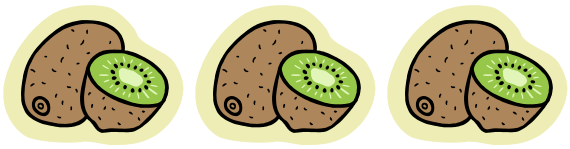
A Pest Management Strategic Plan for Kiwifruit Production in California



The California Kiwifruit Commission (CKC)

The California Minor Crops Council (CMCC)

The California Minor Crops Council received major funding for this project from the EPA Region 9 Agricultural Initiative and the USDA Cooperative States Research, Education, and Extension Service (CSREES) Pest Management Alternatives Program (PMAP).

CMCC received additional support from the California Kiwifruit Commission and the Western Regional Pest Management Center at UC Davis. Funding for this project also has been made available by the Governor's *Buy California* initiative, the California Department of Food and Agriculture, and the U.S. Department of Agriculture, through the University of California's Specialty Crops Research Program.

We gratefully acknowledge the contributions of all of these organizations and their participation in this process.

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EXECUTIVE SUMMARY

California produces virtually the entire United States kiwifruit crop (>98%). In 2002, this commodity generated income of approximately $23 million from about 3700 acres. Acreage has been steadily declining since the late 1990s due to many pressures on the industry. These include resistance management issues, cancellation of or restrictions on pesticides formerly available (e.g., Ronilan®), environmental restrictions on farming and worker practices, declining profitability, urban encroachment, and global competition.

Compared with other commodities, California kiwifruit has relatively few pest problems; as a result, there is very little pesticide usage recorded for this crop. The most important pests are armored scales, omnivorous leaf rollers, soil-borne nematodes and diseases, and post-harvest disease (*Botrytis*). While the number of pests may be relatively low, they can cause significant economic consequences to the grower.

To help transition to "Reduced Risk" pest management in accordance with FQPA and other regulatory activities, the USDA and EPA have requested that all commodities develop Pest Management Strategic Plans (PMSPs) to identify growers' critical research, registration, and educational needs. "Reduced Risk" broadly describes pest management techniques and tools that are safe for consumers, workers, and the environment.

In 2002, several members of the kiwifruit industry met to discuss the long-term issues of insect, mite, disease, weed, and vertebrate control. The work group consisted of growers, packers, shippers, pest control advisers (PCAs), cooperative extension personnel, farm advisors and research scientists, along with representatives from the Environmental Protection Agency Region 9 and the Western Region Integrated Pest Management Center.

The purpose of the industry meeting was to develop a Pest Management Strategic Plan (PMSP) for the issues of greatest concern to kiwifruit growers in California. The input gathered at this meeting provided an important perspective on the pest management products and techniques used in this commodity. Focusing on the pests that have the most significant economic impact on the California kiwifruit industry, the steakholders identified the critical research, regulatory, and educational needs of California kiwifruit growers.

The PMSP for California kiwifruit comprehensively summarizes the crop production and pest management practices used by this industry in California. The foundation for this document is the *Crop Profile for California Kiwifruit,* at http://pestdata.ncsu.edu/cropprofiles/docs/cakiwi.html.

Methyl bromide and Ronilan® are examples of products used in kiwifruit production that are being phased out due to FQPA and other regulatory decisions. The loss of these and other valuable crop protection tools and the widespread reductions in funding for Land Grant University research and extension programs require that all resources be used in the most efficient manner possible. The development of a long-term plan to address the needs of the kiwifruit industry will help to maximize efforts made to generate information and solutions for the growers.

This strategic plan includes an overview of kiwifruit production, seasonal pest occurrences, and integrated pest management techniques throughout California. The plan addresses both current and emerging pest management needs; it is a working document that will need to be updated periodically. Efficacy ratings of various pest control techniques (chemical and non-chemical) used in kiwifruit production have been summarized from input made by growers, pest control advisors, and other experts involved in field activities.

The industry experts (growers, pest control advisors, industry representatives, and university research and extension personnel) listed in Appendices 12 and 13 of this PMSP are resources who can provide more detailed information regarding California kiwifruit production.

This strategic plan will receive periodic updates; it serves principally as a guideline to direct future pest management efforts related to California kiwifruit production. Important documents that provide a basis for this strategic plan are UC ANR Publication 3449 (*Integrated Pest Management Guidelines for Kiwifruit*) and the *Crop Profile for California Kiwifruit* (http://pestdata.ncsu.edu/cropprofiles/docs/cakiwi.html); these documents provide a complete review of cultural and pest management practices for California kiwifruit.

The mention of specific trade names in this document is not an endorsement of any particular product.

Stakeholder Recommendations

As a result of the stakeholder input gathered at the meeting held in November 2002 and revisions made to this document in 2003, the Kiwifruit Work Group identified the following research, regulatory, and educational priorities.

Research Priorities

Finding effective solutions to disease control (especially post-harvest disease control) is the most immediate and serious concern for California kiwifruit growers. Alternatives to using organophosphate insecticides and methyl bromide are also important to continued development of reduced-risk pest management systems for control of insect and nematode pests. Research on soil and plant health management, including vegetation management and pollination, is needed to improve yield and quality of California kiwifruit. The university research and extension programs will remain critical in identifying and adopting new technologies for pest management in California kiwifruit production; there is concern that loss of personnel in these institutions will impede the development of improved horticultural and pest management practices for this commodity.

- Evaluate pre- and post-harvest *Botrytis* management tools
- Evaluate *Phytophthora* management tools
- Evaluate nematode control options
- Evaluate scale control options
- Determine the role of pollination, pruning techniques, thinning, and cane girdling on fruit size
- Evaluate attributes of plant, soil health, and nutrients as these relate to fruit size, quality, and storage

Regulatory Priorities

The kiwifruit industry needs new post-harvest disease control products registered to replace older chemistries that are being phased out by FQPA, and/or that will not be supported by the registrants. Harmonization among IR-4, Cal/EPA, and US EPA should be encouraged to facilitate timely registration of reduced risk products. In addition, all registrants should ensure that all new product registrations are in compliance with provisions of NAFTA, Codex, and all importing countries.

- Expedite the full Section 3 registration of *Botrytis* materials (especially Elevate®)
- Register an oil that is acceptable for use in organic kiwifruit (for scale control, etc.)
- Expedite registrations for OP alternatives: Seize® and Success®
- Expand the pheromone use season
- Keep kiwifruit on generic pesticide labels
- Harmonize Cal/EPA and US EPA registrations to hasten new product registrations
- Identify potential trade irritants as early as possible in the research and registration process; insure there are no conflicts with provisions of NAFTA or Codex

Educational Priorities

The public, including regulators and consumer groups, must be educated about the use of Integrated Pest Management (IPM) in California kiwifruit production and how this system optimizes food production while minimizing risks to workers and the environment. Growers and PCAs need to be educated on improved cultural practices and new materials used in kiwifruit production. University programs in the areas of research and education should be enhanced to provide training on reduced risk pest management and best management practices. Finally, the public should be reminded that eating California kiwifruit is an important part of a healthy lifestyle and that this produce is grown under the highest standards of safety and quality in the world.

- Educate growers and PCAs on the use of Elevate® for post-harvest disease control
- Educate growers on water management for *Phytophthora* control
- Educate growers on current knowledge of plant and soil health and nutrition, pruning, and cultural practices
- Educate growers on resistance management for new chemistries
- Educate growers on use of PGRs and new PGR chemistries
- Educate growers, PCAs, and commodity members on the use of best management practices to protect and improve water and soil quality
- Educate the public on the nutritional values of California grown kiwifruit and their high level of food safety and quality

The California kiwifruit industry appreciates the support of US EPA, USDA, CDPR, and the University of California Land Grant system throughout the development of this strategic plan. We look forward to the valuable assistance provided by these agencies and institutions as we develop responses to the many issues facing the California kiwifruit industry.

