New Jersey Peach Pest Management Strategic Plan

New Jersey Peach Pest Management Workgroup Members
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EXECUTIVE SUMMARY

Research Priorities

- Transition strategies must simultaneously address short- and long-term needs. The immediate grower need is reliable, affordable, low-risk pest management alternatives to augment diminishing availability of standard materials.
- Ultimately, transition strategies must develop practical, affordable IPM systems that employ lower-risk pesticides. Growers want New Jersey peach IPM re-invented in a fashion that merits praise from economic, social, and environmental perspectives. Stable IPM funding is essential if we are to reach that goal.
- Growers need improved understanding of biology for key peach pests and their natural enemies to create biologically-refined monitoring and predictive tools. In New Jersey, pest biology and behavior studies for plum curculio and oriental fruit moth are key prerequisites to the evolution of IPM options.
- Efficacy assessments of developing pest management options, such as lower-risk pesticides and bio-rational controls should be a component of this research. Promising options must be incorporated into existing commercial practice. But, impacts on primary, secondary, and induced pests; beneficials; and "new" pests must be carefully studied.
- New cost-effective tools for insect pest management are needed, instead of reliance solely on cheaper pyrethroids. Pyrethroids are entirely unacceptable as mainstay insecticides in New Jersey peach culture because they induce secondary pests. Low risk insecticides that do not promote scale problems are badly needed for stink bugs and opportunistic fruit pests.
- Additionally, treatment thresholds for key pests need to be developed as economic thresholds are not applicable in peaches (the value of the crop is unknown till picked and/or stored).
- Scale, primarily San Jose and white peach, have become damaging primary pests. This elevation in pest status is attributable to changes in pesticide availability. Research should focus on scale biology and model development to improve timing of insecticide applications.
- Peachtree borer and lesser peachtree borer are also key tree pests. Borer treatment thresholds are presently a long-term research challenge.
- New Jersey growers need monitoring tools for plum curculio, stink bugs, thrips, and tarnished plant bug.
- Likewise, New Jersey peach growers need treatment thresholds to determine if control measures are needed or not.
- Beetles (Japanese, green, June, rose chafers, and white fringed) are occasionally very difficult to control. Research needs should include these occasional but highly problematic pests.
- Although current disease control programs are mostly effective, environmental variation can and does result in major epidemic outbreaks. In addition, some diseases, such as constriction canker, currently lack effective controls. Consequently, key research and extension needs exist.
- Growers need predictive modeling for all peach diseases to better time control practices. Monitoring techniques and sampling protocols need to be developed for key diseases to allow advanced warning of inoculum availability for significant infection. Such information should allow determination of "orchard risk levels" for upcoming growing seasons or specific infection events.
- Brown rot is the key fruit rot organism for New Jersey peaches. It is very effectively controlled by de-methylation inhibitor (DMI) fungicides, often with minimal need for control of the blossom blight and green fruit rot stages of the disease. But, the brown rot organism readily develops fungicide resistance**.** There is a need for more detailed understanding of the organism's biology and for non-DMI control. This would allow improved timing of sprays and development of prudent resistance management strategies.

- Peach scab control relies heavily upon protectants. Scab control is normally good, but can be difficult to control if management the previous season was inadequate. Fruit protection is needed from early-season until 40-days before harvest. Thus, a range of four to six fungicide sprays may be required, depending on the harvest timing. Two important scab fungicides, sulfur and azoxystrobin, are low-risk materials. Chlorothalonil is one of the best fungicides for scab control. A better understanding of the epidemiology should allow more effective and efficient use of newer fungicides
- Since Phytophthora root and crown rot occurs sporadically, orchards are not routinely sprayed. However, when infection does occur, many trees can be killed, causing loss of tree investment as well as yield. A better understanding of those biotic and abiotic factors that augment the risk of infection is needed, thereby allowing greater predictability of disease outbreaks. A fungicide can then be applied only when necessary, improving both the cost-effectiveness of control and the decreasing the likelihood of tree and yield loss.
- Constriction canker was first discovered in New Jersey in 1934 and is endemic to the state's peach and nectarine orchards. Disease severity and yield loss tends to be greatest in middle-aged and older orchards, shortening their duration of greatest productivity. Control is currently limited to removal of cankers via pruning, which has been shown to be approximately 30% effective. Recent research has indicated that chlorothalonil and captan are most effective, but registrations are lacking and many sprays are needed. Further research on basic pathogen biology, epidemiology, and control strategies is needed for development and implementation of a cost-effective management program. Of particular importance is determination of infection criteria to allow optimum fungicide timing. A better understanding of host susceptibility in relation to inoculum availability is also needed. New fungicides continually need to be screened for efficacy.
- Rusty spot management is generally good, but effective control is limited to a single fungicide, myclobutanil. Recent research has identified the critical period for application timing. To increase disease management options and lower the risk of resistance development, alternative fungicides need to be discovered and integrated with myclobutanil for the control of peach rusty spot. Application of any effective biological or biorational control materials may allow reduced use of myclobutanil. In addition to disease control research on integration of materials, further study on pathogen biology is needed to better understand the etiology and epidemiology.
- Bacterial spot is a damaging and problematic key pest on susceptible varieties. Under heavy bacterial spot pressure, even resistant varieties need some protective sprays. Resistant varieties are being planted, but commercially acceptable ones are not available for all harvest seasons; this is particularly valid for nectarines. An estimated 25-35% of the bearing acreage must be sprayed for bacterial spot. Chemical control is solely dependent on materials that face regulatory scrutiny, specifically coppers and the key in-season antibiotic oxytetracycline (Mycoshield). So, better understanding of pest biology and examination of lower-risk control options are essential. Further, resistance management options are very limited, making low-risk, alternative bacterial spot chemistries an important priority.
- Minor fruit rots, anthracnose, rhizopus and gilbertella rots are occasional, but can be damaging diseases when severe. These diseases are only controllable with older fungicides such as captan, Ziram, or Ferbam. Research of low-risk materials for these diseases is a long-term need.
- Research is needed to develop spray technologies that will allow growers to more effectively and economically make pesticide applications.
- New Jersey growers need information on comparative costs versus returns/value added of alternative versus conventional controls. Market research is needed on the economic effects of controls; alternative versus conventional; cost-effectiveness; higher return possible for value added component of new alternatives considered?; e.g. IPM education (market research); promotion issues.
- Research is needed to improve the utilization of cultural weed control methods. New herbicides must be identified and evaluated to improve the control of perennial weeds, aid in resistance management in annual weeds, and serve as potential replacements for simazine and 2,4-D.

- Woody perennial weed control has been difficult to achieve in peach orchards. Glyphosate use is problematic due to its PHI, and since optimum treatment time coincides with harvest time. Studies are needed to identify herbicides for woody perennial weed control.
- Cultural, mechanical, and chemical weed control methods should be combined into an integrated weed management program that includes weed resistant management strategies.
- Research is needed on the impacts of PGR on pests, including determination of consistent responses to bloom delay, blossom thinners, and growth thinners.
- Research on nematode control must focus on pest biology, and development of resistant rootstocks and cultural controls. More environmentally favorable alternatives to methyl bromide are badly needed, especially in the tree nurseries.
- Research is needed on maintaining vigor of planting sites to allow replanting old orchard sites because of the shortage of land.
- Research is needed on managing vertebrate pests in peach orchards.
- Identify, assess, and quantify wildlife species causing damage to peach crops.
- Locate resources to reduce/eliminate wildlife damage to peach crops.
- Identify and implement cost-effective and efficient wildlife damage management strategies.
- Evaluate success of implemented wildlife damage management practices.

Regulatory Priorities

- Regulatory decisions on re-entry intervals (REIs) need to recognize the need to conduct field essential activities. Cost/benefit should be considered in making REI decisions.
- Regulatory decisions on OPs have extended pre-harvest intervals (PHIs). This is a problem when late season insect control is needed. The effect of longer PHIs on IPM programs needs to be fully considered in regulatory decisions and in the evaluation of mitigation options.
- American produce growers, including peach growers, should receive assurance that foreign producers will be held to U.S. standards for pesticide labels. Tolerances should not allow foreign competitors unfair advantages. New Jersey growers believe tolerances should be same for imports as US grown peaches.
- Resistance management is a key concern with orchard pests. Rotating pesticides to expose pests to varied modes-of-action is the most feasible management option. Regulatory decisions should thoroughly consider resistance management and maintain multiple modes-of-action for use against key pests.
- Peaches are highly dependent on hand labor. The quantification of worker exposure to individual pesticides is needed for all key in-orchard activities. Better risk data on both acute and cumulative pesticide exposure in peach production is needed.
- Critical point analysis (HACCP) for both microbial and pesticide residue risks is badly needed to model risks from harvest through shipment.
- Region-wide virus and phytoplasma tree-health programs should be required in order to mitigate potential spread of virus including plum pox virus (PPV), and reduce the incidence of less catastrophic, endemic viruses. Further, nursery certification and elimination of non-certified stocks is an industry priority.
- Examine ways to limit landowner liability exposure to encourage landowners to open hunting access on their property.
- Examine revenue generating ideas like leasing land for hunting and other wildlife related recreation.

- Develop policies to encourage state-funded deer fence programs.
- Abandoned orchards need to be removed.
- Inside/outside regulatory efforts are needed to minimize flooding of market by California peach growers.

Educational Priorities

- Public education in **IPM**, tied to research with the goal of improving economics to the grower is needed. Funding should be increased in research, education, and Extension.
- Public education in **pest management tools** that promote peach farming is needed.
- **Integrated Orchard Management** (IOM and its pest management components) carry considerable management costs that are seldom given due weight for high-value commodities such as peaches. Growers, especially processing growers, need orchard consultants to successfully implement increasingly complex pest management options. The economics of pest management must be re-examined in light of its non-farm benefits to society in order to sustain a badly need cadre of pest management consultants. Integrated Orchard Management is a key element of both worker safety and environmental stewardship.
- Educate growers on the multiple weed control benefits of site specific Orchard Floor Management programs.
- Best management practices for mitigating in-orchard spread of virus and other systemic tree diseases have become an industry priority.

