PEST MANAGEMENT STRATEGIC PLAN
FOR
CALIFORNIA AND ARIZONA LETTUCE PRODUCTION
2003

Summary of a Workshop Held on
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INTRODUCTION

The purpose of this document is to provide the lettuce industry, state and federal regulatory agencies, and pesticide manufacturers with the current status of pest management for lettuce in California and Arizona. Information presented is taken from various sources including crop profiles for iceberg and leaf lettuce, annual reports of the California Lettuce Research Board (CLRB), lettuce growers, pest control advisors, and state and federal research personnel.

THE WORK GROUP

A work group consisting of growers, CLRB members, pest control advisers, regulators, University of California Cooperative Extension Specialists and Advisors, USDA and other technical experts met for one day in Salinas, California. The purpose of the meeting was to identify the needs of the lettuce growers in California and Arizona with reference to possible regulatory action regarding pesticides and the Food Quality Protection Act (FQPA). The outcomes of this meeting were a list of critical needs, general conclusions, and a stakeholder CRITICAL NEEDS list that is provided with this document. Tables listing the efficacy of various pest management tools for specific pests and discussions of many pest specific critical needs are provided throughout the rest of this document.

IMPACT OF FQPA

The Environmental Protection Agency (EPA) is now engaged in the process of re-registering pesticides under the requirements of the FQPA 1996 and FIFRA '88. The EPA is examining dietary, ecological, residential, and occupational risks posed by certain pesticides. EPA's regulatory focus on the organophosphate (OP) and B_2 carcinogen pesticides has created uncertainty as to their future availability to growers. Individual pesticide labels for lettuce have already been modified under the FQPA. The regulatory studies that EPA requires registrants to complete may result in some companies canceling registrations for lettuce, modifying re-entry (REI) and/or pre-harvest (PHI) intervals, or crop rotation statements to the detriment of the lettuce industry.

The EPA, United States Department of Agriculture (USDA), land-grant universities, and the lettuce industry need to pro-actively identify research and regulatory needs for reducing reliance on certain pesticides with effective and economical management alternatives if that should become necessary as a result of EPA's regulatory actions.

The CLRB has already initiated pro-active programs aimed at developing economical alternatives to individual pesticides that may be subject to EPA and/or state regulatory actions.

The use of trade names does not imply endorsement of any product. These names are used for the convenience of the reader.

EXECUTIVE SUMMARY OF CRITICAL NEEDS

Listed below are the most important critical needs for California and Arizona lettuce pest management.

Research: High (H), Medium (M), Low (L) priorities

- (H) Resistant varieties for major disease and insect pests.
- (H) Develop effective, economical management techniques for aphids with emphasis on the lettuce aphid.
- (H) Develop effective, economical management techniques for leafminers.
- (H) IN COAST (L) IN DESERT Develop effective, economical management techniques for downy mildew.
- (H) Develop effective, economical management techniques for lettuce drop.
- (H) Develop effective, economical management techniques for Verticillium wilt.
- (H) Develop effective, economical management techniques for Fusarium wilt.
- (M) (H IN DESERT) Develop effective, economical management techniques for thrips.
- (H) Develop effective, economical management techniques for whiteflies.
- (H) Develop effective economical management techniques for weeds.
- (M) Develop effective, economical management techniques for powdery mildew.
- (M) Develop effective, economical management techniques for anthracnose.
- (M) Develop effective, economical management techniques for bacterial leaf spot.
- (L) Develop effective, economical management techniques for lygus.
- (L) Develop effective, economical management techniques for the major worm pests.

Regulatory: LONG RANGE (L), SHORT TERM (S) priorities

- (L,S) Register new reduced risk, effective and economically viable chemicals for iceberg (head) and leaf (romaine, red and green leaf, and butter) lettuce, preferably with <7-day pre-harvest intervals (PHI), and <24-hour re-entry intervals (REI).
- (L) Register all products on both iceberg and leaf lettuce and, if possible, register all products in Crop Group 4, "Leafy Vegetables (except *Brassica* vegetables)" or Crop Group 4A, "Leafy Greens Subgroup."
- (L) Retain reasonable (i.e., <48 hours) REI for all pesticides.
- (L) Retain existing REI, PHI, and plant back restrictions for organophosphates, and B_2 carcinogens.
- (S) Remove the plant-back restriction for Cyromazine (Trigard).
- (S) Revise the label for acibenzolar-s-methyl (Actigard/Blockade) to allow use on all types of lettuce in all production regions.
- (L) Obtain a registration for abamectin (Agri-Mek) on leaf lettuce.
- (L) Retain existing "buffer zone" requirements for registered pesticides.
- (L) Retain organophosphates for soil insects, aphids and worms.
- (L) Retain individual B_2 carcinogens (e.g., Maneb and pronamide (Kerb)).
- (L) Obtain a registration for oxydemeton-methyl (Meta-systox R) on leaf lettuce when

OP cumulative analysis is completed as part of an IPM and resistance management program.