The California Minor Crops Council received major funding for this project from EPA's Region 9 Agricultural Initiative and the USDA Cooperative States Research, Education, and Extension Service (CSREES) Pest Management Alternatives Program (PMAP).

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November 2003

A PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA KIWIFRUIT

1. KIWIFRUIT PRODUCTION OVERVIEW

The woody, twining vines of kiwifruit are grown in sunny locations protected from strong winds. The vines' size, vigor, longevity, and heavy crop load require a strong, permanent support structure. The vines also require deep, well-drained, slightly acidic (pH 5 – 6.5) soils; kiwifruit is an appropriate crop wherever citrus, peaches, and almonds are successful. Reaching commercial production in three years, kiwifruit can remain productive for over 50 years.

Kiwifruit require at least 240 frost-free days without late winter or early autumn freezes. While all cultivars need a certain period of winter chilling (600 to 850 chill-hours at or below 45°F), their needs vary dramatically. The most popular cultivar, Hayward, does best with a winter rest of 800 hours of chilling (defined as total hours between 32° and 45°F). In dormancy, mature kiwifruit vines can withstand temperatures to 10°F.

A fully canopied vineyard requires approximately 40 to 48 acre-inches of water per year. On a hot California summer day, water use can peak around 7,000 to 8,000 gallons per acre. The most commonly used irrigation systems are the localized or low-volume drip, or micro-sprinklers.

Production Summary

- California grows about 98% of all kiwifruit produced nationally.
- The U.S. ranks seventh in world production of kiwifruit behind Italy, New Zealand, Chile, France, Japan, and Greece; shipping seasons overlap in some cases.
- California's kiwifruit acreage has declined since 1999 due to high production costs and competition from foreign markets.
- One major variety of kiwifruit grown worldwide is "Hayward," from New Zealand.
- The marketing season for California kiwifruit extends from late September into June.
- Approximately 95% of the kiwifruit harvest is sold fresh; about 5% is processed.
- Kiwifruit can be stored for over eight months.
- New kiwifruit varieties with different flavors, colors, and textures are being developed to fill premium niches in world markets; a recently patented golden flesh variety of kiwifruit from New Zealand ("Gold") is being commercially grown on a limited number of acres in California.
- Bees are required for pollen transfer, so honeybees are routinely placed around vineyards for pollination.
- After initial fruit set, only 50 – 60% of the crop will actually make it to the market place due to weather-related factors that affect fruit size and quality, industry enforced quality standards, thinning, and culling.
- Approximately 15 – 20% of the annual U.S. kiwifruit crop is exported, mainly to Mexico and Canada, followed by Korea and Japan.
- The most important pests of California kiwifruit are post-harvest disease (*Botrytis)*, armored scales, omnivorous leaf rollers, soil-borne nematodes and diseases.
- Approximately 8% of California's kiwifruit acreage is organically farmed.

California Kiwifruit Production Regions

While kiwifruit is grown in many parts of California, the majority is produced in the Sacramento Valley (Butte, Yuba, and Sutter counties) and the Southern San Joaquin Valley (Tulare, Kern, Fresno, and Kings counties), with fruit coming occasionally from San Bernardino, Santa Barbara, San Luis Obispo, Ventura, and San Diego counties. Fruit in the San Joaquin Valley ripens 7 to 10 days earlier than that in the north, but otherwise conditions in both growing regions are very similar. Figure 1 shows the primary kiwifruit production regions in California.

Figure 1: Kiwifruit Production Regions

California Kiwifruit Industry

Kiwifruit growers report data from two principal growing regions: the Sacramento Valley and the Southern San Joaquin Valley (SJV), represented on the map by solid black lines. The Southern SJV counties of Fresno, Tulare and Kern produced 52% of the state's total 2002 harvest, while the Sacramento Valley counties of Butte, Solano, Sutter, and Yuba produced about 48%.

Stages and Approximate Length of Time for California Kiwifruit Development

DORMANCY	BUD BREAK THROUGH BLOOM	FRUIT SET THROUGH PRE-HARVEST	HARVEST	POST-HARVEST
December through March	early March through mid-May	mid-May through late September	late September through late November	fruit can be stored more than eight months

Differences in the Major Kiwifruit Production Regions of California

	Southern SJV	Sacramento Valley
Soil Types	sand/loam/clay	sandy loam/loamy sand
Bud Break Period	late April – mid May	May
Dormancy (length)	shorter	longer
Annual Rainfall	6 – 9”	20 – 24”
Temperatures	higher maximums	moderate

Important Pests in the Major Kiwifruit Production Regions of California

Kiwifruit plants are relatively free from pest problems, possibly due to their lack of heavy planting in localized areas.

- Scale (greedy, latania, oleander) insects can be a problem if populations build up too extensively; if present in the soil, nematodes will reduce plant vigor.
- Of the four leaf-rolling caterpillars that attack kiwifruit (omnivorous, fruit-tree, oblique-banded, and orange tortrix), omnivorous leaf roller is the most common and the most damaging.
- *Phytophthora* crown and root rot is one of the more serious diseases of kiwi grown in California.
- *Botrytis,* or gray mold, is the most important post-harvest disease of kiwifruit in California; since the pathogen requires free-moisture for spore germination and infection, disease is more severe when rainy weather occurs during bloom.
- Kiwifruit plants can be severely damaged by root knot nematodes.
- Two-spot spider mites can build up on plants during hot, dry weather, particularly on plants grown in greenhouses and occasionally on plants grown outside.
- Perennial grasses (Bermuda grass, Johnsongrass, and dallisgrass) are persistent weeds in kiwifruit vineyards.
- Major vertebrate pests of kiwifruit include gophers, squirrels, rats, and rabbits. Deer can cause problems by feeding on the leaves; voles can be pests in kiwifruit vineyards where weed growth is not controlled.

2. PEST MANAGEMENT FOR NEW KIWIFRUIT VINEYARDS

Selecting the proper vineyard site and insuring that young kiwifruit plants are well established will affect the vines' lifetime productivity. Evaluating site history, including previous and neighboring crops, cultural practices, pesticide use, and soil conditions, will assist the grower in deciding on optimal sites for new vineyards. Once a site has been selected, appropriate insect, weed, nematode, and disease control measures must be considered, and precautions must be taken to prevent damage to young vines by vertebrate pests.

Selecting well-adapted rootstocks and using certified planting stock will help the grower to avoid specific disease and nematode problems.

Cultural Activities

• Cleanup • Level, backhoe, rip • Fumigation (*Phytophthora* oak root fungus, nematodes) • Weed control (disk, herbicides)	• Install trellis/support system • Install irrigation system • Plant vines • Solarization

INSECTS

In general, fewer pests attach young kiwifruit vines; therefore, fewer in-season sprays are used on young vines than on those in full production. Mites (*Tetranychus* spp.) can be particularly damaging to new plantings, so population levels should be monitored closely. Lepidopterous pests should also be monitored at this time.

Work Group Recommendations for Insect Management in New Vineyards

Research	• Develop economic thresholds for mites • Evaluate efficacy and cost effectiveness of using pheromones for lepidopterous pests in non-bearing vineyards
Regulatory	• Register miticides for non-bearing vineyards
Education	• No recommendations at this time

WEEDS

Weeds can be highly competitive with young vineyards, so they should be carefully managed during vineyard establishment. While most vineyards were fumigated in the past, increasing numbers of new plantings will have to rely on new techniques to control weeds and other soil-borne pests. Methyl bromide has provided excellent broad spectrum control of these pests, including weeds. The only currently available alternative, Vapam®, is limited in its weed control spectrum, is difficult to use, and requires consistent soil moisture conditions to have optimal efficacy.

