due to the phytotoxicity. In years truly conducive to bacterial spot, essentially 100% of the bearing acreage planted to sandy land requires regular Mycoshield use to mature a sellable crop. Bacterial spot is less intense on clay soils, but when conditions for bacterial spot are optimal, all acreage should be treated.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- 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 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.

Regulatory

- 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.

Pest Name: Armillaria root rot and constriction canker

Distribution, damage and importance:

- A virulent, highly persistent tree-killing pest. Infested sites cannot be used for peaches.
- Armillaria root rot and constriction canker are locally devastating diseases for which there are no worthy management options, chemical or otherwise.

Control measures used and recommended:

Chemical:

- No consistently effective materials are available.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- Resistant rootstocks currently under evaluation are the hoped-for tool to mitigate this disease. Research on all phases of Armillaria biology, natural enemies of the fungus, and low-risk chemicals for use pre- and post-plant are important priorities. Sampling tools to specifically locate Armillaria-infested sites would be a boon to growers.

Pest Name: **Viruses**

Distribution, damage and importance:

- Viruses can be devastating to peach culture.
- No controls exist for cleaning up virus-infested trees.
- Remediation for serious viruses, such as plum pox, requires orchard termination.

Control measures used and recommended:

Cultural/mechanical:

- In long-term perennials such as peach, the threat of viruses reiterate the importance of annual screening of propagative material, stringent nursery fidelity to rootstock and scion sources, and isolation of tree nurseries away from major production areas and from areas where key insect vectors are abundant.

Biological:

- None

Chemical:

- None

Chemicals used:

- 1,3-dichloropropene (Telone II) is a pre-plant nematicide which is crucially important to the tree nursery industry. Though not directly involved in freedom from viruses, 1,3-dichloropropene is extremely important as a complement to rotation in nursery nematode IPM programs.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Pest Name: **Nematodes**

Distribution, damage and importance:

- 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.

Control measures used and recommended:

Cultural/mechanical:

- Cultural practices for control are mainly limited to crop rotation strategies.
- Root stock selection is also a very important control measure.

Chemical:

- 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.
- 1,3-dichloropropene is regularly employed as a pre-plant nematicide, augmented by use of Guardian rootstock and cultural management. 1,3-dichloropropene is absolutely imperative for maintenance of commercially competitive orchard longevity on replant sites and to assure availability of clean, nematode-free planting stock.

Chemicals used:

- methyl-bromide (Brom-O-Gas, Meth-O-Gas, and other names)
  - 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)
  - 1,3-dichloropropene is the dominant nematicide used in peaches.
  - Provides excellent pre-plant nematode control.
  - Deep-shank injected and sealed with a water or soil seal.
  - An integral part of nematode control in peach orchards. When combined with good rootstocks, control can be excellent.

- metam-sodium (Vapam)
  - Applied preplant.
  - Generally roto-tilled into the soil.
  - 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)
  - Applied post-plant in the fall for suppression of major peach nematodes.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- Development of safe alternatives to current nematicides.
- Continued development of nematode-resistant rootstocks.
- Development of cultural and biological alternatives to chemical nematicides.

Regulatory

- Maintain current nematicides, especially in light of the scheduled loss of methyl bromide.
- Expedited registration of safer, effective nematicides.

Pest Name: Constriction canker and phomopsis twig blight

Distribution, damage and importance:

- Management options typically target two important peach diseases: constriction canker and phomopsis twig blight.
- These two diseases, for which there are no effective chemical control options, dramatically reduce the tree's capacity to produce and support fruiting wood.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

- The biology of the constriction canker organism should be studied in detail. Efforts should be made to identify and examine the potential utility of any natural antagonists or enemies. A thorough examination of *Prunus* germplasm should be made to identify degrees of susceptibility and resistance material.

Education

- Education should focus on teaching growers about this disease and sharing cultivar susceptibility data.

Pest Name: Scab (*Cladosporium carpophilum*)

Distribution, damage and importance:

- Scab is a major disease in the humid peach production regions east of the Rocky Mountains.

Control measures used and recommended:

Cultural/mechanical:

- 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.