- (L) Obtain a registration for acephate (Orthene) on leaf lettuce when OP cumulative analysis is completed as part of an IPM and resistance management program.
- (L) Obtain a registration for emamectin benzoate (Proclaim) on leaf lettuce.

Education:

- Educate pesticide registrants and the IR-4 on the need to register all products on both iceberg and leaf lettuce.
- Educate EPA on the need to maintain the registrations of OP products for use in IPM programs.
- Educate EPA regarding actual acres treated per day, number of applications, quantities of pesticides handled and involvement of mixer/loader/applicators in aerial and ground applications.
- Educate EPA and pesticide registrants on field worker involvement, worker exposure, and re-entry and pre-harvest intervals.
- Educate regulators on worker activities time lines in lettuce and tie to REIs.
- Educate regulators and registrants on rotational crops and plant back issues.
- Educate pesticide applicators and lettuce and cotton growers on drift of cotton defoliants in San Joaquin Valley.
- Educate applicators and growers about drift from herbicides applied to garlic and onions in the San Joaquin Valley.
- Educate growers on alternate pest control methods aimed at reducing pesticide use.

BACKGROUND

Both iceberg and leaf lettuces (i.e., romaine, green leaf, red leaf, and butter) are annual crops, and the pest spectra for both lettuce types are very similar.

Lettuce is a cool season crop with production in three primary regions (Coastal, San Joaquin Valley and southern Desert Valleys, including Arizona).

Lettuce is produced on raised beds with 38 - 84 inch bed spacings. All lettuce produced in California and Arizona is irrigated by one of three methods (furrow, sprinkler, or drip). Irrigation is initiated shortly after planting and there are typically 6-10 irrigations per crop.

PRODUCTION FACTS - Head (Iceberg) Lettuce

- Iceberg lettuce is a minor crop in the U.S. with approximately 143,000 acres produced in California in 2001 (1).
- California and Arizona account for approximately 98% of the U.S. production (2).

CALIFORNIA

- California produces approximately 72% of the iceberg lettuce grown in the U.S. annually (2).
- In 2000 California produced 93,389,511 million 50-pound carton equivalents of iceberg lettuce (3).
- Approximately 33% of the iceberg lettuce harvested in California in 2000 was harvested in bulk (3).
- In 2000 iceberg lettuce was ranked in the top 10 California farm commodities with an export 1999 value of $866,168,000 (1).
- In 2000 lettuce was ranked in the top 15 California farm export commodities with a value of $148,200,000 (1).
- The cost to produce (i.e., grow) a carton of iceberg lettuce with a “wrapped pack” containing 24 heads ranges from $2.47 to $3.24 per carton (3).
- The cost to harvest (i.e., harvest and handling) a carton of iceberg lettuce with a “wrapped pack” containing 24 heads is approximately $6.25 per carton (3).

ARIZONA

- Arizona produces approximately 26% of the iceberg lettuce grown in the U.S. annually (2).
- In 2001, 52,000 acres of head lettuce were planted in Western Arizona. Two thousand acres of head lettuce were planted throughout other parts of Arizona. Head lettuce harvested for fresh market in Arizona increased from 47,700 in 1999 to 53,600 acres in 2001 (6).

- Between 1999 and 2001, value of head lettuce in Arizona increased from $188,694,000 to $338,740,000 (7).
- For a major grower/shipper, 2001-2002 lettuce production costs in Yuma, Arizona ranged between $2.40-$3.40 with a weighted average of $2.91 per box. Pack charges ranged from $3.95 per box to $5.90 per box and had a weighted average of $4.75 (8).
- Between 1999 and 2001, yield per acre in Arizona head lettuce production increased from 645 to 762 Cwt. In 2001, production in Arizona was 20,872 (1,000 Cwt) (9).

PRODUCTION FACTS - Leaf Lettuce

- Leaf lettuce is a minor crop in the U.S. with approximately 78,000 acres produced in California in 2001 (1).
- California and Arizona account for approximately 98% of the U.S. production (2).