Several herbicides are registered for non-bearing vineyards, but none controls all weed species. Prowl® and Surflan® provide good control of grasses, but do not control many key broadleaf weeds. Surflan® supplies have recently become limited due to production issues. However, Farm Saver®, which, like Surflan® also is oryzalin, is registered for use on kiwifruit. Goal® is a very good broadleaf material, but is expensive and does not control grasses. Paraquat is a good burn-down material, but lacks residual control. Glyphosate works well on perennial grasses.

The following annual and perennial weeds are problems in young kiwifruit vineyards in California.

Annuals:		**Perennials:**
• Annual bluegrass	• Horseweed	• Johnsongrass
• Barnyard grass	• Knotweed	• Dallisgrass
• Common chickweed	• Lambsquarter	• Bermuda grass
• Common groundsel	• Mustard	• Curly dock
• Crabgrass	• Pigweed	• Field bindweed
• Fiddleneck	• Purslane	• Dandelion
• Filaree	• Shepherd's purse	• Yellow nutsedge
• Flaxleaf fleabane	• Wild oats	

Work Group Recommendations for Weed Management in New Vineyards

Research	• None
Regulatory	• Determine registration status of Prowl® for non-bearing kiwifruit • Register materials for nutsedge and flaxleaf fleabane
Education	• None

DISEASES

During kiwifruit vineyard establishment, care must be taken to control diseases, since disease at this point will impact the vines' productivity over their commercial lifetime. Site selection and preparation for planting will determine microclimate conditions during the life-span of the vineyard. Major diseases during this stage include *Phytophthora* root rot, *Armillaria* root rot (oak root fungus), and crown gall. Many of these diseases can be managed by fumigation, irrigation management, and proper site selection following non-host rotation crops or fallow fields. Replacements for methyl bromide are needed.

Work Group Recommendations for Disease Management in New Vineyards

Research	• Methyl bromide alternatives • Alternatives to arsenic-treated posts
Regulatory	• Expedite registration of methyl bromide alternatives
Education	• Educate growers on planting techniques and irrigation management • Provide enhanced education on factors a grower must consider in establishing a new vineyard • Educate growers on arsenic-free posts

NEMATODES

Root knot nematode is the one major species of nematodes important in kiwifruit. These plant parasitic nematodes move from the soil into the roots and feed by puncturing them and sucking their cell contents. Nematode damage interferes with nutrient and water uptake and nematodes may vector certain diseases. Soil conditions and application procedures determine nematicides' efficacy, which may be quite variable. None of the available nematicides are as effective as methyl bromide; therefore, the loss of methyl bromide as a fumigant for new vineyards causes significant concern about plant health and nematode management in kiwifruit. No effective biological control materials are commercially available for nematode control in kiwifruit.

Cultural controls include proper site selection, (e.g., root knot species are more damaging in coarser textured soils). Growers can avoid planting a crop, but leaving ground fallow is generally not economically viable. Another technique is to precede planting with grass crops such as barley, wheat, or Sudan grass.

Work Group Recommendations for Nematode Management in New Vineyards

Research	• Methyl bromide replacements
Regulatory	• Expedite methyl bromide replacement registrations
Education	• Educate growers on fumigant requirements which are constantly changing

VERTEBRATE PESTS

Rodents and vertebrates can significantly damage young kiwifruit vines, and can also interfere with irrigation and other cultural activities. Rabbits, voles, gophers, squirrels, and deer are the most troublesome species, and birds are pests in established vineyards. Sites adjacent to unmanaged ground or pastures will harbor more vertebrate pests, but monitoring and implementing control actions may discourage the buildup of populations within vineyards. Vertebrate pests may be controlled by use of barriers, traps, frightening tactics, and lethal methods, but care must be taken to comply with any endangered species restrictions in specific geographies.

Damage from rabbits and gophers can be limited by using trunk protectors, but these devices can encourage ant problems and can girdle young vines. Weed management can reduce habitat for voles and thus reduce damage potential from this pest. Tools to manage gophers include flood irrigation to disrupt and collapse tunnels, and strychnine for lethal control.

Currently there are no identified needs for vertebrate management in new vineyards.

3. PEST MANAGEMENT FOR ESTABLISHED KIWIFRUIT VINEYARDS

DORMANCY
(approximately December through March)

During the cooler weather and shorter days of fall and winter, the vines are in a resting phase called dormancy. In order to complete dormancy and achieve maximum bloom, buds must be exposed to at least the minimum amount of required chilling. Important pest management activities during this time include monitoring for and treating scales and weeds.

Field Activities

- Prune
- On-going scouting for insects and diseases (regional differences in timing)
- Application of plant growth regulator
- Trellis repair
- Shredding brush/ brush disposal
- Tying, taping, or clipping canes
- Dormant OP chemical control for scale – no workers in the field; oil for scale control
- Weed control both pre- and post-emergence
- Fertilization (starting in February)
- Replant – bareroot/winter or container/spring (post-frost) is determined by regional differences, and timing is related to type of plant

INSECTS

Three types of armored scales can be found in kiwifruit: greedy scale (the most common), latania scale, and oleander scale (which has a very wide host range). All of these scales have a similar biology. Their eggs are laid in summer. When the eggs hatch, the crawlers disperse, then attach their mouthparts to the plants and begin to feed. Several generations occur throughout the season. These scales enter winter as partially mature crawlers that become adults in the spring.

Scales damage kiwifruit by attacking the bark, leaves, and fruit, appearing as small, thin, light gray circular to oval specks. Moderate to heavy populations can be most easily spotted during the dormant period, when vines are free of leaves and the bark is exposed, so monitoring of scale closely coincides with pruning activities during dormancy.

Heavy scale infestations can affect plant vigor and can result in scales being present on the fruit at harvest. Such infested fruit is considered off-grade, and the insects' continued feeding can lead to premature ripening of the fruit in cold storage. This can be a serious problem because kiwifruit typically are stored for long periods. Often the pack-out inspection will help growers determine the need to treat for infestation.

Scales can be managed by the introduction of natural enemies such as lacewings, predaceous mites, and parasitic wasps. Oil spray is an organically acceptable method of control, but growers must treat scales as soon as discovered because oil is effective only on low to moderate populations.

When populations are moderate to high, insecticides plus oil will be the most effective treatment. The preferred time to apply chemicals to manage scales is during the dormant period, when the scales are mostly in the crawler stage. Applications are made after pruning and tying to ensure the best possible coverage of the vines, and to promote worker safety, as few field activities occur during this time of the year.

Methidathion (Supracide®) liquid is an extremely effective scale control, but its efficacy is reduced in the wettable powder form unless mixed with oil, and the manufacturer may not continue this registration.

Phosmet (Imidan®) is not very effective because label rates are so low that it must be used with oils to maximize scale control, and phosmet has resistance problems.

Horticultural oil (Volck® Supreme Spray oil) is effective only on low to moderate infestation levels of scale.

Work Group Recommendations for Insect Management during Dormancy

Research	• Evaluate Seize® (Esteem® replacement) for control of scale • Evaluate and develop OP alternatives • Evaluate JMS Stylet-Oil® and other organically acceptable oil for use on scale in organic production – delayed dormant application
Regulatory	• Expedite registration of Seize® • Expedite organic label for JMS Stylet-Oil® • Petition National Organic Standards Board (NOSB) to allow continued use of Volck® and any other dormant oils that are currently labeled for kiwifruit use
Education	• Educate growers and PCAs about need for good coverage as it relates to performance of Seize® 35 WP • Educate/petition NOSB on value of continued use (only product for organic producers) of Volck® Supreme Spray and any other dormant oils that are currently labeled for kiwifruit use

WEEDS

Kiwifruit vines are always subject to competition from weeds; younger vines are the most sensitive. Most activities during dormancy attempt to control weeds before the cold winter months. Winter annual weeds are generally not as troublesome as summer and perennial weeds. Cultivation, mulching, chemical mowing, and pre-emergence herbicides are the most extensively used tools for weed management during dormancy. Weed control options vary depending upon planting systems and irrigation methods. Mowing and cultivating is generally limited to the rows between the berms on which the vines are planted. Vineyard floor management helps to control frost damage in the winter and spring.