Biological:

- None

Chemical:

- 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 two unregistered strobilurin class, reduced-risk fungicides which may display scab control, trifloxystrobin (Flint) and BAS 500 F (Cabrio). Strobilurins have a high potential for cross-resistance, and this class is now seen as vital to management of DMI-resistant brown rot strains.

Chemicals used:

Sulfur (a multi-site fungicide)

- A reduced-risk fungicide.
- Requires more frequent spraying (7- to 10-day intervals are more common with sulfur than 14-day intervals) for satisfactory control.
- Very widely used in middle Georgia, where scab potential tends to be lower.
- 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.

Captan (a multi-site fungicide)

- The long-term standard against which other scab materials are evaluated.
- Very widely used in most eastern peach production areas, especially during the critical early-season period when scab is often most severe.
- Also important for anthracnose control.

chlorothalonil (Bravo, Equus) (a multi-site fungicide)

- EPA has some concerns that chlorothalonil is a potential carcinogen. Its risk is lower than that of captan.
- 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
- A very important tool for blossom blight, an effective non-strobilurin-non-DMI.

Strobilurins

Resistance management is an imperative for the strobilurins. No more than two consecutive applications of strobilurins before rotating with another fungicide class; eliminate non-essential uses to focus on pre-harvest brown rot management.

- azoxystrobin (Abound)
  - A reduced-risk fungicide.
  - More efficacious than sulfur.
  - Use for scab should be very limited. Replace with captan, saving strobilurins for pre-harvest brown rot.

Methyl benzimidazole carbamates (MBCs)

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.

- thiaphanate methyl (Topsin-M)
  - Has excellent scab efficacy against populations that have not developed Benlate resistance.
  - Also an occasional but valuable option for control of brown rot blossom blight.

State/local pesticide restrictions or limitations, export issues, etc.:

- None

Critical issues:

Research

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

Regulatory

- Captan or chlorothalonil are extremely important for resistance management. Continued availability, even if usage options were narrowed, is a priority.
- Effective reduced-risk fungicides other than strobilurin class are a key need.

Other Diseases

- Anthracnose, phomopsis, and botryospheria pocket rots are occasional, but serious, diseases that can be managed with either captan or azoxystrobin (Abound). Wherever possible, strobilurins should be saved for pre-harvest brown rot.
- Rhizopus rot and Gilbertella rot outbreaks require use of DMI fungicides. Brown rot resistance management efforts rely on restricting DMI use to the key pre-harvest period, and alternating as much as possible with non-DMI chemistries.

Soil and Root Diseases

- *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 which are relatively minor under current management 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 their minor importance, insufficient research has been done with these diseases. Detailed information is needed to address the epidemiology, etiology and fungicidal sensitivity of the pathogens which cause these diseases.
- *Constriction canker is not controlled effectively by current fungicides or cultural controls.* Additional examination of disease biology and evaluation of new control options is a clear research need. Screening of germplasm to classify susceptible and more tolerant cultivars and initiate breeding to improve commercial lines is an obvious need.

Orchard Floor Management General Overview

Orchard floor management (OFMG) programs are holistic pest management approaches that consider the impacts of weeds on orchard productivity and longevity. Weeds in peaches, and other long-term perennial orchard systems, should be managed within systems that consider the impacts of weeds on tree performance from establishment through the final years of production. The OFMG program of choice for eastern peaches uses herbicides to maintain bare-ground in the tree row, with vegetation, ideally a grass sod, between rows. The herbicide strip minimizes weed competition directly over the bulk of the trees' productive roots. Grass sod middles reduce erosion by serving as a deceleration strip for runoff water, while providing for improved trafficability for equipment movement through the orchard, especially during periods of wet weather.

Weeds compete readily with trees for water, nutrients, and sometimes light. Weed competition reduces fruit yield, fruit size, tree growth and, therefore, the vigor of mature trees, while dramatically delaying development of young orchards. North Carolina State University research has shown that weeds can reduce tree growth in newly planted orchards by as much as 87%. Such reductions in growth delay orchard development, reducing productivity and return early in orchard life. In established orchards, weed competition reduces total yield, fruit size and crop value. Tree vigor is also negatively impacted by weed competition. In addition to the obvious reductions of yield, fruit quality and return bloom, low vigor trees are more attractive to opportunistic, but injurious pests such as borers and gummosis.