BACKGROUND

Production Information

- Peaches are a perennial crop requiring at least 6 years to recoup investment costs. Average tree life expectancy is 12-14 years.
- New Jersey ranks 4th in the U.S. in bearing acres of peach production and 4th - 5th in utilized pounds of production. New Jersey produced 2.3% of the total U.S. crop on 5.1% of the national bearing acreage, (USDA National Agricultural Statistics Service).
- 58.0 million pounds of peaches valued in excess of $ 24.7 million were produced during the 2000 crop year on 8,000 acres.
- Nearly 100% of the crop is sold to the fresh market. New Jersey ranks 2^{nd}-5^{th} in value of production because of fresh market sales.
- Peach-bearing acreage has decreased from 10,800 in 1994 to 8,000 in 1998 and remains at 8,000 acres in 2000.
- Rutgers University estimated that it costs approximately $ 3,129 per acre to produce peaches in NJ in 1996.
- The Southern district (Gloucester, Cumberland, Camden, and Atlantic counties) is the major growing region in New Jersey where 88.5% of the county production is concentrated. Gloucester county is the main growing area where 55.4% of New Jersey's peach production is located, followed by Cumberland county (17.7%), Camden county (7.7%), and Atlantic county (7.7%) of the New Jersey peach production respectively. The Central district (Burlington, Monmouth, Middlesex, and Mercer counties) represents 4.8% of the total production. The Northern District (Bergen, Hunterdon, Morris, Sussex, and Warren counties) produces 2.2% of the crop, while the remaining counties produce 4.6% of New Jersey's peach crop.

Critical Pest Information

- New Jersey peach pest complexes are intricate; pest pressure is often heavy, and may be season-long.
- In the 1990s, most of the **eastern** peach producers' most damaging pests, plum curculio, Oriental fruit moth, borers, scab and brown rot, have been well controlled. Options for scale and bacterial spot are more problematic.

Insects

- The importance of particular pests varies by region within the state.
- **Plum curculio** (PC) and **Oriental fruit moth** (OFM) are the key peach pests in New Jersey. Both pests have typically been controlled with organophosphate (OP) pesticide applications.
- **Oriental Fruit Moth**. This primary pest attacks both stone and pome fruit. There are normally four generations of this insect each year but a fifth generation may occur in the southern two-thirds of the state during a warm year. First generation larvae bore into succulent twigs usually about the time when shucks split. Later generations attack shoots and developing fruit, often boring into the fruit close to the stem as tiny larvae. First and second brood larval control is timed using degree day accumulations from Biofix and usually commences about the time of shuck split.
- **Plum curculio.** This pest has 1 generation per year in the north and 2 generations per year in the southern part of the New Jersey. The insect overwinters as an adult in and around the orchard. Warm spells (70 F and above) around apple bloom time prompts movement to the trees. Females feed on and oviposit in the fruit. Petal fall, shuck split, shuck fall and 1^{st} cover are critical spray timings for this pest. PC is best controlled with OP insecticides. Pyrethroids are only fair against this pest.

- **Tufted Apple Bud Moth and Variegated Leafroller.** These insects have similar life histories, habits, and damage. In New Jersey, tufted apple bud moth usually outnumbers variegated leafroller but both may be found in the same orchard. There are two generations per year. Adults generally begin flying and laying eggs from about mid-June to mid-July and from about mid-August through mid-September. In recent years, most damage has come from the second generation of moths because either spraying has stopped, fruit is tightly clustered, insufficient spray volume was used, or because of resistance development. Damage appears as a "shotgun" type of scarring on the upper and side surfaces of the fruit. Heavier crops are most likely to sustain damage.
- The red-banded leafroller with three + generations per year and the fruit tree leafroller with one generation per year. The oblique banded leafroller is starting to show up in some orchards.
- **Scale insects** and **greater and lesser peachtree borers** are common peach pests throughout New Jersey that damage and destroy trees. Scale insects suck sap from foliage, twigs, and branches. Severe scale infestations are difficult and expensive to control and can easily shorten an orchard's productive life by 2 years. Borer infestations weaken trees, make them more susceptible to disease, and can dramatically shorten tree productivity and longevity.
- **San Jose scale, white peach scale, peachtree borer and lesser peachtree borer** must be carefully managed or orchard productivity and longevity suffer, with disastrous financial impacts. Peach growers may have $2,400/a invested in orchard establishment before trees begin to bear. Typical orchard longevity is 12-14 years. However, in many orchards, costs to control scale and other tree pests no longer allow growers to recoup orchard establishment costs within the typical 6 to 8 years.
- **Lesser Peach Tree Borer** attacks weak and injured trees, winter-damaged orchards, and diseased trees Adult borers (moths) are attracted to injured trees and deposit eggs in wounds from May through early July and again in September.
- **Peach Tree Borer.** Peach tree borers usually fly from mid-June on but most of the larvae are present in the trees by early September.
- **Plant bugs** and **stink bugs** are important pests that damage fruit and can be mechanical vectors of brown rot. These insects, in combination with other insect pests such as aphids and Japanese beetles, present a complex insect management challenge for peach growers. These pests will become more problematic as we loose OP insecticides.
- **Catfacing Insects.** The tarnished plant bug and the dusky, green, and brown stink bugs collectively form the group called catfacing insects. Their feeding on peaches during the pink and petalfall through shuck split periods generally results in dimpled, fuzz-free areas and aborted fruit. Feeding during the shuck fall to second and third covers results in unsightly, slightly sunken, callused, black blemishes on the skin surface generally 1/16 to 1/4 inch in diameter. These insects overwinter as adults and move into peach orchards about the time buds begin to swell. Because these bugs are strong fliers, their presence may be widespread, and depending upon availability of other host plants, injury can vary considerably from block to block. Other hosts include vetch, alfalfa, clover, goldenrod, fleabane, dog fennel, pigweed, ragweed, lambsquarter, and dozens of different kinds of flowers and commercial vegetables.
- **Green Peach Aphid.** Large numbers of aphids suck the plant juice from the leaves causing them to become stunted, curled, and discolored (yellow) by June. Aphids normally disperse to other host plants by mid-June. Aphids can also vector serious diseases such as Plum Pox virus.
- Several species of **thrips** can damage tree fruit. Western flowers thrips and flowers thrips feeding damage can result in russetted fruit while late season damage takes on a silvering appearance. Cold, wet springs are not favorable for this pest because it delays development, and heavy rains can actually kill these frail insects. Mowing ground cover during bloom and harvest should be avoided to prevent

thrips from leaving the ground cover for the fruit. Also, eliminating flowering weeds in the orchard should prevent thrips populations from increasing and subsequent movement to the crop.

- **European Red Mite and the two-spotted spider mite** are the major mite pests of peaches in New Jersey. European Red Mite overwinters in the egg stage on twigs and in bark crevices. Eggs normally hatch during the early bloom bud stages, whereupon the mite larvae crawl to the unfolding leaves and commence feeding. European Red Mites can build up to the point where leaf bronzing is visible by mid- to late July. Early control measures often increase the likelihood of good predator-to-prey ratios by allowing mite predators to keep mites below treatment levels.
  The two-spotted spider mite overwinters as an adult on perennial plants (weeds) and orchard trees. Dormant oil sprays are not effective for controlling this species, however, most other miticides are satisfactory. In spring, two-spots serve as food for the predator mite, *Amblyseius fallacies* and the lady bird beetle, *Stethorus punctum* before they climb trees in search of European Red Mites.
- **Japanese beetle** females lay eggs in the grassy area between drive rows. The eggs hatch in mid-July though August into C-shaped grubs that feed on grass roots. Adult beetles emerge from the grass the following July. Feeding by adults on ripening fruit can cause severe damage and make the fruit unmarketable. In some areas of New Jersey, for unknown reasons, Japanese beetles have become less of a problem.

Diseases

- **Blossom blight** rarely limits yield by killing flowers. However, infected blooms can develop into cankers that then provide inoculum for preharvest infection, causing brown rot.
- **Brown rot** can result in 100% yield loss during harvest if environmental conditions are favorable and control is inadequate. Good to excellent disease control is possible with up to three fungicide applications, but is very much dependent on resistance-prone DMI fungicides.
- **Bacterial spot** incidence can approach 100% of the fruit infected in disease favorable seasons. Less susceptible cultivars are available, but these are not always horticulturally desirable or available for a given harvest season.
- **Peach scab** can cause significant yield loss if not managed well over successive seasons. If the pathogen is allowed to build-up in an orchard, control in the subsequent year can be difficult, and is very much dependent on protectant fungicides.
- **Constriction canker** kills the current season's fruit bearing shoots, resulting in a direct yield loss. The disease is most problematic in older established orchards, causing fairly consistent losses each year, and contributing to their early decline. Removal of cankers via pruning is the only available form of control, as no fungicides are currently registered.
- **Peach rusty spot** incidence can reach 90% fruit infection on highly susceptible cultivars such as "Jerseyqueen". Severe fruit infections result in russetting of the fruit surface, rendering it unmarketable.
- **Leucostoma canker**, also called Cytospora canker, can be found in most established orchards. The resulting perennial cankers kill main scaffold limbs or weaken them so that they break under normal fruit loads.
- **Phytophthora root and crown rot** occurs sporadically, but can kill significant numbers of trees, particularly in young orchards.
- **Anthracnose** and **Rhizopus rot** are diseases of secondary importance, but can cause significant fruit loss if conditions are favorable for infection and control is lacking.
- **Prunus necrotic ringspot virus**, **tomato ringspot virus** (peach stem pitting) are diseases of periodic importance.
- **The plum pox virus** is a serious threat to the industry.