There are very few herbicide options for kiwifruit vineyards. However, combinations and/or sequential applications of the available herbicides can provide very effective, economical control. Most commonly, herbicides are used just in the vine row to control weeds. This reduces the total use of herbicides and also keeps the surface roots in the vine row from being cut by equipment.

Pre-emergence herbicides such as Surflan®, Farm Saver®, Goal®, and Devrinol® are used to control weeds before they emerge. They can be applied in fall after harvest, or the treatment can be split into two applications: fall and spring. Most pre-emergence herbicides must be incorporated with water, so unless the orchard has solid set sprinklers, the application must be followed by rain. Post-emergence herbicides such as Roundup®, Goal®, Gramoxone®, and Touchdown® control weeds already growing in the vineyard and should be applied whenever monitoring indicates a need. They may be combined with a pre-emergence treatment or applied as spot treatments during the growing season. Performance of all of these products is generally good, depending on the particular weed species being treated.

The following weeds are of most concern in dormant kiwifruit vineyards in California.

- Annual bluegrass
- Annual grasses
- Mustard
- Fiddleneck
- Mallow
- Chickweed
- Filaree
- Flaxleaf fleabane
- Wild oats
- Lambsquarter
- Common groundsel

Work Group Recommendations for Weed Management during Dormancy

Research	• Evaluate new pre-emergence herbicides • Develop methyl bromide alternatives for fumigation • Coordinate research efforts of UC researchers, ARS, CSU, registrants, and commodity groups so that efforts are not duplicated
Regulatory	• Gramoxone® (paraquat dichloride) re-entry restrictions are inconsistent – need to shelter PHIs • Encourage and facilitate registration of methyl bromide alternatives • Register Visor® (thiozopyr) and Chateau® (flumioxazin)
Education	• Increase awareness of the importance of monitoring and identification in weed control • Provide training on environmental awareness for air quality and TMDL runoff issues • Provide training on proper timing of deep irrigation to interrupt weed cycles

DISEASES

There are no chemical or biological controls for bleeding canker bacterial disease. The major management tactic is to protect vines from stresses caused by winter injury (pruning wounds), and to prune infected vines one foot below the leading edge of the canker to limit the spread of this disease.

Crown gall, a minor problem, can be limited by avoiding injury to vines through careful use of equipment and machinery during weed control, pruning, and removal of suckers.

Work Group Recommendations for Disease Management during Dormancy

Research	• None at this time
Regulatory	• None at this time
Education	• Educate growers and PCAs on proper identification of diseases

VERTEBRATES

Vertebrates can significantly damage kiwifruit vines, and may also interfere with irrigation and other cultural activities. Traps and propane blasters work fairly well in managing and reducing populations of gophers, the most troublesome vertebrate species during dormancy.

Rabbits, voles, deer, coyotes, and rats are occasional problems. Sites adjacent to unmanaged ground or pastures will harbor more vertebrate pests, but monitoring and implementing control actions may discourage the buildup of populations within vineyards. Owl boxes can be installed to encourage nesting, which increases owl predation on vertebrate pests.

The work group has no recommendations at this time for vertebrate control during dormancy.

PLANT GROWTH REGULATORS (PGRs)

Hydrogen cyanamide (Dormex®) is a dormancy-breaking PGR used to stimulate bud burst, causing a more uniform and increased percentage of bud break. Worker safety issues are associated with the use of this product.

Work Group Recommendations for PGR Use during Dormancy

Research	• Evaluate AVG® and other PGRs for use on kiwifruit
Regulatory	• None
Education	• Continue training workers on the safe and effective use of Dormex®

BUD BREAK THROUGH BLOOM
(approximately March through mid-May)

Field Activities

• Monitor bud break	• Frost protect if needed
• Move bee colonies into vineyard	• Supplemental pollination by hand/spray/dust
• Pre-bloom bud thinning	• Application of pre-harvest fungicide
• Scout for disease and insects	• Weed control – flaming and weed eater (organic), mowing, cultivation, and herbicide applications (pre- and post-emergence)
• Sample and analyze soil for nutritional content and presence of nematodes	• Check irrigation system
• Irrigation	• Maintain plant nutrition and fertilization, foliar nutrition

INSECTS

Leaf rollers are the most important insect species in kiwifruit during the early part of the season, when leaf rolling caterpillars can feed on developing buds and flowers. Of the four leaf rolling lepidopterous pests of kiwifruit, the omnivorous leaf roller (OLR) is the most damaging. This troublesome species has many hosts, and populations can become quite high if not managed.

Natural control of leaf rollers can occur, but generally will not reduce populations to below damaging level. Mating disruption pheromones are very effective as stand-alone products for reducing infestations and plant damage by OLR.

Boxelder bugs can be an occasional pest in early season. Imidan®, the only product registered for boxelder bugs, is applied as buds are opening; it provides only fair control of this pest. No effective biological or cultural controls exist.

Work Group Recommendations for Insect Management from Bud Break through Bloom

Research	• Evaluate expanded window of pheromone use for control of OLR
Regulatory	• Expand label for Checkmate® and Nomate® for season-long control of OLR
Education	• Educate growers on the effective use of pheromones

WEEDS

Vineyard floor management helps to control frost damage in winter and spring; it is best to have no floor vegetation during periods of frost. Spring annual weeds are generally not as troublesome as summer and perennial weeds. Cultivating, mowing, tilling, applying synthetic or natural mulches, using propane burners, and hand cultivating are non-chemical management tools for weeds. Chemical mowing and pre-emergence and post-emergence herbicides are commonly used. The following weeds are of most concern in kiwifruit vineyards in California during spring.

Annuals:		**Perennials:**
• Annual bluegrass	• Horseweed	• Johnsongrass
• Barnyard grass	• Knotweed	• Dallisgrass
• Common chickweed	• Lambsquarter	• Bermuda grass
• Common groundsel	• Mustard	• Curly dock
• Crabgrass	• Pigweed	• Field bindweed
• Fiddleneck	• Purslane	• Dandelion
• Filaree	• Shepherd's purse	• Yellow nutsedge
• Flaxleaf fleabane	• Wild oats	

No one product or technique will control all weed species. Glyphosate (Roundup®) and paraquat (Gramoxone®) work well as contact herbicides. Napropamide (Devrinol®), oryzalin (Surflan® or Farm Saver®), and oxyfluorfen (Goal®) all work well as pre-emergence materials, but Goal® can be used only until February 15 due to phytotoxicity concerns.

Work Group Recommendations for Weed Management from Bud Break through Bloom

Research	• Evaluate and develop control options for flaxleaf fleabane
Regulatory	• Expand the Goal® label for continued use after February 15 at a lower rate
Education	• If Goal® use period is expanded, educate growers on its use

DISEASES

Phytophthora root and crown rot, a major disease caused by *Phytophthora* spp., can seriously damage and even kill kiwifruit vines if not managed properly. The lower temperatures and higher moisture during winter and spring favor development of these diseases. *Phytophthora,* depending upon the particular species, can affect feeder roots, primary roots, and the crown.

The major means to reduce disease incidence is to manage soil moisture by improving surface and sub-surface water drainage. Water must not allowed to pool by the vines, so irrigation sets should be shorter but more frequent, and sprinklers and emitters should be positioned away from the base of the vines. Weed control around the vines will also help prevent standing water. In general, avoiding saturated conditions will help to manage this disease.

Other cultural techniques are also beneficial. Planting on berms encourages good drainage, and cover crops help improve water penetration near the base of the vines.

The only chemical registered for control of *Phytophthora* is Ridomil®, but it is registered for only non-bearing kiwifruit. No effective biological controls are available.