Weed control is critical to the integrated management of other orchard pests. Research has shown that, for each week an orchard is maintained weed-free, marketable fruit yield increases up to 255 lb per acre. Broadleaf weeds are hosts to cat-facing insects. Eliminating broadleaf winter annual weeds from the entire orchard floor reduces cat-facing insect populations, aiding in their management with insecticides. Broadleaf weeds are also hosts to nematodes that vector tomato ring spot virus. In the cooler production areas of the Southeast and in the Mid-Atlantic production areas, it is critical that broadleaf weeds be controlled to prevent population increases of dagger nematodes, which vector viruses, in effect mitigating the gains otherwise provided by pre-plant nematicide application. Voles, rodent pests that can be significant causes of tree mortality, are strongly favored by vegetation beneath and around trees. Weeds provide overhead cover, which protects voles from predators and serves as a source of food and water. 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, which can be crucial during spring frost-freeze events. Bare soils absorb heat from the sun, which is released during the evening hours, modestly warming the orchard. Orchards with bare soils are frequently a few degrees warmer during frosty cold events. Although the temperature elevation may be only a few degrees, this is sometimes enough to prevent or reduce fruit losses during spring freezes. Soil surfaces covered with succulent plant material, residual plant mulches, or tilled will be considerably cooler than bare-soil surfaces. Close mowed row middles and orchard perimeters facilitate air drainage out of the orchard and air circulation within the orchard, thus lessening frost and disease potential.

Weeds inhibit worker efficiency in orchards. Peach orchard management is heavily dependent on hand labor for pruning, fruit thinning and harvest. High populations of weeds can inhibit worker mobility and therefore worker efficiency. Some perennial weeds, notably brambles and poison ivy, are especially troublesome. Brambles have briars, which scratch workers and attach themselves to clothes. Poison ivy and poison oak can cause severe skin irritation and rashes.

Herbicide-resistant orchard weeds are a serious and escalating concern. Orchards present especially difficult resistance management challenges, because orchard weeds must remain in a managed state year around. Rigorous in-row weed control must be maintained in a long-term perennial system that is intolerant of tillage. Weed resistance to simazine, oryzalin, pendimethalin, paraquat, and even glyphosate is well documented. Considerable on-going selective pressure favors the development of resistance against the more heavily relied upon herbicides.

Orchard weed resistance management is based on active rotation and tank mixing of pre-emergence herbicides. Addition of non-selective tank mixed post-emergence herbicides further reduces selective pressures which favor resistance development. Non-selective herbicides should be used to control gross failures of pre-emergence herbicides before escaped weed populations have time to develop seed or proliferate vegetatively. Unfortunately, options for rotating to pre-emergence herbicides of dissimilar 'modes of action' are limited by too few available herbicide classes. The registration of new herbicides from classes of chemistry unique to peach would aid resistance management.

Typical weed control programs in established, bearing eastern peach orchards are year around efforts that can be seen as beginning with a fall pre-emergence herbicide application to control winter annual broadleaf weeds in the herbicide strip. Four to six weeks pre-bloom post-emergence herbicides (paraquat or 2,4-D) are used beneath the trees (between the herbicide strips in the sod middles), or tree-to-tree. This late-winter post-emergence application lessens the attractiveness of orchards to plant bugs by controlling winter annual broadleaf weeds that are preferred hosts of sucking bugs. Tree-to-tree herbicide application also burns-down emerged annual weeds and the tops of perennial grasses in the sod middle, which improves retention of radiant energy and re-radiation of heat on cold, still mornings. Later in spring another pre-emergence herbicide is applied in the herbicide strip to provide residual control of summer annual weeds that compete with trees and reduce yield and fruit size. During the summer post-emergence herbicides (paraquat or glyphosate) are used to control perennial grass weeds and escaped summer annual weeds. The cycle is begun again the next fall, as pre-emergence herbicides are tank-mixed with post-emergence herbicides, paraquat or glyphosate.