Nematodes

- Nematodes are extremely important to peach production, since nematodes cause **direct damage** and play a major role in **peach tree short life**. Nematodes are also **important vectors of certain peach viruses**, such as peach rosette mosaic virus and tomato ringspot virus. On replant sites, nematodes are key risk factors influencing orchard health and productivity.
- **Root knot** (Meloidogyne spp.), **ring** (Criconemella xenoplax), **lesion** (Pratylenchus vulnus), and **dagger** (Xiphinema spp.) nematodes are the major nematodes of concern to peach production.

Weeds

- **Weeds compete readily with trees for water, nutrients, and sometimes light. Weed competition reduces fruit yield, tree growth and, therefore, the development of young orchards.** Delaying orchard development reduces early productivity and return. In established orchards, weed competition reduces total yield and fruit size, resulting in decreased crop value.
- **Established perennial weeds are among the most difficult to kill as** they often reproduce vegetatively, as well as by seed. The longer that perennial weeds are allowed to grow uncontrolled, the larger their root system becomes, the more they spread, and the harder they are to control. Perennial weeds include: grasses, sedges, as well as herbaceous and woody broadleaf weeds**.** One application of appropriate herbicide at recommended rates may not provide complete control, but regrowth should be limited and competitive ability reduced. Follow-up spot treatments are used to improve the long-term result of the initial herbicide application.
- Weed control is critical to the integrated management of other orchard pests. Weeds serve as hosts to cat-facing insects. Eliminating winter annual weeds from the entire orchard floor reduces cat-facing insect populations, aiding in their management with insecticides.
- **Broadleaf weeds** are undesirable in an orchard sod growing between the tree rows due to competition with the crop as well as possible increased mowing requirements. Further, many weeds are alternate hosts for diseases, insects, and nematode pests.
- **Broadleaf weeds** are hosts to nematodes that vector tomato ring-spot virus. Following pre-plant nematicide application, it is critical that broadleaf weeds continue to be controlled to prevent population increases of Dagger nematodes which vector viruses.
- There are higher herbicide and application costs, and less effective and less consistent weed control in **trickle irrigated crops**. Herbicide(s) that are least soluble in water and most strongly adsorbed to the soil will delay, but not prevent herbicide failure and weed breakthroughs in trickle irrigated crops.
- Vegetation around trees makes orchards attractive to **voles.** Weeds provide cover for protection from predators and are a source of water, as well as food. Maintaining a clean herbicide strip in the tree row is part of an integrated approach for vole management.

Vertebrates

- Drake and Grande (2002) surveyed 406 acres in fruit production (129 acres in northern New Jersey, 277 acres in southern New Jersey) during the 2000 growing season. **Economic loss to fruit growers from wildlife** totaled $154,636.89, or $379.94 per acre. Compared to the 1997-1999 statewide per acre average, fruit growers that we surveyed lost 10% of their crop's value due to wildlife depredation. On average, deer were responsible for about 79% of the total economic loss.

- The current evidence is inconclusive as to whether lowering deer densities actually reduces the incidence of Lyme disease. It has been suggested that lowering deer densities may reduce tick abundance (Daniels et al. 1993, Stafford 1993); however, this may not necessarily result in a decrease in Lyme disease (Wilson et al. 1988, Conover 1997, DeNicola et al. 2000).
- There are many lethal and non-lethal options available to manage deer populations causing damage to fruit production. However, **deer control options are problematic**. Hunting is the most cost-effective and efficient management tool available, although anti-hunting sentiment, lack of access to deer on private property, and a host of other issues can make this management option difficult to implement. Permanent, high-tensile woven wire deer fence is the only management option that can completely eliminate deer depredation. However, the cost of purchasing materials and installing the fence can be prohibitive, and other issues such as aesthetics and zoning ordinances can be problematic. Other management options like habitat modification and repellents provide variable effectiveness and can be costly.

Critical Pesticide Information

- The immediate grower need is **reliable, affordable, low-risk alternatives** to augment diminishing availability of standard materials.
- Well over 90% of New Jersey peaches receive a single, hand-gun directed spray with the OP chlorpyrifos (Lorsban) for borers. In New Jersey, the timing of borer flights allows growers to delay this spray until after harvest. This provides a 6-month+ interval between application and fruit set. The chlorpyrifos borer spray also suppresses scale.
- Current insect IPM systems rely heavily on the organophosphates (OPs) phosmet (Imidan) and azinphos-methyl (Guthion, Sniper). Organophosphates are reliable, they do not require extreme precision in time of application, they are largely untroubled by resistance and they do not induce outbreaks of secondary pests such as scale or mites. Organophosphate uses should be retained for early- and, at least, mid-season applications.
- Current peach insecticide options include OPs, carbamates, and pyrethroids. OPs and carbamates are questionable long-term options until the reregistration process is complete.
- With the loss of methyl parathion and changes in the availability of other OPs, IPM in peaches needs to be reinvented.
- Peach producers also make limited, but predictable, use of the carbamates carbaryl (Sevin) and methomyl (Lannate), and the pyrethroids permethrin (Ambush/Pounce) and esfenvalerate (Asana).
- Pyrethroids are entirely unacceptable as mainstay insecticides in New Jersey peach culture, as their use induces outbreak levels of scale and mites.
- Plum curculio is best controlled with OP insecticides. Pyrethroids are only fair against this pest.
- For best results in controlling Tufted Apple Bud Moth and Variegated Leafroller, New Jersey growers increase spray volume per acre and thin to remove fruit clusters.
- In New Jersey orchards, Tufted apple bud moth and variegated leafroller are two leafrollers that are somewhat resistant to Guthion and Imidan. The red-banded leafroller with three + generations per year and the fruit tree leafroller with one generation per year are still susceptible to most insecticides. The oblique banded leafroller is starting to show up in some orchards. The most important times to control these latter two pests are in the petal-fall and first cover sprays.
- Insecticide protection is recommended primarily for the control of the second brood of the Lesser peach tree borer in early September, and slightly later in northern counties of New Jersey. Applications should be made with a hand gun to the point of run off, making sure to cover all cankers. Lorsban 4E, Thiodan, Asana, or Pounce should be applied post-harvest with a handgun.

- Control of peach tree borer can be achieved by drenching the tree trunk and scaffold limbs with Thiodan 50WP at the 1.5 pounds per 100-gallon rate, Lorsban 4E at the 1.5 quarts per 100-gallon rate, or Asana XL at 4 oz per 100 gallon-rate after harvest. Trees should be treated for peach tree borers the same time that the scaffold limbs are treated for lesser peach tree borers. The fumigating action of the insecticide, along with its residual action, should give good kill for those larvae already in the tree, if applied by early to mid-September. The residual action should also provide control for those young larvae still hatching from eggs. For best results, apply 0.5 to 1 gallon of spray to each trunk, preferably with a handgun. Airblast sprayers are not suited for borer control because not enough spray reaches the target area.
- **Scale infestations** in the Southeast and mid-Atlantic regions have increased dramatically during the 1990s. This is a **classic example of pesticide-induced crisis**. Scale populations increased after regulatory actions encouraged pyrethroid use while forcing season-long reliance on phosmet, a material with modest scale efficacy. Azinphos methyl (Guthion, Sniper) has better scale efficacy than phosmet, but its 14 day re-entry interval (REI) essentially precludes azinphos-methyl's use while peaches are being thinned, the key period of scale crawler activity. Use restrictions and then loss of encapsulated methyl parathion altered the balance of an eastern peach IPM system that was remarkably free of scale and mite problems. **Severe scale infestations can easily shorten an orchard's productive life by 2 years. Sacrificing 2 years of production easily projects to a 20+% loss of profit potential** [14 yrs- 6 yrs to recoup costs = 8 yrs production, less 2 yrs production lost to scale-induced orchard decline]. **Low-risk scale insecticides and better tools to time sprays are needed to improve scale control. Primary in-season insecticides must not exacerbate scale as the pyrethroids do.**
- Where catfacing by tarnished plant bug and the dusky, green, and brown stink bugs has been a problem, insecticide applications are essential at petal fall and shuck split. Additional bug controls are needed during the shuck split to shuck fall period through third covers, depending upon the extent of the bug populations. Early season orchard cultivation is risky because it to forces the bugs up into the trees. Eliminating alternate weed hosts in the orchard should reduce damage caused by this pest complex
- For best results in controlling green peach aphid, Thiodan or Lannate should be applied dilute at pink bud and again at petal fall. Lannate will provide fair control of oriental fruit moth and catfacing insects. Make applications before leaves become curled and discolored.
- Plant bugs, stink bugs and assorted opportunists are sporadic pests in OP-based insect management systems. If OPs are retained as early season options-- to take advantage of their broad spectrum control and provide a resistance management option - alternative control tactics become more feasible. These fruit pests are difficult to monitor and gaps in the understanding of biology and behavior limit control tactics to cultural controls that only modestly diminish stink bug pressure. Low risk insecticides that do not promote scale problems are badly needed for stink bugs and opportunistic fruit pests.
- Loss of one or more of the older protectant fungicides (captan, chlorothalonil, dithiocarbamates, benzimidazoles) would increase the risk of pathogen resistance development to newer site-specific chemistries (DMI's, strobilurins).
- Loss of protectant fungicides would increase the cost of disease control.
- Captan is the only registered fungicide known to control anthracnose, a disease of secondary importance on fruit. However, without this fungicide, an increase in yield loss would likely occur. Similar increases in fruit or tree damage may occur for other diseases currently viewed as secondary.
- Constriction canker causes 20-30% yield loss in older orchards, contributing significantly to an earlier than expected decline in production. Recent research has shown that the fungicides chlorothalonil and captan provide significantly better control of this disease than sterol inhibitors, strobilurins,

benzimidazoles, or copper. Loss of these protectants would prevent the potential extension of an orchard's useful, productive life.