Bleeding canker and crown gall are bacterial diseases of kiwifruit; there are no biological controls and only one chemical control (Gallex®) for these diseases. The best way to minimize these diseases is to avoid injury to vines caused by common cultural practices such as pruning, and by equipment used for weed control.

Botrytis rot can be a major disease problem, especially after rain. The best cultural activity to manage this disease is maintaining sanitary field conditions. Fungicides can be applied for *Botrytis* control at full bloom. Currently there are only a couple of chemical control options: Trilogy®, which has questionable efficacy; and Ronilan®, which provides only fair to good control due to high levels of resistance. Ronilan® is scheduled for cancellation in 2004 due to FQPA and manufacturer considerations; however, a full Section 3 registration is being pursued for another fungicide, Elevate®. There are no known biological controls for this important disease.

Bacterial leaf spot and blossom blight diseases are thought to be caused by a variety of *Pseudomonas* species and may exist as normal bacteria on leaf surfaces. When injury occurs or conditions are favorable, disease may develop in leaves and flower parts. There are no known biological, cultural, or chemical controls for this disease in kiwifruit.

Work Group Recommendations for Disease Management from Bud Break through Bloom

Research	• Evaluate new materials for *Botrytis* control • Develop organic controls for *Botrytis* • Evaluate mefenoxam in IR-4 trials
Regulatory	• Expedite the registrations of Elevate®, Scholar®, and Vanguard®
Education	• Provide training on resistance management • Provide training on water management • Provide training on nitrogen management • Provide training on disease identification

NEMATODES

Root knot nematodes can be problems in established kiwifruit vineyards. Nematode damage interferes with nutrient and water uptake, and nematodes may vector certain diseases.

The best cultural techniques for managing nematodes are to provide proper irrigation and fertilization to maintain good tree vigor. Growers should avoid using cover crops that are susceptible to root knot nematode and avoid practices which lead to soil compaction. Solarization is an option in individual vine replants, but this technique provides only fair management of nematodes.

Nemacur®, a product registered for use via irrigation systems, provides only poor to fair control and will be phased out in the near future.

Biological controls for nematodes are very limited. Crustacean shell meal applied to the surface provides only fair control of nematodes.

Work Group Recommendations for Nematode Management from Bud Break through Bloom

Research	• Evaluate the benefits/effects of using cover crops • Evaluate crustacean shell (chitin) and other post-plant nematicides for control of nematodes • Develop organic nematode management tools
Regulatory	• Expedite the registration of post-plant nematicides
Education	• Provide training to growers and PCAs on nematode identification and damage

VERTEBRATES

Gophers are the most troublesome vertebrate pest in kiwifruit during the spring. Traps, propane blasters, and owl boxes work fairly well in reducing populations of gophers.

Rabbits, voles, deer, coyotes, and rats also occasionally cause kiwifruit vineyard problems.

The work group does not have any recommendations for vertebrate control for the period of bud break through bloom.

POLLINATION

Kiwifruit vines are dioecious; they require pollen transfer from male plants to female plants in order to set fruit. Although a variety of insects can effectively move pollen to kiwfruit flowers, pollination of female vines is traditionally accomplished by placing honey bee colonies in and around vineyards. Adequate pollination is a function of establishing the proper ratio of male to female vines and providing sufficient numbers of pollinators in the vineyard when vines are receptive. Pollination and the resulting seed formation strongly influence final fruit size and shape. Growers would like to see pollination improved to increase kiwifruit yield and quality.

Work Group Recommendations for Pollination Management

Research	• Evaluate techniques to improve pollination (e.g., number and placement of hives) • Look at geographical differences in bee activity • Determine the effect of pollination on fruit size • Evaluate male-to-female ratios for better pollination • Determine and evaluate ways to increase/maintain foraging activity • Evaluate attractants as a way to increase pollination activity and fruit set • Evaluate different male cultivars and pruning techniques to encourage bloom
Education	• Educate beekeepers and growers on methods to increase bee foraging (e.g., number and placement of bees)

FRUIT SET THROUGH PRE-HARVEST
(approximately mid-May through late September)

After successful pollination, fruit set and development occur. Thinning is often done at this time to remove misshapen fruit and/or to increase the size of the remaining fruit. A variety of pest control activities also takes place, focusing on insect and weed control.

Field Activities

- Scout for disease and insects
- Summer prune
- Irrigation
- Application of plant growth regulator (CPPU)
- Application of insecticides
- Fruit sizing evaluations
- Cane girdling
- Thin fruit
- Take soil samples
- Check irrigation system
- Weed control
- Application of preharvest fungicide
- Check and maintain plant nutrition and fertilization (leaf tissue sampling in July)

INSECTS

Pre-harvest insect pests are predominantly leaf rollers, which tend to be more of a problem in the southern production area. Pheromones work very well in mating disruption programs. *Bacillus thuringiensis* (Bt) products work fairly well, although up to eight applications may be needed per season to provide commercial control of leaf rollers. These products are approved for organic growers. Cryolite® works fairly well, although coverage with this material is critical. Phosmet® works only fairly well at the rates currently labeled; if rates were increased, performance would be better. However, it is unlikely that the registrant will make this label change due to concerns about organophosphate insecticide use and "risk cup" issues related to FQPA.

Work Group Recommendations for Insect Management from Fruit Set through Pre-Harvest

Research	• Conduct Spinosad® research to support label on kiwifruit
Regulatory	• Register Spinosad® • Register Spinosad® formulation approved for organic growers
Education	• Provide new product training for growers and PCAs

WEEDS

Summer annual and perennial weeds are the most competitive with kiwifruit vines, and also cause the most interference with normal cultural and pest management activities. Shallow cultivations, mowing, tilling, mulching, hand hoeing, and use of contact herbicides are the major weed control options during this time of the year.

Currently used products include Roundup® and Gramoxone®; both provide good contact activity on most weeds.

Annuals:	**Perennials:**
• Barnyard grass	• Johnsongrass
• Crabgrass	• Dallisgrass
• Flaxleaf fleabane	• Bermuda grass
• Horseweed	• Curly dock
• Knotweed	• Field bindweed
• Lambsquarter	• Dandelion
• Pigweed	• Yellow nutsedge
• Purslane	

Work Group Recommendations for Weed Management from Fruit Set through Pre-Harvest

Research	• None
Regulatory	• Expand Goal® registration so that it can be used after February 15
Education	• If Goal® registration is expanded, educate growers on its use

DISEASES

As mentioned in an earlier section, *Phytophthora* can cause major problems in kiwifruit. The chief means to reduce disease incidence is to manage soil moisture by improving surface and sub-surface water drainage. Any technique which improves water penetration and reduces standing water near the base of vines will be beneficial. No effective biological controls for *Phytophthora* are available.

Armillaria tends to be more of a problem in northern California kiwifruit vineyards. It appears that the presence of *Phytophthora* in the soil and in plant tissues predisposes kiwifruit roots and crowns to problems with *Armillaria*. As with *Phytophthora*, irrigation management is the best tool to reduce potential problems with *Armillaria*. No effective biological controls are available for *Armillaria.*

Botrytis rot can be a major disease problem, especially if rainy weather or high humidity occurs at any point during fruit development. Since fruit will be harvested and stored for long periods of time, it is extremely important that *Botrytis* problems are addressed prior to harvest. The best cultural way to manage this disease is to maintain sanitary field conditions. In addition, managing irrigation and nutrients to enhance fruit firmness will reduce *Botrytis* problems. Summer pruning to open up dense canopies will also help. Ronilan® is applied for *Botrytis* control 7 – 21 days before harvest. However, this fungicide provides only fair to good control, due to high levels of resistance in the field, and it is scheduled for cancellation in 2004 due to FQPA and manufacturer considerations. A great need exists for fungicides which provide good post-harvest disease control. There are no known biological controls for this important disease.