Weed management in a newly planted orchard begins the summer before trees are planted. Perennial weed species that are particularly difficult to control in established orchards can be managed with some success before trees are planted. Once the young trees are planted, pre-emergence herbicides like flumioxazin, pendimethalin and oryzalin are commonly used for residual pre-emergence weed control. Post-emergence herbicides used during the first year include paraquat, clethodim, sethoxydim, fluazifop, MSMA, bentazon, and clopyralid. Weed management during initial establishment and the following year is critical. Weeds are highly competitive with young trees, which can be severely stunted by weed competition. Returns from young orchards improve most rapidly when good weed control allows rapid tree growth.

Orchard Floor Management Research, Regulatory and Education Priorities

Research

- Determine if sequential herbicide applications could be used to reduce total herbicide rates.
- Determine if irrigation, micro-jet or drip, could be used to reduce the necessary width of tree-row herbicide strips, thereby reducing herbicide use.
- Screen new, lower-risk herbicide chemistries with favorable environmental and toxicological profiles which might reduce reliance on simazine and diuron.
- Screen herbicides for woody perennial weed control in orchards.
- Conduct detailed determinations of specific key weed/peach tree interactions. Species should include common weeds like Palmer amaranth, morning glory species, large crabgrass, bermuda grass, yellow and purple nutsedge, and perennial woody species.
- Determine the significance of weed competition post-harvest on bud development and carbohydrate storage impacting winter hardiness.
- Assess the impact weed control practices have on minimizing tree loss associated with rodent pests such as voles.
- 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 the annual peach production cycle.
- New herbicides must be evaluated as potential replacements for simazine and 2,4-D.
- Screen potential new herbicides to determine peach’s tolerance.
- Once crop tolerance has been determined, weed efficacy screening in orchards needs to be conducted.
- 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 of post-harvest weed competition 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.

Regulatory

- Shorter pre-harvest intervals for peach herbicides would facilitate multiple, lower rate applications as a means of maintaining weed control while potentially reducing seasonal herbicide rates. Research is needed to demonstrate how well this approach would work under varying orchard conditions.
- Expand labels of non-bearing only herbicides to include uses in bearing orchards.

- Register the following unregistered herbicides for OFMG in bearing peach orchards:
  flumioxazin (Chateau) [Dicarboximide]
  fluoroxypyr (Starane, Vista) [Pyridine]
  halosulfuron (Permit, Sandea) [Sulfonylurea]
  mesotrione (Callisto) [Benzoylcyclohexanedione]
  rimsulfuron (Matrix) [Sulfonylurea]
  sulfentrazone (Spartan) [Aryl Triazinone]
  thiazopyr (Mandate) [Pyridine]

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.

Weed Management Options

Chemical

- A number of herbicides are registered for use in non-bearing (365-day PHI) orchards only. Full labeling for use of these herbicides in bearing orchards would improve herbicide resistance management options and provide better control for species that are difficult to control when narrow herbicide options force over-reliance on a few pre-emergence materials.
- Glyphosate is the only herbicide registered for use in peaches that will control perennial weeds. However the optimum application time for perennial weed susceptibility is late summer and early fall. Glyphosate's crop tolerance concerns limit use in peaches to no later than 90 days after peach bloom. Peaches bloom in late winter to early spring. An effective herbicide for woody perennial weed control later in the growing season is a great need.
- Yellow and purple nutsedge are serious and increasingly difficult problems for peach producers. Currently there are no effective nutsedge herbicides labeled for use in bearing orchards. Bentazon (Basagran), which controls yellow nutsedge but not purple nutsedge, is labeled for use on non-bearing peaches. A bearing peach label is needed.