- Alternative fungicides are needed for management of rusty spot of peach. Current disease control is dependent on a single fungicide, myclobutanil.
- Materials for bacterial spot management are limited to the antibiotic oxytetracycline and copper bactericides. Resistance development and phytotoxicity are problematic with the former and latter materials, respectively. New strategies and materials are needed to prevent epidemic outbreaks.
- 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.
- In tree fruit such as peach, **weeds** must be managed within a holistic **orchard floor management (OFM)** program. The OFM program of choice uses herbicides to maintain bare-ground in the tree row with an adjoining grass sod between rows. The herbicide strip minimizes competition, while the perennial grass sod reduces erosion and provides an adequate surface for equipment movement through the orchard even during periods of wet weather.

IPM Issues

- Although cultural practices and biocontrol play important roles in management of both diseases and insects, thorough spray coverage with effective pesticides is essential to sustain commercially competitive production.
- New Jersey peach growers lack the comprehensive IPM tools needed to move beyond scheduled prophylactic spray programs. In New Jersey peaches the biologically-refined management tools required for as-needed pest management responses are lacking for most key pests.
- NJ peach growers, as with other eastern peach growers, lack treatment thresholds to determine if control measures are warranted. This lack of information leads to extra spraying of pesticides.
- Essentially 100% of New Jersey peaches receive a single, handgun directed, post harvest spray for borers with the OP chlorpyrifos. This treatment also suppresses scale. Since there is more than a 7 month interval between this application and fruit set; this important IPM practice presents no risk of fruit contamination. It is analogous to similar treatments in nursery production.
- Mating disruption for control of borers and oriental fruit moth has demonstrated that effective control is possible but a significant amount of additional field implementation is necessary before use is widespread.
- Cultural practices for nematode control are mainly limited to crop rotation strategies. Root stock selection is also a very important control measure. However, use of chemical nematicides and fumigants continues to play a crucial role in control strategies for peach nematodes.
- Due to high market expectations, growers (especially wholesale marketers) must strive for fruit with a nearly flawless appearance. Currently even our most evolved programs require multiple pesticide applications to manage fruit and tree pests. For growers, the potential loss associated with pest injury mandates development of affordable, highly reliable, low-risk IPM options.
- Ultimately, transition strategies must develop practical, affordable IPM systems that employ lower-risk pesticides. Growers want eastern peach IPM re-invented in a fashion that merits praise from economic, social, and environmental perspectives. Stable IPM funding is essential if we are to reach that goal.

Resistance Management Issues

- Growers need pesticides to grow peaches. The need several different classes of pesticides with different mode of actions to minimize the development of pesticide resistant pests.
- Since the use of a single herbicide repeatedly will lead to an increase in herbicide resistant weeds or weed species, growers are encouraged to use herbicide combinations, herbicide rotations, and sequential or spot treatments. As such, maintaining materials that exhibit different modes of action is critical. This is of particular concern in the case of glyphosate-resistant horseweed (marestail) which is a prolific seed producer and seed is windborne; it that has been identified in Maryland, Delaware, and New Jersey.

Consumer Education Issues

- **Export/Import Issues**: American produce growers, including peach growers, should receive assurance that foreign producers will be held to U.S. standards for pesticide labels. Tolerances should not allow foreign competitors unfair advantages. New Jersey growers believe tolerances should be same for imports as US grown peaches.

Other Peach Pest Management Issues

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

OUTLINE OF PLAN

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

INSECTS & MITES

(Pertinent to the regulatory needs throughout the document, the following products are on the EPA 2002 Work Plan for approvals on stone fruit crops, including peach, nectarine, etc.: diflubenzuron, lambda-cyhalothrin, pyriproxyfen, deltamethrin, and imidacloprid.)

1) <u>Oriental fruit moth (OFM)</u>

- This primary pest attacks both stone and pome fruit.
- 1st generation larvae attack terminals causing dieback and flagging.
- Larvae of subsequent generations are the most common internal feeding caterpillars in peach.
- Azinphos-methyl, phosmet, and pyrethroids provide excellent control.
- Zero tolerance for wormy fruit.
- Entire loads have been rejected when wormy fruit was detected.
- Degree-day spray timing model is only effective during the early season.
- Trap catch thresholds are not standardized; trap density not specified; not validated.

A. Labeled Insecticides

Currently Used Organophosphate (OP) insecticides

1) **azinphos-methyl (Guthion, Sniper)**
    - Azinphos-methyl is effective for control of OFM, provides up to 2 weeks of residual activity, depending on weather.
    - Field failures due to resistance reported in some mid-Atlantic and upper mid-West orchards.
    - Some processors prohibit use of azinphos-methyl and other OPs.
    - Safe to mite predators.
    - OFM are losing their susceptibility to OP insecticides in certain areas.
    - Resistance and recent increase in re-entry intervals to 14-days limits azinphos-methyl's utility.
2) **phosmet (Imidan)**
    - Phosmet provides effective control, but in areas with high OFM pressure phosmet requires more applications and higher rates than azinphos-methyl because of its shorter residual.
    - Phosmet is the dominant peach insecticide in the Southeast. It is the primary insecticide in the East during thinning and pre-harvest, because its REI and PHI are shorter than those of azinphos-methyl.
    - Phosmet is easier on beneficials than other OPs.
    - OFM are losing their susceptibility to OP insecticides in certain areas.
    - Field failures due to resistance reported in some mid-Atlantic and upper mid-West orchards.
    - Some processors prohibit use of phosmet and other OPs.

Carbamate insecticides

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

Pyrethroid insecticides

1) **esfenvalerate (Asana)**
   - Esfenvalerate is a short-residual material, requires many applications.
   - Post-bloom use of pyrethroids typically upsets IPM programs by destroying beneficial mites and insects, which seriously exacerbates scale and mite problems.
   - Pests readily develop resistance to pyrethroids in systems where they are used repeatedly.
   - Esfenvalerate is very economical, but use limited due to concerns about disrupting IPM programs, potential resistance problems, and short residual.
2) **permethrin (Ambush, Pounce)**
   - Permethrin is a short-residual material, requires many applications.
   - As with esfenvalerate, permethrin is difficult to use in an IPM context. It is detrimental to beneficial mites and insects, which exacerbates scale and mite problems.
   - Pests rapidly develop resistance to pyrethroids.
   - Permethrin (7-day PHI) has a shorter pre-harvest interval than esfenvalerate (14-day PHI), which is useful when salvage treatments are needed near harvest
3) **Kaolin and Spinosad**
   - Only slight OFM activity.

Other registered products

1) **methoxyfenozide (Intrepid) [IGR-ecdysone receptor antagonist]**
   - Likely replacement product for sister-compound, tebufenozide (Confirm), thought to have better OFM activity.
   - Reduced Risk product.
2) **pyriproxyfen (Esteem) [IGR-pyridene selective juvenile hormone mimic]**
   - Only moderately effective on OFM, timing is critical (must be on foliage prior to OFM egg lay). Timing for use against scale is being investigated.
   - Projects limited use for OFM because of its modest efficacy and anticipated long PHI (reference 45-day apple PHI).
   - Reduced Risk product.
   - Cost prohibitive.

B. Alternative Management Options

1) Pheromone-based mating disruption (MD) of OFM

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

2) **Pheromone trapping** to determine timing of control actions.

3) **Insect phenology models** (degree-day, egg hatch, etc.) to time applications. Nj is cooperating with Penn State to develop a refined DD-model for OFM.

C. Unregistered Chemicals or Other Control Materials: There are only a few experimental new insecticides that are effective and their registrations are not imminent. In addition, some are selective, thus, will have to be tank mixed with other insecticides.

1) indoxacarb (Avaunt) [Oxadiazine]

- Overall effectiveness unknown, short residual.
- Small plot trials suggest moderate effectiveness against plum curculio.
- Reduced Risk product.

2) thiacloprid (Calypso) [Chloronicotinyl]

- Effectiveness unknown.
- Has plum curculio and aphid activity. Small plot trials suggest moderate OFM effectiveness.

3) thiamethoxam (Actara) [Chloronicotinyl]

- Effectiveness unknown.
- Plum curculio and aphid activity. OFM efficacy is unknown.

Potential New Chemistries

1) pyridalyl [pyridine chemistry]

- Safe on beneficials, good lep activity, possible OP replacement.

2) novaluron

- Strictly contact IGR, effective on leps, Reduced Risk product.

D. Strategies for Future Control ("To Do" list for OFM)

Regulatory needs

- Expedite registration of new insecticides and other control tactics as they become available.
- Develop and implement a program that will allow researchers to test new chemistries on up to 250 acres prior to full registration (different than the EUP program which doesn't work).
- Develop protocol whereby needed pesticides remain available if residue analysis indicates insignificant risk.

Research needs

- OFM's ecology is inadequately understood. There is a major knowledge gap regarding OFM movement from adjacent orchard and non-orchard habitats.
- Develop treatment thresholds.
- Determine effectiveness of new insecticides.
- Evaluate new mating disruption delivery systems and assess the usefulness and economics of MD alone and in conjunction with the full array of insecticidal options.
- Make on-farm research monies available.
- Evaluate resistance, especially cross-resistance of OPs and new chemistries.

- Conduct residue and post-harvest interval studies.