Work Group Recommendations for Disease Management from Fruit Set through Pre-Harvest

Research	• Continue to evaluate new materials for *Botrytis* • Develop organic controls for *Botrytis* • Research mefenoxam (Ridomil® Gold)
Regulatory	• Expedite the registrations of Elevate®, Scholar®, and Vanguard®
Education	• Provide training on resistance management • Provide training on water management • Provide training on nitrogen management • Provide training on disease identification

SNAILS

Snails can occasionally be a serious pest in kiwifruit orchards, feeding on various above ground plant parts and fruit. Copper bands make good barriers to keep snails from moving up the vines. Weed control around the base of the vines reduces snail problems. Commercial formulations of methaldehyde provide excellent control of snails.

Decollate snails provide very good biological control of pest snails; however, decollates are used only in the southern production region because they may be released only in the following California counties: Fresno, Kern, Imperial, Los Angeles, Madera, Orange, Riverside, San Bernardino, San Diego, Santa Barbara, Tulare, and Ventura. Additional information about using decollate snails in kiwifruit vineyards may be found on the internet at http://www.ipm.ucdavis.edu/PMG/NE/decollate_snail.html.

There are no work group recommendations for snail control in kiwifruit.

VERTEBRATES

Vertebrate control issues and management techniques for gophers, rabbits, voles, deer, coyotes, and rats in this season are similar to those described in the previous sections.

The work group has no recommendations for vertebrate control for the period from fruit set through pre-harvest.

PLANT GROWTH REGULATORS (PGRs)

Plant growth regulators affect cell division and are used to increase fruit size. A new plant growth regulator, CPPU, N-(2-chloro-4-pyridinyl)-N-phenylurea - a diphenylurea-type cytokinin, can be applied two to three weeks after bloom. This product is currently in the process of registration; its use is allowed under an Experimental Use Permit (EUP).

Work Group Recommendations for PGR Management from Fruit Set through Pre-Harvest

Research	• None
Regulatory	• Obtain full registration of CPPU
Education	• Educate growers on proper use of CPPU

HARVEST AND POST-HARVEST
(approximately late September through November)

Field Activities

• Hand pick fruit (single pick) • Cool fruit • Pack fruit • Cold storage of fruit	• Pre-condition (pre-ripen) fruit – exposure to ethylene to promote ripening • Recondition fruit to eliminate *Botrytis* infected and soft fruit

DISEASES

Post-harvest loss to *Botrytis* is the most serious disease management issue that growers face. The *Botrytis* organism grows very slowly, but because of long storage periods (eight months or longer) losses can be severe. Good post-harvest disease management begins in the field by managing vines to develop firm fruit which is free of injury. Soft fruit should not be harvested, as it is more susceptible to disease. Fruit should be brushed to remove floral parts which harbor *Botrytis* inoculum. Exposure to ethylene gas during pre-cooling and storage should be avoided.

No fungicides are currently registered for post-harvest use, although Elevate® has a Section 18 with US EPA. The industry is currently seeking Section 3 registration on fenhexamid (Elevate®) and fludioxonil (Scholar®) for use as post-harvest fungicides.

No biological controls for *Botrytis* currently exist.

Work Group Recommendations for Disease Management for Harvest and Post-Harvest

Research	• Evaluate ozone and other post-harvest treatments for *Botrytis* control • Evaluate curing as a means to reduce disease in storage • Evaluate application methods for improved performance of post-harvest fungicides
Regulatory	• Expedite registration of post-harvest fungicides Elevate® and Scholar® • Petition the National Organic Standards Board (NOSB) to allow use of ethylene to ripen organic kiwifruit (currently allowed on organic bananas)
Education	• Educate growers on application methods for new post-harvest fungicides when registrations come through

4. CRITICAL ISSUES FOR THE CALIFORNIA KIWIFRUIT INDUSTRY

The following items, listed in order of priority, were identified by the Kiwifruit Work Group as being the most critical to the sustained viability of the California kiwifruit industry:

Research	• Evaluate pre- and post-harvest *Botrytis* management tools • Evaluate *Phytophthora* management tools • Evaluate nematode control options • Evaluate scale control options • Determine the role of pollination, pruning techniques, thinning, and cane girdling on fruit size • Evaluate attributes of plant and soil health nutrients as these relate to fruit size, quality, and storage
Regulatory	• Expedite the full Section 3 registration of *Botrytis* materials (especially Elevate®) • Register an oil that is acceptable for use in organic kiwifruit (for scale control, etc.) • Expedite registrations for OP alternatives: Seize® and Success® • Expand the pheromone use season • Keep kiwifruit on generic pesticide labels • Harmonize Cal/EPA and US EPA registrations to hasten new product registrations • Identify potential trade irritants as early as possible in the research and registration process; insure there are no conflicts with provisions of NAFTA or Codex
Education	• Educate growers and PCAs on the use of Elevate® for post-harvest disease control • Educate growers on water management for *Phytophthora* control • Educate growers on current knowledge of plant and soil health and nutrition, pruning, and cultural practices • Educate growers on resistance management for new chemistries • Educate growers on use of PGRs and new PGR chemistries • Educate growers, PCAs, and commodity members on the use of best management practices (BMPs) to protect and improve water and soil quality • Educate the public on the nutritional values of California grown kiwifruit and their high level of food safety and quality

REFERENCES

Publications

*Crop Protection Reference, 2001 (*Seventeenth Edition). C and P Press, New York

UC IPM Pest Management Guidelines: Kiwifruit, UC ANR Publication 3449

Post-Harvest Technology of Horticultural Crops, UC ANR Publication 3311

Agricultural Chemical Usage 2001 Fruit Summary, August 2002, USDA National Agricultural Statistics Service

On-line Reports and Websites

County Agricultural Commissioners' Data – 2001
http://www.nass.usda.gov/ca/; select the **"**Publications - California Statistical Reports" link

California Department of Pesticide Regulation Pesticide Use Reports 1999 – 2001
http://www.cdpr.ca.gov/; select "Reference links" to reach Pesticide Use Information

Crop Data Management System, Inc.
http://www.cdms.net/manuf/manufac.asp

For a history of California kiwifruit production,
http://www.calharvest.com/hock.html

For Crop Profile information,
http://pestdata.ncsu.edu/cropprofiles/docs/cakiwi.html

For additional NASS production data,
http://www.usda.gov/nass/pubs.html; select the "Reports by Commodity" link

For kiwifruit production information from The California Rare Fruit Growers, Inc.,
http://www.crfg.org/pubs/ff/kiwifruit.html

APPENDICES

1. 2002 California Kiwifruit Production Statistics

COUNTY	HARVESTED ACREAGE	YIELD (Tons/Acre)	PRODUCTION (Tons)	TOTAL VALUE ($)
Butte	1,164	4.4	5122	3,206,000
Fresno	455	3.7	1700	2,788,000
Kern	217	7.5	1630	2,170,000
Monterey	7	3.4	24	30,000
Placer	21	4.0	83	124,300
Solano	26	6.0	156	156,000
Sutter	156	4.4	686	784,100
Tulare	1,363	4.3	5890	10,602,000
Yuba	295	8.6	2543	3,118,000
State Totals	**3,704**	**Average 4.8**	**17,834**	**22,978,400**

Source: County Agricultural Commissioners' Data (USDA/NASS/CASS)

Note: the *CDFA Resource Directory – 2002* contains additional production statistics which may be seen at http://www.cdfa.ca.gov/publications.html