PRE-EMERGENCE

Common name	Trade name	Herbicide Class	Notes
diuron	Karmex	Urea	Trees 3-years and older. One of the two most widely used pre-emergence herbicides in eastern peach orchards. Effectiveness and low cost make it attractive to growers.
flumioxazin	Chateau		Very good pre-emergence control. Desirable toxicology and environmental fate.
isoxaben	Gallery	Benzamide	Non-bearing Use Only
napropamide	Devrinol	Amide	
norflurazon	Solicam	Pyridazinone	Heavily used material.
oryzalin	Surflan & generics	Dinitroaniline	
oxyfluorfen	Goal	Diphenylether	
pendimethalin	Prowl	Dinitroaniline	Non-bearing Use Only
pronamide	Kerb	Amide	
simazine	Princep & generics	Triazine	One of the two most widely used pre-emergence herbicides in eastern peach orchards. Effectiveness and low cost make it attractive to growers.
terbacil	Sinbar	Uracil	

POST-EMERGENCE

Common name	Trade name	Herbicide Class	Notes
bentazon	Basagran	Benzothiadiazole	Non-bearing Use Only
clethodim	Select	Cyclohexenone	Non-bearing Use Only
clopyralid	Stinger	Pyridine	
fluazifop	Fusilade DX	Aryloxyphenoxy	
glyphosate	Roundup & generics	Phosphono Amino Acids	One of the two most important management products for emerged weeds. It provides broad spectrum, economical control. Weed management would be significantly more difficult without this herbicide.
MSMA	Various formulations	Organic Arsenical	Non-bearing Use Only
paraquat	Gramoxone Max	Bipyridilium	One of the two most important management products for emerged weeds. It provides broad spectrum, economical control. Weed management would be significantly more difficult without this herbicide.
sethoxydim	Poast	Cyclohexenone	
2, 4-D amine	Various formulations	Phenoxy	2,4-D (amine) effectively controls winter annual broadleaf weeds. 2,4-D provides selective control of annual broadleaf weeds without injury to grass middles which are maintained between the tree rows for erosion control and to provide a durable travel surface through the orchards during periods of wet weather. Winter application of 2,4-D also enhances control of plant bugs by selectively eliminating annual broadleaf weeds that are preferred hosts for these insects.

Non-chemical

None

- *Tillage is not a viable management option in peaches.* Tillage destroys in-row perennial ground covers (primarily sods) which are vitally important because of their roles in minimizing erosion and enhancing trafficability of orchard rows for vehicles and equipment during wet weather. Tillage also damages tree roots and may result in the formation of “plow pans” which may impede the movement of water and nutrients through the soil and restrict root development. Tillage also fluffs the soil, eliminating any positive bare-ground, frost-protection impacts. As compared to other orchard floor management practices, tillage is the most expensive and will result in greater fossil fuel usage than other practices. Tillage promotes peach tree short life, a serious complex of mortality factors that is often a major cause of premature orchard decline.
- *Mulches are inappropriate as orchard floor management options for peaches because they harbor rodent pests and increase the risk of tree root diseases*, which are increasingly problematic. Economically, mulches are expensive.
- Flame cultivation is similarly impractical as a weed management option in peaches. Flame cultivation can injure roots, with resultant long-term negative effects on tree health. In-row vegetative covers that are necessary to prevent erosion and maintain trafficable surfaces for equipment would often be quite flammable during dry weather conditions in summer when weed control may be necessary.

Weed Pest-by-Pest Profiles

Orchard weed complexes are diverse, at least 25+ weed species are common to eastern peach orchards. Accordingly, weed control strategies focus on providing control of ALL orchard weeds, not by individual species. For clarification on the use of particular herbicides, refer to weed control under the heading 'Herbicides Used' in the following section of this document.

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 timed 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.

Pre-emergence Herbicides

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

Post-emergence Herbicides

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

Unregistered Chemicals

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

Further Resources

Southeastern peach, nectarine and plum pest management & culture guide. Brannen, Horton, Bellinger & Ritchie, Senior Editors. 2005. UGA Extension Bulletin 1171. 46 pp.

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Peach growers' handbook. Horton and Johnson, Editors. 2005. UGA Extension Handbook 1. 311 pp.