Education needs

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

2) Plum curculio (PC)

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

A. Labeled Insecticides

Organophosphate (OP) Insecticides Currently Used for PC Control

1) **phosmet (Imidan)**
   - Phosmet provides excellent PC control.
   - Phosmet is the dominant peach insecticide. Phosmet is the primary insecticide in the East during thinning and pre-harvest, because its REI and PHI are shorter than those of azinphos-methyl.
   - Phosmet is easier on beneficials than other OPs.
   - Some processors prohibit use of phosmet and other OPs.
2) **azinphos-methyl (Guthion, Sniper)**
   - Azinphos-methyl provides excellent PC control, it has better residual efficacy than phosmet.
   - Some processors prohibit use of azinphos-methyl and other OPs.
   - Azinphos-methyl's 14-day re-entry interval (REI) limits its utility.
3) **diazinon**
   - Diazinon use is almost exclusively post-harvest, because it has shown fruit finish problems (phytotoxicity) when used in conjunction with sulfur-containing compounds. Elemental sulfur and captan (sulfur-containing) are the standard scab fungicides, effectively eliminating diazinon from in-season use.
   - Trials in apples have shown diazinon to be a mediocre PC insecticide.

Carbamate insecticides

1) **carbaryl (Sevin)**
   - A marginally effective PC insecticide.
   - Carbaryl is used in peach primarily for June beetles, rose chafers. Its short pre-harvest interval (1-day PHI) make it useful for as-needed salvage treatments just before harvest.
   - Toxic to beneficial insects and mites and disruptive to established IPM programs.
   - Some processors prohibit use of carbaryl and other carbamates.
2) **methomyl (Lannate)**
   - Methomyl is seldom used for PC.
   - Methomyl is a short residual material that is highly toxic to applicators and its PC efficacy is mediocre. Methomyl is also detrimental to beneficial complexes; its use has induced mite problems.
   - Some processors prohibit use of methomyl and other carbamates.
   - Applicator safety is a concern, very little methomyl is used.
3) **formetanate HCl (Carzol)**
   - Formetanate HCL's PC efficacy is poor.
   - Formetanate HCL can only be used once at petal fall.

Pyrethroid insecticides

1) **esfenvalerate (Asana)**
   - Esfenvalerate is a short residual material, with mediocre PC activity.
   - Post-bloom use of pyrethroids disrupt IPM programs by destroying beneficial mites and insects, which seriously exacerbates scale and mite problems.
   - Pests readily develop resistance to pyrethroids in systems where they are used repeatedly.
   - Esfenvalerate's long pre-harvest interval (14-day PHI) diminishes its potential as a pre-harvest material. As-needed pre-harvest sprays are the only recommended pyrethroid uses. Accordingly, Asana is no longer recommended to southeastern growers.
   - The resistance problems that prevail with regular pyrethroid use should also be kept in mind.
2) **permethrin (Ambush, Pounce)**
   - Permethrin is a mediocre PC material.
   - As with esfenvalerate, permethrin use is associated with scale and mite problems.
   - Pests rapidly develop resistance to pyrethroids.
   - Permethrin (7-day PHI) has a shorter pre-harvest interval than esfenvalerate (14-day PHI), which is useful when salvage treatments are needed near harvest.

Other insecticides

1) **endosulfan (Thiodan) [chlorinated hydrocarbon]**
   - Endosulfan may have PC activity.
   - Endosulfan is insecticidally active at relatively cool temperatures, which is useful, especially at petal fall.
   - Processor restricts use of this product.
   - Endosulfan's regulatory future is questionable.

B. Alternative Management Options

1) Where applicable, **row cropping and annual tillage** of adjacent cropland suppresses PC by compromising overwintering habitat.
2) **Trapping** to determine timing of control actions is only marginally effective.
3) **Insect phenology models** (degree-day, egg hatch, etc.) to time applications. Not reliable at this time

C. Unregistered Chemicals or Other Control Materials

1) indoxacarb (Avaunt) [Oxadiazine]

- Has PC activity.
- May help with re-entry (REI) considerations during thinning and picking.

2) thiacloprid (Calypso) [chloronicotinyl]

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

3) thiamethoxam (Actara) [chloronicotinyl]

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

4) diflubenzuron (Dimilin) [IGR-benzoyl phenyl urea]

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

5) imidacloprid – not effective.

D. Strategies for Future Control ('To Do' list)

Regulatory needs

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

Research needs

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

Education needs

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

3) <u>**Aphids (Green peach & other potential plum pox virus vectors)**</u>

Green peach aphid (GPA)

- GPA is a common pest in New Jersey. GPA sucks plant juices from leaves and blossoms; heavy infestations can slow tree growth and reduce fruit set.
- GPA is a known vector of the plum pox virus.
- Trees should be monitored weekly from bloom until 4-6 weeks after shuck fall.
- Larger trees can tolerate higher levels of infestation.
- Resurgence of GPA following sprays of broad-spectrum foliar insecticides is attributed to the destruction of natural predators and to insect resistance.

A. Labeled Insecticides

Organophosphate insecticides

- OPs do not provide control of GPA.

Carbamates in use for GPA Control

1) methomyl (Lannate)

- Methomyl resistant GPA populations exist in many orchards.

Chlorinated Hydrocarbons

1) endosulfan (Thiodan, Phaser)

- Endosulfan resistant GPA populations exist in many orchards.
- Some processors prohibit use.

Other insecticides

1) **imidacloprid (Provado)** Section 18 in NJ, NY, PA, WV.
   - Very effective, Section 3 registration pending in 2003.

B. Alternative Management Options

1) **Parasitoids and predators** often help suppress GPA populations. However, aphids are the prime in-orchard vectors of plum pox virus (PPV). Biocontrol is unlikely to be effective enough to be of use in areas seeking to mitigate potential spread of PPV.
2) Orchard scouting programs.
3) Need treatment thresholds to prevent tree and fruit damage.

C. Unregistered Chemicals or Other Control Materials

1) Triazamate [carbamate]

- Selective for aphids.
- Safe to beneficials and bees; good IPM fit.

2) Pirimicarb

- Selective for aphids.

3) thiamethoxam (Actara)

- Small plot trials suggest good efficacy.
- OP alternative.

4) thiacloprid (Calypso)

- Effective on aphids; very safe to bees.

5) **acetamiprid (Assail)** [chloronicotinyl]
   - Reduced Risk product.
   - Excellent on sucking insects, contact and systemic; testing needed.

6) **pymetrozine** [pyridine azomethine]
   - Controls sucking insects, testing needed.
   - Reduced Risk product and OP alternative.
7) **flonicamid** [pyridine carboxamide chemistry]
   - Candidate for Reduced Risk.
   - Selective for sucking insects; significant feeding deterrent; testing needed.
8) **dinotefuran** [tetrahydrofuryl guanidine chemistry]
   - Reduced Risk product.
   - Efficacy research needed.

D. Strategies for Future Control ('To Do' list)

Regulatory needs

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

Research needs

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

Education needs

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

4) <u>Plant Bugs & Stink Bugs</u>

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

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

A. Labeled Insecticides

Organophosphate insecticides currently used for plant bugs or stink bugs

1) **azinphosmethyl (Guthion)**
   - Good control and broad spectrum.

2) **phosmet (Imidan)**
   - Acceptable control and broad spectrum.

Pyrethroids insecticides

1) **esfenvalerate (Asana)**
   - Short residual, many applications required.
   - Post-bloom use of pyrethroids frequently upsets IPM programs by destroying beneficial mites and insects, and seriously exacerbates scale and mite problems
   - Pests readily develop resistance to pyrethroids; if they are used repeatedly, resistance should be expected.
   - Economical, but use limited due to concerns about disrupting IPM programs.
2) **permethrin (Ambush or Pounce)**
   - Permethrin is slightly less efficacious than esfenvalerate.
   - Permethrin has a shorter pre-harvest interval than esfenvalerate, which makes it more useful in as-needed pre-harvest sprays.
   - Permethrin shares all of the IPM concerns noted for Asana.

Chlorinated hydrocarbon

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

Carbamates

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

B. Alternative Management Options

1) No reliable monitoring options are available for plant bugs or stink bugs.
2) Suppression of broadleaf weeds on the orchard floor will help minimize abundance and damage of plant bugs and stink bugs. When done pre-bloom, broadleaf suppression also minimizes exposure of bees to insecticides.
3) Monitoring tools are lacking, treatment thresholds are non-existent.

C. Unregistered Chemicals or Other Control Materials

1) **indoxacarb (Avaunt)**
   - Some stinkbug activity; needs more research.
2) **thiamethoxam (Actara)**
   - Effectiveness is unknown, needs more research.
   - Moderate toxicity to plant bugs and stink bugs.
   - Significant feeding deterrent to plant bugs and stink bugs.
3) **thiacloprid (Calypso)**
   - Needs more research.
   - Moderate toxicity; very safe to bees.
   - Significant feeding deterrence.
4) **azadirachtin (Neemix, Ecozin)**
   - Significant feeding deterrence.
   - Short residual.

5) **flonicamid** [pyridine carboxamide chemistry]
- Selective for sucking insects; significant feeding deterrent; needs to be researched.
- Candidate for Reduced Risk.

D. Strategies for Future Control ('TO DO' list) for plant bugs and stink bugs

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

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

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

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

A. Labeled Insecticides

Organophosphate insecticides

1) **chlorpyrifos (Lorsban)**
   - Widely used during the dormant season; oil enhances efficacy.
2) **methidathion (Supracide)**
   - Effective during the dormant season; oil enhances efficacy.
3) **azinphos-methyl (Guthion)**
   - Cover sprays provide good control of crawlers if properly timed.
   - Some processors prohibit use of this product.
4) **phosmet (Imidan)**
   - Cover sprays moderately effective controlling crawlers.
   - Some processors prohibit use of this product.
5) **diazinon**
   - Effective for control of crawlers.
   - Used post-harvest only, as growers fear fruit finish problems with diazinon.
   - Some processors prohibit use of this product.