2. Crop Development, Cultural Practices, and Pest Management Activities for California Kiwifruit

Northern Production Region

Crop Development	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Dormancy	■	■	■									■
Bud Break through Bloom			■	■	■							
Fruit Set through Pre-Harvest					■	■	■	■	■			
Harvest									■	■	■	
Post-Harvest and Storage	■	■	■	■	■	■	■			■	■	■
Cultural Practices	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Field Sanitation	■	■	■	■	■	■	■	■	■	■	■	■
Prune Canes (Dormant season)	■	■										■
Tape, Tie, or Clip Canes	■	■	■									■
Scouting	■	■	■	■	■	■	■	■	■	■	■	■
Fertilizer Application		■	■	■	■	■	■	■				
Monitoring Bud Break			■	■	■							
Frost Protection			■	■	■					■	■	
Pre-bloom Thinning				■	■							
Fruit Thinning					■	■	■					
Move Bees to Vineyard				■	■							
Take Soil Samples			■	■	■	■	■	■	■	■	■	
Irrigate				■	■	■	■	■	■	■		
Summer Pruning of Female Plants					■	■						
Fruit Sizing Evaluations				■	■	■	■	■	■			
Trellis Repair	■	■	■									■
Replant	■	■	■	■								
Shredding and Disposal of Brush	■	■	■		■	■	■	■				■
Harvest									■	■	■	
Pruning Male Plants					■	■						
Pest Management Activities	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling for Nutrient Analysis		■	■	■	■	■	■	■	■	■	■	
Irrigation Scheduling			■	■	■	■	■	■	■	■		
Petiole Sampling						■						
Insecticide Applications	■	■	■	■	■	■	■	■	■			
Herbicide Applications		■	■	■	■	■	■	■	■	■	■	
Fungicide Applications					■				■	■		
Insect Scouting	■	■	■	■	■	■	■	■	■	■	■	■
Disease Scouting	■	■	■	■	■	■	■	■	■	■	■	■
PGR Applications	■	■				■						
Vertebrate Control	■	■	■	■	■	■	■	■	■	■	■	■

Data based on collective field observations and experiments

2. Crop Development, Cultural Practices, and Pest Management Activities for California Kiwifruit (continued)

Southern Production Region

Crop Development	J	F	M	A	M	J	J	A	S	O	N	D
Dormancy	■	■	■									■
Bud Break through Bloom			■	■	■							
Fruit Set through Pre-Harvest					■	■	■	■	■			
Harvest									■	■	■	
Post-Harvest and Storage	■	■	■	■	■	■	■			■	■	■
Cultural Practices	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Field Sanitation	■	■	■	■	■	■	■	■	■	■	■	■
Prune Canes (Dormant season)	■										■	■
Tape, Tie, or Clip Canes	■	■	■									
Scouting	■	■	■	■	■	■	■	■	■	■	■	■
Fertilizer Application			■	■	■	■	■	■				
Monitoring Bud Break		■	■	■								
Frost Protection		■	■	■								
Pre-bloom Thinning				■	■							
Fruit Thinning				■	■	■	■					
Move Bees to Vineyard			■	■	■							
Soil Sampling for Nutrient Analysis		■	■	■	■	■	■	■	■	■	■	
Irrigate			■	■	■	■	■	■	■	■		
Summer Pruning of Female Plants					■	■	■	■				
Fruit Sizing Evaluations					■	■	■	■	■			
Trellis Repair	■	■	■									■
Replant	■	■	■	■								
Shredding and Disposal of Brush	■	■	■		■	■	■	■				■
Harvest									■	■	■	
Pruning Male Plants					■	■						
Pest Management Activities	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling		■	■	■	■	■	■	■	■	■	■	
Irrigation Scheduling			■	■	■	■	■	■	■	■		
Petiole Sampling						■						
Insecticide Applications	■	■	■	■	■	■	■	■	■			
Herbicide Applications		■	■	■	■	■	■	■	■	■	■	
Fungicide Applications				■	■				■	■		
Insect Scouting	■	■	■	■	■	■	■	■	■	■	■	■
Disease Scouting	■	■	■	■	■	■	■	■	■	■	■	■
PGR Applications	■	■			■							
Vertebrate Control	■	■	■	■	■	■	■	■	■	■	■	■

Data based on collective field observations and experiments

3. Seasonal Pest Occurrence in California Kiwifruit

Northern Production Region

Insects and Mites	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Greedy Scale	■	■							■	■	■	■
Latania Scale	■	■							■	■	■	■
Oleander Scale	■	■							■	■	■	■
Omnivorous Leaf Roller					■	■	■	■	■			
Fruit-tree Leaf Roller					■	■						
Oblique-banded Leaf Roller					■	■	■	■				
Orange Tortrix						■						
Raisin Moth						■						
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Filaree	■	■	■							■	■	■
Malva	■	■	■							■	■	■
Bermuda Grass			■	■	■	■	■	■	■	■		
Johnsongrass			■	■	■	■	■	■	■	■		
Dallisgrass			■	■	■	■	■	■	■	■		
Nutsedge			■	■	■	■	■	■	■	■		
Pre-emergence Applications	■	■	■	■						■	■	
Post-emergence Applications		■	■	■	■	■	■	■	■	■		
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Armillaria Root Rot	■	■	■	■	■	■	■	■	■	■		
Botrytis Fruit Rot				■	■		■	■	■			
Phytophthora		■	■	■	■	■						
Nematodes	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot		■	■	■					■	■		
Vertebrate Pests	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Gophers	■	■	■	■	■	■	■	■	■	■	■	■
Voles		■	■	■	■	■	■			■	■	

Data based on collective field observations and experiments

3. Seasonal Pest Occurrence in California Kiwifruit (continued)

Southern Production Region

Insects and Mites	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Greedy Scale	■	■							■	■	■	■
Latania Scale	■	■							■	■	■	■
Oleander Scale	■	■										
Omnivorous Leaf Roller					■	■	■	■	■			
Fruit-Tree Leaf Roller						■	■					
Oblique-banded Leaf Roller					■	■	■	■				
Orange Tortrix					■							
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Filaree	■	■	■							■	■	■
Malva	■	■	■							■	■	■
Bermuda Grass			■	■	■	■	■	■	■	■		
Johnsongrass			■	■	■	■	■	■	■	■		
Dallisgrass			■	■	■	■	■	■	■	■		
Nutsedge			■	■	■	■	■	■	■	■		
Pre-emergence Applications	■	■	■	■							■	■
Post-emergence Applications	■	■	■	■	■	■	■	■	■	■		
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Armillaria Root Rot	■	■	■	■	■	■	■	■	■	■		
Botrytis Gray Mold (post-harvest)	■	■	■	■						■	■	■
Phytophthera		■	■	■	■	■	■	■				
Nematodes	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot				■	■	■			■	■	■	
Vertebrate Pests	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Gophers	■	■	■	■	■	■	■	■	■	■	■	■
Voles		■	■	■	■	■				■	■	

Data based on collective field observations and experiments

4. Efficacy of Insect Management Tools Used in California Kiwifruit

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance, NA=Not Known

PRODUCT	TRADE NAME	INSECTS		
		Scales (Greedy, Latania, Oleander)	Omnivorous Leaf Roller	Orange Tortrix
Chemical				
Bacillus thuringiensis	Bt	NA	F-E	F-E
Cryolite	Kryocide®	NA	F	F
Methidathion	Supracide® (Section 24c)	E	NA	NA
Oils (Dormant)	(Section 24c)	G	NA	NA
Phosmet	Imidan® (Section 24c)	P	G	G
Non-Chemical				
Pruning to open up canopy		G	NA	NA
Use of Pheromones		NA	G-E	NA
Natural Enemies (parasites/predators)		F	F	F
Nutrition Management		P-F	NA	NA
Scouting		G-E	G-E	G-E

Data based on collective field observations and experiments

4. Efficacy of Insect Management Tools Used in California Kiwifruit (continued)

Impact of Insecticides on Beneficial Organisms

Efficacy Ratings: L = Low, H = High

PRODUCT	TRADE NAME	BENEFICIAL ORGANISMS				
		Predatory Mites	General Predators	Parasites	Honey Bees	Duration of Impact to Natural Enemies
Bacillus thuringiensis	Bt	L	L	L	none	none
Cryolite	Kryocide® (dormant applications only)	L	L	L	none	short to none
Methidathion	Supracide®	L	L	L	L	moderate
Petroleum oil		H	H	H	L	short to none
Phosmet	Imidan®	L	L	L	H	short