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

PEACH INSECTICIDE AND MITICIDE CLASSES, HUMAN EXPOSURE RISKS, FINISH AND EFFICACY RATINGS

Insecticide or Miticide	Class	Toxicity to Applicator or Thinner	Fruit Finish	Scale	Thrips	Oriental fruit moth	Plum curculio	Plant or Stink bugs	June beetles, etc.	Mites	Borers
Acramite	carbazate	low	not known	P	P	P	P	P	P	E	P
Actara	nicotinoid	low		P may promote scale	P	G	G-E	P	P	P	P
Apollo	tetrazine	low	acceptable	P	P	P	P	P	P	E ovicide	P
Asana	pyrethroid	low	acceptable	P may promote scale	F-G	E	F-G	G-E	G-E	P may promote mites	G
azinphos methyl Guthion or Sniper	OP	**very high**	acceptable	G-E	F	E	E	G-E	E	P	F
Carzol	formamadine	moderate	acceptable	P	G-E	P	P	G-E	P	G-E	P
diazinon	OP	moderate	**fruit finish problems may be seen if used with sulfur or captan**	G-E	F-G	E	F	F-G	G-E	P	F
endosulfan Thiodan or Phaser	cyclodiene	**moderate to high**	not known	F-G	F-G	G-E	P	G-E	G-E	P may promote mites	G-E
Imidan	OP	moderate	acceptable	G-E	F	E	E	G-E	E	P	F
Lannate	carbamate	**very high**	acceptable	P	G-E	G-E	F	F-G	G-E	P may promote mites	P
Lorsban	OP	moderate	NA	F	F	P	G-E	P	P	P	E
oils dormant or light summer oil	miscellaneous	low	**do not use within 2 weeks of sulfur or captan**	G-E	P	P	P	P	P	G-E	P
permethrin Ambush or Pounce	pyrethroid	low	acceptable	P may promote scale	F-G	E	F-G	G-E	G-E	P may promote mites	F
Proaxis	pyrethroid	low	acceptable	P may promote scale	F-G	E	F-G	G-E	G-E	P may promote mites	F
Provado	nicotinoid	low		P	P	P	F	P	E	P	P
Pyramite or Nexter	pyridazinone	moderate	not known	P	P	P	P	P	P	E	P
Sevin	carbamate	low	acceptable	P may promote scale	P	G-E	F-G	F-G	E	P may promote mites	P
SpinTor	spinosyn	low	not known	P	G-E	F-G	P	P	P	P	P
Vendex	organotin	moderate	acceptable	P	P	P	P	P	P	G-E	P
Warrior	pyrethroid	low	acceptable	P may promote scale	F-G	E	F-G	G-E	G-E	P may promote mites	F

Key to Response Symbols: E = Excellent Control; G = Good Control; F = Fair Control; P = Poor Control.

EFFECTIVENESS OF DISEASE CONTROL MATERIALS ON PEACHES, NECTARINES AND PLUMS IN THE SOUTHEAST

Pesticide	Class	Leaf curl	Bacterial spot	Blossom blight	Scab	Anthracnose	Red spot	Sooty peach	Brown rot	Rhizopus rot
Abound	strobilurin	P	P	P	G-E Resistance a threat	G-E	P	P	G-E Resistance a threat	P
Flint	strobilurin	P	P	P	G-E Resistance a threat	G-E	P	P	P	P
coppers	multi-site toxins	G	G Resistance a threat	P	P	P	P	P	P	P
Botran	multi-site toxin	P	P	F	P	P	P	P	F	F-G
Mycoshield	antibiotic	P	G-E Resistance a threat	P	P	P	P	P	P	P
captan	multi-site toxin	P	P	F-G	G-E	G	P	F-G	G	F
Ferbam	multi-site toxin	E	P	P	P	P	G	P	P	P
Thiram	multi-site toxin	G	P	P	P	P	G	P	P	P
Ziram	multi-site toxin	G	F	P	F	P	G	G	P	P
sulfur	multi-site toxin	P	P	F	G	P	P	P	F	P
chlorothalonil	multi-site toxin	G-E	P	G	G-E	P	P	P	P	P
Syllit + captan	multi-site toxins	P	F-G	P	G-E	P	F	F	G	F
Rovral	dicarboximide	P	P	G	P	P	F-G	F-G	P	P
Elite	DMI (dimethylation inhibitor)	P	P	E	P	P	P	P	E Resistance a threat	P
Indar	DMI	P	P	E	F-G	P	P	P	E Resistance a threat	P
Nova	DMI	P	P	G	P	P	P	P	G Resistance a threat	P
Orbit or PropiMax	DMI	P	P	E	P	P	P	P	E Resistance a threat	P
Topsin-M and Thiophanate Methyl	MBC (methyl benzimidizole carbamate)	P	P	G-E Resistance a threat	G-E Resistance a threat	P	P	P	G Resistance a threat	P
Vangard	anilinopyrimidine	P	P	G-E	P	P	P	P	P	P
Scholar	phenylpyrrole	P	P	P	P	P	P	P	E	G-E
Pristine	strobilurin and anilide	P	P	E	G-E	G-E	P	P	E	P