Other insecticides currently registered

1) Oil

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

B. Alternative Management Options

1) Several parasitoids attack scale and can provide some population suppression.
2) Pruning of infested branches can help reduce populations.
3) Remove alternate host plants adjacent to orchards.
4) Pheromone traps to determine start of male flight have limited use; males are weak fliers.
5) Black sticky tape can be used for monitoring crawlers.
6) Degree-day models are used in other tree fruit cropping systems.
7) Prohibit use of pyrethroids as these insecticides kill scale natural enemies.

C. Unregistered Chemicals or Other Control Materials

1) pyriproxyfen (Esteem)

- An insect growth regulator; OP alternative; needs additional testing.
- Reduced Risk product.
- Very effective against scale in CA, but needs testing in New Jersey peaches.

2) imidacloprid (Provado)

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

3) thiamethoxam (Actara)

- Initial testing shows good efficacy; further research needed.

4) thiacloprid (Calypso)

- Initial testing shows good efficacy; further research needed.

5) buprofezin (Applaud)

- Insect growth regulator; OP alternative; needs testing.
- Reduced Risk product.

D. Strategies for Future Control of scale(s) ('To Do' list)

Regulatory needs

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

Research needs

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

Education needs

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

6) <u>Thrips (primarily flowers and western flower thrips)</u>

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

A. Labeled Insecticides

Organophosphate insecticides

None.

Carbamates

1) **methomyl (Lannate)**
   - methomyl has peach labels in NJ, WV and PA.
2) **formetanate HCL (Carzol)**
   - Standard thrips material on peaches and nectarines, also controls plant bugs and stink bugs.
   - Not labeled for use after petal fall.

Other insecticides currently registered

1) **spinosad (Spintor)**
   - Small-plot trials indicate that spinosad provides good control of thrips.
   - A newly registered, 'Reduced Risk' material.
2) **pyridaben**
   - Needs testing; but sufficient efficacy against thrips is not expected.

Unregistered Chemicals or Other Control Materials

1) **pyriproxyfen (Esteem)**
   - An insect growth regulator; OP alternative, good IPM fit, not active on adults.
   - Reduced Risk product.
2) **thiamethoxam**
   - Efficacy needed.
3) **flonicamid** [pyridine caboxamide chemistry]
   - Efficacious against certain thrips species; more research is needed, significant feeding deterrent.
   - Candidate for Reduced Risk.
4) **dinotefuran [tetrahydrofuryl guanidine chemistry]**
   - Efficacy research needed.
   - Reduced Risk product.
5) **novaluron**
   - Strictly a contact IGR; more research is needed.
   - Reduced Risk product

B. Alternative Management Options

1) Flailing blooms over a white sheet of paper provides some indication of relative thrips abundance.

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

Regulatory needs

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

Research needs

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

Education needs

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

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

Rose Chafer

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

A. Labeled Insecticides

Organophosphate insecticides

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

Carbamates

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

Pyrethroids

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

B. Alternative Management Options

1) Traps for population monitoring.
2) Mass trapping provides some suppression.

C. Unregistered Chemicals or Other Control Materials

1) **Kaolin**
   - May have efficacy, although persistent white residue adhering to fruit at harvest could easily prevent its use in fresh peach production; more research is needed.
2) **azadirachtin (Neemix, Ecozin)**
   - Repellency effect.
   - Short lived.

3) **thiamethoxam (Actara)**
   - Moderate lethal effect.
   - Good feeding deterrence.
4) **imidacloprid (Provado)**
   - Appears to have activity against Japanese beetle; needs testing, effective control is likely.

D. Strategies for Future Control ('To Do' list)

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

Research needs
- Screening/developing new products.
- Potential of various attractants and repellents.
- Effectiveness of kaolin and azadirachtin, alone, or in combination with mass trapping.

Education needs
- Programs will be needed as new options become available.

8) Japanese Beetle (JAB)

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

A. Labeled Insecticides

Organophosphate insecticides

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

Carbamates

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

Pyrethroids

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

B. Alternative Management Options

1) Traps for population monitoring.

C. Unregistered Chemicals or Other Control Materials

1) **Kaolin**
   - May be efficacious, persistent white residues adhering to fruit at harvest are a problem, more research is needed.
2) **azadirachtin (Neemix, Ecozin)**
   - Repellency effect.
   - Short lived.
3) **thiamethoxam (Actara)**
   - Moderate lethal effect.
   - Good feeding deterrence.
4) **imidacloprid (Provado)**
   - Should be effective against Japanese beetle; research needed.

D. Strategies for Future Control ('To do' list)

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

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

Education needs
- Programs will be needed as new options become available.

9) <u>Borers</u>

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

A. Labeled Insecticides

Organophosphate insecticides

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

Chlorinated Hydrocarbons

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

Pyrethroids

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

B. Alternative Management Options

1) Mating disruption shows promise for borer control, especially for LPTB.
2) More research on efficacy is needed.
3) Pheromone traps for monitoring.

C. Unregistered Chemicals or Other Control Materials

None identified.

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

Regulatory needs

- Provide incentives for research of new products.

Research needs

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

Education needs

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

10) <u>Leafrollers</u>

Obliquebanded leafroller (OBLR)
Tufted apple budmoth (TABM)

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

A. Labeled Insecticides

Organophosphate insecticides

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

Carbamates

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

Pyrethroids

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

Other labeled insecticide options

1) **spinosad (Spintor)**
   - Good efficacy at high rate.
   - Cost is prohibitive (Expensive).
   - Short residual, frequent applications needed.
2) **methoxyfenozide (Intrepid)**
   - Good efficacy
3) **pyriproxifen (Esteem)**
   - Only moderately effective.
   - Small plot trials suggest suppression of feeding, but not lethality.
4) **azadirachtin**
   - Testing needed.

B. Alternative Management Options

1) Pheromone trapping and phenology models for timing of control actions needed.
2) **Pheromone-based mating disruption**
   - Not effective as a stand-alone control, supplemental insecticide sprays are needed.
3) **Bacillus *thuringiensis* (Dipel, Javelin, etc.)**
   - Temperature sensitive, often too cool to allow for good efficacy.
   - Short residual, multiple applications required.

C. Unregistered Chemicals or Other Control Materials

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

2) **indoxacarb (Avaunt)**
   - Effectiveness is questionable.
   - Reduced Risk product.
3) **emamectin benzoate (Proclaim)**
   - Research is needed.
4) **diflubenzuron** (IGR)
   - Research is needed.
5) **novuralon** (IGR)
   - Research is needed.

D. Strategies for Future Control ('To Do' list)

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

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

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

Pest management aids
1) Traps for population monitoring.

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

A. Labeled Insecticides

Organophosphate insecticides used for peach mite control

None

Miticides currently registered

1) 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.

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

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

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

5) hexythiazox (Savey) [Carboxamide chemistry]
- Safe on beneficials.
- Primarily an ovicide.

6) pyridaben (Pyramite) [Pyridazinone]
- Fast acting.
- Need higher rates for TSSM.
- Moderate toxicity to beneficials.

7) bifenazate (Acramite) [carbazate chemistry]
- Quick knockdown, safe for predatory mites, higher rates needed for ERM.
- Reduced Risk product.

8) Kaolin
- Causes mite outbreaks.

B. Alternative Management Options

1) Several generalist and specific predators and predaceous mites are important in the management of mites.
2) Selection and timing of insecticide applications can directly impact mites.
3) Orchard scouting programs

C. Unregistered Chemicals or Other Control Materials

1) abamectin (AgriMek)
- Must be applied with adjuvant; long residual activity.

2) milbemectin
- Excellent miticide.
- Reduced Risk product.

3) etoxazole [oxazoline chemistry]
- Research needed.

4) **fenpyroximate** [phenoxypyrazole chemistry]
- Research needed.
- Reduced Risk product.

D. Strategies for Future Control ('To Do' list)

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

Research needs
- Develop treatment thresholds.
- Screening and development of new compounds.
- Better tools to help target the timing of sprays.
- Potential for biological control.

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

NEMATODES

Nematodes are extremely important to peach production, since nematodes cause direct damage and play a major role in peach tree short life. Nematodes are also important vectors of certain peach viruses, such as peach rosette mosaic virus and tomato ringspot virus. **Root knot** (*Meloidogyne* spp.), **ring** (Criconemella xenoplax), **lesion** (*Pratylenchus vulnus*), and **dagger** (*Xiphinema* spp.) nematodes are the major nematodes of concern to peach production.

One of the most serious nematode problems is peach stem pitting. This disease is caused by the tomato ringspot virus (TmRSV) transmitted by the **dagger** nematode (Xiphinema spp.). Dagger nematodes and TmRSV are both common in orchards. Trees infected with TmRSV lose vigor and eventually die.
On replant sites, nematodes are also key risk factors influencing orchard health and productivity. Replanted fruit trees frequently have difficulty becoming reestablished, often because of interactions between nematodes and other soil microorganisms. The root-lesion nematode, *Pratylenchus penetrans*, is often the cause of the problem. However, replant disease can be prevented by assessing the risk of problems with preplant nematode assays and by proper site preparation.

Site selection based upon representative sampling for nematodes is very important. Since nematodes are usually not uniformly distributed in a field, a carefully prescribed sampling procedure must be followed to obtain root and soil samples representative of the area surveyed.

Cultural practices for control are mainly limited to crop rotation strategies. Root stock selection is also a very important control measure. However, use of chemical nematicides and fumigants continues to play a crucial role in control strategies for peach nematodes. Pre-planting fumigation or applications of nematicides are commonly used practices. Post-plant nematicide application is often a site-specific response to "hot" nematode sites, hence its use is more selective.