Adapted from *UC IPM Pest Management Guidelines: Kiwifruit*

5. Efficacy of Disease Management Tools Used in California Kiwifruit

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	DISEASES				
		***Armillaria* Root Rot**	***Botrytis* Fruit Rot**	***Botrytis* Gray Mold (Post- Harvest)**	***Phytophthora***	**Bleeding Canker**
Chemical						
Methyl Bromide		F-G	P		F-G	P
Vinclozolin*	Ronilan®		F-G	G	P	P
Mefenoxam	Ridomil® Gold	P	P	P	E-G	P
Metam Sodium**	Vapam®	F	NA	NA	F	NA
Fenhexamid***	Elevate®	NA	F	F	NA	NA
Non-Chemical						
Orchard Sanitation		G	G			
Irrigation Management					G	G
Fertilizer Management		G	G		F	
Certified Planting Stock					G-F	
Avoiding Injury to Vine					G	G

Data based on collective field observations and experiments

*The registration of Ronilan® (vinclozolin) was cancelled in December 2002; old labeled product can be used until supplies are exhausted (the fungicide was registered only for pre-harvest use)
**Metam-sodium is registered as a pre-plant fumigation treatment
***Currently, fenhexamid is registered under an emergency registration for pre- or post-harvest use on kiwifruit

6. Efficacy of Nematode Management Tools Used in California Kiwifruit

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	NEMATODES		
		Root Knot	Root Lesion	Ring
Chemical				
Methyl Bromide		G	G	G
Fenamiphos	Nemacur®	P-F	P-F	P-F
Metam Sodium	Vapam®	F-G	F-G	F-G
Non-Chemical				
Clean Cultivation		F	F	F
Soil Sampling		F-G	F-G	F-G
Resistant Rootstock Selection		F-G	F-G	F-G
Trap Crops		P	P	P

Data based on collective field observations and experiments

7. Efficacy of Weed Management Tools Used in California Kiwifruit

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	Johnsongrass	Bermuda Grass	Dallisgrass	Nutsedge	Curly Dock	Field Bindweed	Mallow	Annual Bluegrass	Mustard	Filaree	Annual Grasses	Purslane	Fleabane
Chemical														
Glyphosate	Roundup®	G-E	G	G	P	G	P	P	G	G	F	G	G	P
Napropamide	Devrinol®	P	P	F	F	P	P	G	G	P	G	G	F	P
Oryzalin	Surflan®, Farm Saver®	P	F	F	P	P	F	G	G	F	P	G	G	P
Oxyfluorfen	Goal®	P	P	P	P	P	P	E	F	G	F	F	G	P
Paraquat Dichloride	Gramoxone®	F	P	P	F	F	P	F	F	G	F	F	G	P-F
Non-Chemical														
Cultivation		P	P	P	G	G-E	P	G-E	G-E	G-E	G-E	G-E	G-E	G-E
Cover Crops		P	P	P	P-F	P-F	P	P-F	P-F	P-F	P-F	P-F	P-F	P
Mowing		P	P	P	P	F	P	P	P	F	F	P	P	P
Tilling		P	P	F	P	G	G	G	G	G	G	F	G	G

Data based on collective field observations and experiments

8. Efficacy of Vertebrate Management Tools Used in California Kiwifruit

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	VERTEBRATE				
		CA Ground Squirrel	Pocket Gopher	Meadow Vole	Deer	Rabbits
Chemical						
Diphacinone	Ramik®, Promar®	G	P-F	G		P
Chlorophacinone	Rozol®	G	P-F	G		P
Strychnine			F-E			
Zinc Phosphide	Phosvin®	G	P	G		
Aluminum Phosphide	Phostoxin®	G	F-G			
Gas cartridge		G	P			
Repellents		P	P	P	F	F
Non-Chemical						
Exclusion		P-G	F-G	P-G	E	E
Predators		P-G	P-G	P-G	P	P-G
Cultural Barriers (e.g., trap crops)		P	P	P	P	P
Cultural Control (e.g., cover crop management)		P	F	G	P	
Trapping		G	G	P		P
Shooting		F			P-F	F
Hazing techniques		P	P	P	P	P

Data based on collective field observations and experiments

9. Efficacy of Plant Growth Regulators Used in California Kiwifruit

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None

PRODUCT	TRADE NAME	EFFICACY
Hydrogen cyanamide	Dormax®	F-E
CPPU		F-E

Data based on collective field observations and experiments

10. Chemical Use on California Kiwifruit 1999-2001

Pounds of Active Ingredient (AI) Used

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Insecticides					
Bacillus thuringiensis	Bt	34	20	5	20
Cryolite	Kryocide®	1,890	2,439	5,887	3,405
Fenamiphos	Nemacur®	510	956	436	634
Methidathion	Supracide® (Section 24c)	731	102	419	417
Phosmet	Imidan® (Section 24c)	51	11	39	34
Fungicides					
Methyl Bromide		0	0	0	0
Vinclozolin	Ronilan®	1,113	1,426	1,057	1,199
Herbicides					
Glyphosate	Roundup®	4,168	6,873	3,197	4,746
Napropamide	Devrinol®	787	1,827	210	941
Oryzalin	Surflan®	2,038	869	106	1,004
Oxyfluorfen	Goal®	919	856	223	666
Paraquat Dichloride	Gramoxone®	679	973	530	728
Rodenticides					
Aluminum Phosphide	Phostoxin®	3	0	0	1
Strychnine		0	3	0	1
PGRs					
Hydrogen Cyanamide	Dormex®	12,929	20,633	12,491	15,351

Data from CDPR

10. Chemical Use on California Kiwifruit 1999-2001 (continued)

% of Vineyard Acres Treated

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Insecticides					
Bacillus thuringiensis	Bt	9	6	2	6
Cryolite	Kryocide®	4	6	23	11
Fenamiphos	Nemacur®	10	14	12	12
Methidathion	Supracide® (Section 24c)	14	2	12	9
Oils (Dormant)	(Section 24c)	0	0	0	0
Phosmet	Imidan® (Section 24c)	1	0	1	1
Fungicides					
Methyl Bromide		0	0	0	0
Vinclozolin	Ronilan®	19	23	19	20
Herbicides					
Glyphosate	Roundup®	54	50	64	56
Napropamide	Devrinol®	6	15	3	8
Oryzalin	Surflan®	22	10	2	11
Oxyfluorfen	Goal®	24	23	19	22
Paraquat Dichloride	Gramoxone®	19	22	18	20
Rodenticides					
Aluminum Phosphide	Phostoxin®	0	0	0	0
Strychnine		0	2	0	1
Zinc Phosphide		0	0	0	0
PGRs					
Hydrogen Cyanamide	Dormex®	25	40	29	31

Data from CDPR

11. Chemical Use on California Kiwifruit 2002

% of Kiwifruit Acreage Treated and Total Pounds Active Ingredient (AI) Used

PRODUCT	% BASE ACRES TREATED	TOTAL POUNDS AI
Insecticides		
Bacillus thuringiensis (products combined)	1.36	43
Cryolite	13.57	426
Fenamiphos	12.76	401
Methidathion	4.86	153
Petroleum (products combined)	18.37	577
Phosmet	0.04	1
Fungicides		
Vinclozolin	13.84	435
Herbicides		
Glyphosate, isopropylamine salt	57.47	1,805
Napropamide	2.57	81
Oryzalin	0.73	23
Oxyfluorfen	19.68	618
Paraquat Dichloride	35.10	1,102
Rodenticides		
Aluminum Phosphide	0	0
Strychnine	0.09	3
PGRs		
Hydrogen Cyanamide	11.02	346

Data from CDPR

12. Members of the California Kiwifruit Work Group

(SJV=San Joaquin Valley, UC=University of California, KAC=Kearney Agricultural Center)
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