These ratings are benchmarks, actual performance will vary.

Key to Response Symbols: E = Excellent Control; G = Good Control; F = Fair Control; P = Poor Control.

WEED RESPONSE TO HERBICIDES USED IN FRUITS AND NUTS

	Karmex, etc.		Chateau		Solicam		Sinbar		Prowl		oryzalin		simazine		oxlyfluro-fen		Gallery		Fusilade Select[+]		MSMA		glyphosate		Gramoxone *		2,4-D		Stinger[4]		Poast	
Application Method[1]	**PRE**		**PRE**		**PRE**		**PRE**		**PRE**		**PRE**		**PRE**		**PRE**		**PRE**		**PDS**		**PDS**		**PDS**		**PDS**		**PDS**		**PDS**		**PDS**	
Time of Year[2]	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	F	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**
BIENNIAL AND PERENNIAL WEEDS																																
asters	F	G					F	G	P	P	P	P		G	F	F		G	P	P			G	E	F	F	F				P	P
bahiagrass	P	P	P	P	P		P-F	P-F	P	P	P	P	P	P	P	P	P	P	F	P	F		F	F	F	F	P	P			F	P
bermudagrass	P	P	P	P	F	F	F	P	P	P	F	F	P	P	P	P			G	F			F	G	F	P	P	P			G	P-F
briars	P	P	P	P	P	F	P	P	P	P	P	P	P	P	P	P			P	P			P-F	G-E	P	P	F	F			P	P
camphorweed						G	F		P	P	P	P		G		G			P	P			G		F						P	P
dallisgrass	P	P	P	P	F		P-F	P-F	P	P	P	P	P	P	P	P			F	F			G	G	F	P	P	P			P	P
dogfennel	P	F	P	P		E	G	G	P	P	P	P	P	F			G	G	P	P			G	G	F	P			F		P	P
horsenettle	P-F	P	F	P	P	P	F	P	P	P	P	P	P-F	P	P	P	P	P	P	P			F	G	P	P	F				P	P
johnsongrass	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	G	P	F-G		F	G	F	P	P	P			G	F
nutsedge	P	P	P	P	P-F		P-F	P-F	P	P	P	P	P	P	F	F	P	P	P	P	G		F	G	F	F	P				P	P
plantains			G	G		G		F	P	P	P	P	P	G			G	G	P	P			E	E	F	F	G	G			P	P
wild garlic/onion	P	P	P			G			P	P	P	P	P	P			P	P	P	P			G	G	F	F	G	G			P	P
ANNUAL GRASSES																																
barnyardgrass	G		G		G		G		G		G		G		F		P	P	G		G		E		G		P	P			G	
crabgrass	G		E		G-E		G		E		E		G		F				G		G		E		G		P	P			G	
crowfootgrass	G				G		G		E		E		G		F				G		G		E		G		P	P			G	
fall panicum	F		G		E		G		G		G		G						G		G		E		G		P	P			G	
goosegrass	G		E		E		G		E		E		G		F				G		G		E		G		P	P			G	
johnsongrass (seedling)	F		G		G		G		G		G		P						E		G		E		E		P	P			E	
ryegrass, annual		G		F				F		F		F-G		G-E	P				G	G	F		G	G	F	G	P	P			E	E
sandbur	G				G		G		G		E		G		P				G		G		E		G		P	P			G	
signalgrass, broadleaf	G		G		G		G		E		G		P		P				E		F		E		G		P	P			E	
Texas panicum	P		G		F		F		G		G		F		P				E		F		E		E		P	P			E	