A. Labeled Nematicides:

1) **Methyl-bromide (Brom-O-Gas, Meth-O-Gas, and other names)** is generally sold as a combination of methyl bromide and chloropicrin. Though methyl bromide gives excellent control of nematodes, it will be completely phased out by 2005, in accordance with the Montreal Protocol. Methyl bromide is soil-injected as a pre-plant application; plastic tarp is applied to seal the gas as it is applied.
2) **1,3-Dichloropropene (Telone)** is often utilized for pre-plant nematode control. It is deep-shank injected and sealed with a water or soil seal. While possibly not as efficacious as methyl bromide, this material is an integral part of nematode control in peach orchards. When combined with good root stocks, control can be excellent.
3) **Metam-sodium (Vapam)** is also applied preplant. It is generally roto-tilled into the soil. It is probably the least efficacious of the three pre-plant materials, but when applied in combination with 1,3-dichloropropene, it can broaden and increase nematode control.
4) **Fenamiphos (Nemacur)** is applied post-plant in the fall for suppression of major peach nematodes. . Bayer has requested voluntary cancellation of fenamiphos (i.e., will not support reregistration); cancellation to become effective May 2005. EPA plans to complete the IRED for the compound.

B. Alternative Management Options

C. Strategies for Future Control ('To Do' list)

Regulatory Needs:

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

Research Needs:

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

DISEASES

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

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

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

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

Pertinent to the regulatory needs throughout the document, the following products are on the EPA 2002 workplan for approvals on stone fruit crops, including peach, nectarine, etc.: trifloxystrobin [foliar] and fludioxonil [for post-harvest use only]. Benlate [benomyl], is being voluntarily cancelled by registrants, and EPA published a Federal Register notice which was the final cancellation order, effective Jan. 15, 2002; existing stocks may be sold by persons other than the registrants until Dec. 31, 2002.)

A. Labeled Brown rot Fungicides:

De-methylation Inhibitors (DMIs): Resistance management is a primary concern with this essential class of brown rot fungicides.

1) **propiconazole (Orbit)**
   - One of the standard materials, quite heavily relied on for pre-harvest brown rot control.
2) **fenbuconazole (Indar)**
   - Indar is often relied on when disease pressure is greatest.

3) **tebuconazole (Elite)**
   - Elite is often used in the last pre-harvest application as it may provide longer lasting brown rot control on the harvested fruit.
4) **myclobutanil (Nova)**
   - Nova is only modestly effective against brown rot. It is generally not recommended brown rot control.

Methyl benzimidazole carbamates (MBCs): MBCs are resistance prone and should be used judiciously, likely no more than once per season. MBCs are important as alternative, non-DMI chemistries, to provide brown rot control with an alternative toxic mode of action.

1) **benomyl (Benlate)**
   - Benlate is recommended mainly for blossom blight.
2) **thiophanate-methyl (Topsin-M)**
   - Topsin-M is recommended mainly for blossom blight.

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

1) **iprodione (Rovral)**
   - Rovral is labeled for use before petal fall in both peach and plums.
   - Brown rot resistance to Rovral and other dicarboxamindes exists, so these materials must be used with caution.
   - Rovral has some activity against Botrytis and gummosis.
   -

Anilinopyrimidine

1) **cyprodinil (Vangard)**
   - Vangard is labeled for control of blossom blight phase only.
   - Vangard has some activity against Botrytis.
   - Reduced Risk product.

Hydroxyanilide

1) **fenhexamid (Elevate)**
   - Newly registered; efficacy data are being developed for stone fruit.
   - May provide a resistance management tool.
   - Reduced Risk product

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

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

Multi-Site Fungicides

1) **chlorothalonil (Bravo, Equus)**

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

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

Phenylpyrrole

1) **Fludioxonil (Scholar)**
   - Scholar's post-harvest use in stone fruit is presently allowed under the auspices of state-to-state Section 18 registrations.
   - Scholar is a highly efficacious material.
   - Scholar is classified by EPA as Reduced Risk

B. Unregistered Potential Fungicides:
Strobulurins

1) **trifloxystrobin (Flint)**
   - Flint is felt to have high potential for cross-resistance with Abound and other soon to be labeled strobilurins.
   - Reduced Risk product
2) **BAS 500 F (Cabrio)**
   - Cabrio will likewise pose a high potential for cross-resistance with other strobulurins.
   - Classified by EPA as Reduced Risk
3) **BAS 516 (chemistry not disclosed)**
   - Unknown efficacy.
   - Combination of fungicides.
   - Classified by EPA as Reduced Risk
4) **Pyrimethanil (Scala)**
   - Stone fruit registration classified as Reduced Risk

C. Strategies for Future Control:

Regulatory Needs

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

Research Needs

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

2) <u>Scab (*Cladosporium carpophilum*)</u> **Scab is a major disease in the humid peach production regions east of the Rocky Mountains.** Scab requires an almost season-long fungicidal program (from petal fall or shuck split until 4 weeks before harvest). Early applications (until 6 weeks past petal fall) are most important for scab control. Lower disease pressure later in the season frequently allows use of extended spray intervals or alternate-row middle spraying, thereby reducing pesticide input. There are no alternatives to chemical control. Scab cannot be controlled with cultural practices such as pruning or sanitation, and there is no peach germplasm available with reduced susceptibility to scab.

A. Labeled Fungicides

1) sulfur

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

2) captan

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

3) chlorothalonil (Bravo, Equus)

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

Limited Site Fungicides

Strobilurins

1) azoxystrobin (Abound)

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

Methyl benzimidazole carbamates (MBCs)

1) benomyl (Benlate)

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

B. Unregistered Potential Fungicides:

1) **trifloxystrobin (Flint)**
   - Reduced-risk fungicide (strobilurin class).
   - Strobilurins have a high potential for cross-resistance.
2) **BAS 500 F (Cabrio)**
   - Reduced-risk fungicide (strobilurin class)
   - Strobilurins have a high potential for cross-resistance.
   - Good efficacy on scab
3) **BAS 516 – good efficacy on scab**

C. Strategies for Future Control

Regulatory needs

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

Research needs

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

3) <u>Constriction Canker (*Phomopsis amygdali*)</u>

- Constriction canker, an important endemic fungal disease in middle and older aged orchards in New Jersey, contributes to early decline and loss of orchard productivity
- Major epidemics in New Jersey during the 1950's resulted in thousands of trees of susceptible cultivars to be removed
- The shoot blight phase kills fruit bearing twigs, causing direct yield loss in the current growing season.
- Shoot death tends to occur on lower half of tree, making it difficult to maintain productive, low-height trees that are easier to manage (thinning, harvest, spraying)
- Yield loss in moderately infected orchards averages 20-30%. Individual, severely infected blocks have been observed to have as much as 75% fruit loss. Unlike many other diseases, e.g. bacterial spot, annual loss from constriction canker is fairly consistent once a sufficient number of cankers occur in an orchard.
- Cultivars differ in susceptibility, but few are resistant. Cultural control, removing cankers via pruning, is only partially successful and labor intensive.

A. Labeled Fungicides

- No fungicides are currently labeled for control of constriction canker.

B. Unregistered Potential Fungicides:

1) **Chlorothalonil and captan** appear most effective, although many sprays are needed during the fall, postharvest season for adequate control
2) **Azoxystrobin, myclobutanil, benomyl, and copper** were found less effective
3) Many newer **reduced-risk fungicides**, such as trifloxystrobin, BAS 500 F, BAS 516, and cyprodinil need to be examined for efficacy

C. Strategies for Future Control

Regulatory Needs

- Extension of chlorothalonil and/or captan labels to include postharvest applications (once research makes this economical)
- Labeling any reduced-risk fungicides found to be effective

Research Needs

- Development of a disease forecasting model to reduce number of applications needed for effective control; reduces cost of control and minimizes environmental impact
- Evaluate reduced-risk materials for efficacy

4) **<u>Rusty Spot (tentative: *Podosphaera leucotricha*)</u>**

- Rusty spot is an important disease on a number of commonly grown New Jersey cultivars, including Jerseyqueen, Encore, Loring, Jerseyglo, Bounty, and Autumnglo. Fruit infection can approach 90% in disease favorable seasons.
- The apple powdery mildew pathogen, *Podosphaera leucotricha*, is believed to be a causal agent, but other powdery mildew species may also be involved.
- Infection only occurs on fruit, and is initially manifested as orange to rust-colored lesions. Eventually, the lesion becomes smooth and russetted as the epidermal cells are killed. Severe infections can result in cracking as the tissue expands during preharvest fruit swell.
- Highly susceptible cultivars require four applications of myclobutanil from petal fall through second cover. Other DMI's, strobilurins, and sulfur are less effective than myclobutanil.

A. Labeled Fungicides

De-methylation Inhibitors (DMI's) – resistance management is major concern

1) **Myclobutanil (Nova)**
   - most effective fungicide
   - necessary for adequate control on highly susceptible cultivars
2) **Tebuconazole (Elite) –**
   - second best material for control; may be useful for control on less susceptible cultivars
3) **Fenbuconazole (Indar)**
   - only moderately effective; not recommended
4) **Propiconazole (Orbit) –** not effective

Strobilurins

1) **Azoxystrobin (Abound)**
   - only moderately effective; not recommended

Benzimidazoles

1) **Thiophanate-methyl (Topsin-M)**
   - slightly effectively; not recommended

Multi-Site Fungicides, Protectants

2) Chlorothalonil, captan, and ziram – not effective

3) **Sulfur** – partially effective (50% control); may be useful for less susceptible cultivars

B. Unregistered Potential Fungicides:

1) **Trifloxystrobin (Flint)** – recent testing indicates not as effective as myclobutanil; control ability may be equivalent to tebuconazole; reduced-risk, potential for cross-resistance
2) BAS 516 – combination of fungicides currently in testing

C. Strategies for Future Control

Regulatory Needs

- Labeling any reduced-risk fungicides found to be effective

Research Needs

- Examination of "powdery mildew active" biological and biorational control materials for integrated use with myclobutanil
- Study on the pathogen biology to improve understanding of the etiology, epidemiology, and ultimately control
- Continue evaluate reduced-risk materials for efficacy

5) Bacterial Spot

Bacterial spot (*Xanthomonas arboricola* pv. *pruni*, syn. *X. campestris* pv. *pruni*) is a major bacterial disease of susceptible peach cultivars. Though resistant cultivars are available, many of the more profitable cultivars currently in commercial production are moderately to severely susceptible to bacterial spot. This disease effects fruit, leaves, and twigs. Economic loss occurs when fruit are infected. Fruit losses may approach 100% on highly susceptible cultivars if conditions are favorable for disease and controls are not applied.