WEED RESPONSE TO HERBICIDES USED IN FRUITS AND NUTS (continued)

	Karmex, etc.		Chateau		Solicam		Sinbar		Prowl		oryzalin		simazine		oxlyfluro-fen		Gallery		Fusilade Select[+]		MSMA		glyphosate		Gramoxone *		2,4-D		Stinger[4]		Poast	
Application Method[1]	PRE		PRE		PRE		PRE		PRE		PRE		PRE		PRE		PRE		PDS		PDS		PDS		PDS		PDS		PDS		PDS	
Time of Year[2]	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
ANNUAL BROADLEAF WEEDS																																
bristly starbur	G		G		F		E		P		P		F		F-G		P	P	F	P	F		G		F-G		G				P	
chickweed	G	G		E	E	E		E		G		G		G				G	P	P			G	G	F	G	F	F			P	P
cocklebur	G		F		F		G		P		P		F		G		P	P	P	P	E		E		G		E	E	E		P	
crotalaria	G		P				G		P		P				E		P	P	P	P	G		E		G		G		G		P	
croton, tropic	G		E		E		G		P		P		F-G		E		P	P	P	P	F		E		F-G		G				P	
evening primrose		G	G	E			F	G	P		P			G-E	F	G		G	P	P			P-F	F	F	F-G	F	G			P	P
Florida beggarweed	G		G		G		E		P		P		G		P		P	P	P		E		E		E		F				P	
Florida pusley	G		E		G		E		G		G		G		E		F	F	P		F		G		F[3]		F				P	
horseweed	F	G	G	G	G	G	G	G	P	P	P	P	P	G	P	F		G	P	P			G-E	G-E	F*	F	G		E	E	P	P
jimsonweed	G		G		G		E		P		F		F-G		G		G		P		F		E		G		E		E		P	
lambsquarters	E		E		F		E		E		E		E		E		E		P		F		G		G		E				P	
morningglories	G		G-E		F-G		G-E		P		F		F-G		F-G		F		P		F		G		G		G				P	
pigweeds	G		E		F		E		G		G		F-G		E		E		P		F		G		G		G				P	
prickly lettuce		G			G			E	P	P	P	P	G	E		G		G	P	P			G	G	F	G	G	G	G	G	P	P
prickly sida (teaweed)	G		G		G-E		E		P		P		F-G		E		G		P		P		G	F	G	P	G				P	
purslane, common	E		E		E		E		E		E		E		E		E		P		F		E		G		E				P	
ragweed, common	E		E		G		E		P		P		G		E		E		P		F		G		G		E	E	G		P	
sicklepod	G				F		E		P		P-F		F-G		F				P		F		G		E		E		E		P	
wild radish	F-G	G	E	E	F	G	E	E	P	P	P	P	G	E	G-E	E		E	P	P			E	E	F	G	G	G			P	P

[1] PRE = Pre-emergence; PDS = Post-emergence Directed Spray.
[2] S = Spring; F = Fall.
[3] Gramoxone will control only the seedling stages of Florida pusley.
[4] Stinger is very effective on the following species not included in the chart; all clover, vetch, thistle, nightshade species, and curly dock.
* Gramoxone and Rely provide only contact control of many species.
[+] Fusilade and Prism are fluazifop and clethodim, respectively; and have similar activity on most weeds. Weed response also reflects Select herbicide.

Key to Response Symbols: E = Excellent Control; G = Good Control; F = Fair Control; P = Poor Control.
If no symbol is given, weed does not occur in specific season (spring or fall) or weed response is unknown.

Appendix A: Workshop Participants

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