Existing controls are extremely important, but they are not as consistently effective as controls for scab and brown rot. Three to five copper-containing bactericides are used from early bud-swell through late bloom (i.e., early shuck off). Rates of copper are reduced from ca. 2.0 lb metallic copper per acre at the early spray to ca. 0.4 lb metallic copper per acre at the late bloom application. The fungicides Ziram or Ferbam are recommended as a tank-mix with the copper sprays, as it appears to enhance the activity of copper against the bacteria. The antibiotic, oxytetracycline is used after bloom and up to 21 days before harvest on a 7- to 14-day spray interval depending on weather conditions.

A. Currently Used Bactericides and Antibiotics:

1) **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.

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

B. Unregistered Potential Fungicides:

1) **Zinc sulfate**
2) ***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.

C. Strategies for Future Control:

Regulatory Needs

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

Research Needs

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

6) Soil and Root Diseases

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

7) Minor and Potentially Emerging Diseases

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

WEEDS

General Conclusions

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

Critical Weed Management Needs

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

Seasonal Orchard Floor Management Strategies in Peach

1) <u>Dormant Season Peach Orchard Floor Management</u>

Broadleaf Weeds are divided into winter annual weeds and perennial weed species.

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

A. Herbicides Currently Recommended

1) **2,4-D amine** (Various trade names) [Phenoxy]
    - 2,4-D amine or paraquat are applied to row middles. May be applied in herbicide strip if fall preemergence was not used.
    - 2,4-D will not adequately control species like white clover.
2) **paraquat (Gramoxone Max, Boa)** [Bipyridilium]
    - used in areas where warm-season perennial are planted in row middles.
    - paraquat is applied to row middles. May be applied in herbicide strip if fall preemergence was not used.
3) **simazine**
4) **dichlobenil** (Casoron)

B. Non-chemical options:

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

C. Unregistered Chemicals

1) **clopyralid (Stinger)** [Pyridine]
2) **halosulfuron (Sempra)** [Sulfonylurea]
3) **triclopyr** (Garlon)
4) **fluoxypyr** (Starane)
5) **metolachlor** (Dual Magnum)

D. Strategies for Future Control

Regulatory

- None

Research

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

Education

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

2) **Late Spring and Summer Season Peach Orchard Floor Management**

Grass and Broadleaf Weeds:

- Common summer weeds include pigweed (various species), common lambsquarters, morning glory (various species), large crabgrass, goosegrass, fall panicum, foxtails, bermudagrass, Johnsongrass, horsenettle, horseweed, brambles, Virginia creeper, poison-ivy and yellow nutsedge.
- Summer weeds compete with trees for water and nutrients.
- In newly planted orchards, weed competition reduces growth and delays tree development, which drastically reduces early yields.
- In established orchards, competition from summer weeds reduces fruit size and yield.
- Weeds are primarily a concern in the herbicide strip, within the tree row.
- Late spring pre-emergence herbicides will provide residual control. However, post-emergence herbicides may be needed to control escaped weeds.
- All herbicides are applied as directed sprays.
- Perennial grass weeds (bermudagrass) must be controlled with Fusilade or Poast.

A. Currently Recommended Pre-emergence Herbicides

1) **simazine** (Princep and various generic formulations) [Triazine]
    - most commonly used peach herbicide
2) **diuron** (Karmex) [Urea]
    - commonly used, often in tank mix with Sinbar and a residual grass herbicide
3) **terbacil** (Sinbar) [Uracil]
    - commonly used, often in tank mix with Karmex
4) **norflurazon** (Solicam) (Pyridazinone)
5) **oryzalin** (Surflan) [Dinitroaniline]
6) **pendimethalin** (Prowl) [Dinitroaniline]
    - non-bearing use only
7) **isoxaben** (Gallery)
    - non-bearing use only

B. Currently Recommended Peach Post-emergence Herbicides:

1) **paraquat** (Gramoxone) [Bipyridilium] – commonly used
2) **glyphosate** (Roundup) [Phosphono Amino Acids] – commonly used
3) **fluazifop** (Fusilade) [Aryloxyphenoxy]
4) **sethoxydim** (Poast) [Cyclohexenone]
5) **2,4-D**

C. Nonchemical Options

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

D. Potential Alternative Peach Herbicides

1) **thiazopyr** (Visor) [Pyridine]
2) **halosulfuron** (Sempra) [Sulfonylurea]
3) **fluroxypyr** (Starane) [Pyridine]
4) **flumioxazin** (Valor) [PPO inhibitor]
5) **oxadiargyl** (Topstar) [Oxadiazole]
6) **clopyralid** (Stinger) [Pyridine]
7) **triclopyr** (Garlon) [Pyridine]
8) **S-metolachlor** (Dual Magnum) [Amide]

E. Strategies for Future Control

Regulatory

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

Research

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

Education

- Educate growers on the multiple benefits of site specific Orchard Floor Management programs.

3. <u>Post-harvest (Fall) Orchard Floor Management</u>

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.
- Post-harvest herbicide applications are in the herbicide strip only.
- 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.

A. Currently Recommended Peach Pre-emergence Herbicides

1) **diuron** (Karmex) (Urea)
2) **norflurazon** (Solicam) (Pyridazinone)
3) **oxyfluorfen** (Goal) (Diphenylether)
4) **pronamide** (Kerb) (Amide)
5) **simazine** (Princep and various generic formulations) (Triazine)
6) **oryzalin** (Surflan)
7) **terbacil** (Sinbar)

B. Registered Postemergence Herbicides

1) **glyphosate (Roundup)** (Phosphono Amino Acids) – dormant application only
2) **paraquat (Gramoxone)** (Bipyridilium)
3) **2,4-D** [Phenoxy]
4) **sethoxydim**
5) **Fusilade DX**

C. Nonchemical Options

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

D. Unregistered Chemicals

1) **thiazopyr** (Visor) (Pyridine)
2) **halosulfuron** (Sempra) (Sulfonylurea)
3) **fluroxypyr** (Starane) (Pyridine)
4) **flumioxazin** (Valor) (PPO inhibitor)
5) **oxadiargyl** (Topstar) (Oxadiazole)
6) **clopyralid** (Stinger) [Pyridine]
7) **triclopyr** (Garlon) [Pyridine]
8) **fluoxypyr** (Starnane) [Pyridine]
9) **S-metolachlor** (Dual Magnum) [Amide]

E. Strategy for Future Control

Regulatory

- None.

Research

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

Education

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

VERTEBRATE PESTS

1. **Deer**
   A. Legal Status: The New Jersey Division of Fish and Wildlife (NJDFW) have sole authority for managing deer hunting seasons and issuing depredation permits.
   B. Damage Prevention and Control Methods
      1) Exclusion using assorted fencing designs
      2) Frightening using loud noises, lights, dogs, etc.
      3) Repellents
      4) Shooting and hunting
2. **Voles**
   A. Legal Status: Voles are classified as a non-game animal and can be controlled as necessary when causing damage.
   B. Damage Prevention and Control Methods
      1) Exclusion using hardware cloth
      2) Habitat modification
      3) Toxicants using zinc phosphide or anticoagulants
      4) Trapping
3. **Groundhogs**
   A. Legal Status: Groundhogs are considered a game species, and as such, are managed according to a groundhog season by the New Jersey Division of Fish and Wildlife. Property owners (i.e., farmers) or their agents may control groundhogs at anytime of the year by lawful means subject to local ordinances.
   B. Damage Prevention and Control Methods
      1) Exclusion using welded wire, woven wire, or electric fences.
      2) Fumigants (Note: one fumigant, aluminum phosphide, is a restricted use pesticide).
      3) Live trapping
      4) Shooting
4. **Crows**
   A. Legal Status: Crows are considered a migratory species and are protected under the Migratory Bird Treaty Act. Under this Act, crows may be controlled without a Federal permit when causing damage or it is anticipated they will depredate agricultural crops. No state permit is necessary to control crow damage. In addition, a crow season is typically established each year.
   B. Damage Prevention and Control Methods
      5) Exclusion using plastic netting or parallel wire grid
      6) Habitat modification by thinning tree roosts
      7) Frightening using loud noises, scare devices, and chemical agents (Note: Avitrol, a chemical agent, is a restricted use pesticide)
      8) Trapping
      9) Shooting and hunting
5. **Rabbits**
   A. Legal Status: Rabbits are considered a game species, and as such, there is a specified rabbit hunting season.
   B. Damage Prevention and Control Methods
      1) Exclusion using assorted fencing designs or tree guards
      2) Habitat modification
      3) Repellents
      4) Trapping
      5) Shooting and hunting

6. <u>Bear</u>

A. Legal Status: Bears have game animal status but as of December 2002, there is no black bear season.

B. Damage Prevention and Control Methods
   1) Exclusion using assorted fencing designs and bear-proof buildings and trash receptacles
   2) Habitat modification
   3) Frightening using loud noises, lights, and dogs, etc.
   4) Repellents
   5) Aversive conditioning (i.e. pepper spray, rubber bullets)
   6) Trapping

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