CALIFORNIA

- California produces approximately 81% of the leaf lettuce grown in the U.S. (2).
- Romaine is the dominant leaf lettuce type in California with approximately 63% of production followed by green leaf - 23%, red leaf - 10%, and butterhead - 4% (3).
- Production of leaf lettuce in California has increased from 48,068,087 cartons in 1998 to 54,168,905 in 2000 (3).
- From 1999-2000 leaf lettuce was ranked in the top 20 California farm commodities with a 1999 value of $440,768,000 (1).
- The cost to produce (i.e., grow) a carton of romaine lettuce weighing approximately 38 pounds and containing 24 heads ranges from $2.24 to $2.97 per carton (3).
- The cost to harvest (i.e., harvest and handling) a carton of romaine lettuce containing 24 heads is approximately $5.00 per carton (3).
- The cost to produce (i.e., grow) a carton of red or green leaf lettuce weighing approximately 25 pounds and containing 24 heads ranges from $2.40 to $2.75 per carton (4).
- The cost to harvest (i.e., harvest and handling) a carton of red or green leaf lettuce containing 24 heads ranges from $3.45 to $3.60 per carton (4).
- The cost to produce (i.e., grow) a carton of butterhead lettuce weighing approximately 18 pounds and containing 24 heads ranges from $2.25 to $2.55 per carton (4).
- The cost to harvest (i.e., harvest and handling) a carton of butterhead lettuce containing 24 heads ranges from $2.70 to $2.85 per carton (4).

ARIZONA

- Arizona is the second largest producer of romaine lettuce, after California, planting 22% of the nation's romaine lettuce acreage in 2001. Between 1999 and 2001, acres

of romaine lettuce planted in Arizona increased from 10,100 to 12,300 (9).
- Between 1999 and 2001, the value of leaf lettuce grown in Arizona has increased from $40,219,000 to $75,455,000 (10).
- Arizona accounts for 15.4% and 18.1% of the leaf and romaine lettuce production in the U.S. (10).
- Land preparation and growing expenses for romaine lettuce in Yuma County are estimated at $2.38 for a carton while total harvest and post-harvest costs are $4.35 per carton (11).

Economics of Conventional Lettuce Production

The following sources of data are available for lettuce production costs:

- California Lettuce Research Board web site at www.calettuceresearchboard.org.
- University of California web site at http://www.agecon.ucdavis.edu/outreach/crop/cost.htm

Economics of Organic Lettuce Production

There are substantial differences in the cost of production for organic and conventional lettuce production. The main difference in cost is related to weed control and the use of organic fertilizers. Organic pesticide costs are slightly higher than conventional pesticides. The majority of the growing practices have the same costs. For example, the same types of tractors are used to prepare the ground for planting, the same type of planter is used, and same type of irrigation pipe and pumps can be used to irrigate lettuce. The differences in cost of production are reflected on a cost per acre and a cost per unit basis.

The cost of weed control is a significant cost of production of organic lettuce, as there are no effective organic herbicides available for organic producers. Most organic producers rely on cultivation and hand labor, which greatly increases production costs.

Organic fertilizers have lower nutrient contents (% of nutrient per ton) than conventional. They have to be applied more frequently and in higher quantities than conventional fertilizers. The products' lower cost do not offset the larger amounts used on a per acre basis. The cost per acre due to fertilizers and weed control ranges from 20 – 35% more for organic than conventional lettuce production.

The cost of production per unit is highly influenced by yield per acre. Organic lettuce production usually has a lower yield per acre on a seasonal basis than conventional lettuce production. The lower yields are the result of leaving pest contaminated or undersized product in the field. The yield reduction can range from 20 – 35% in different organic lettuce fields during a season. The cost per unit for organic lettuce production with lower yields ranges from

35 - 45% more than conventional lettuce production.

FOUNDATION FOR PEST MANAGEMENT STRATEGIC PLAN

I. PEST MANAGEMENT PRIOR TO OR AT PLANTING

Several IPM strategies are utilized prior to planting; these include crop rotation and the planting of pest resistant cultivars.

The rotation of lettuce with other crops should be an integral part of a farm management program. The benefits of crop rotation include the potential to reduce soil diseases such as Verticillium wilt and lettuce drop. Other benefits derived from rotational crops include loosening of compacted soils with fibrous cereals, deriving additional nitrogen from a legume crop, and increasing soil organic matter.

The development of germplasm and/or varieties with resistance to the major diseases and insects of lettuce is critical to the implementation of IPM programs on lettuce. The CLRB is funding research at both the University of California and the USDA aimed at the development and release of germplasm with resistance to both diseases (e.g., downy mildew) and insects (e.g., lettuce aphid) on lettuce.

Land preparation is the first step required for a successful lettuce crop. Land preparation consists of proper grading (particularly if furrow irrigation is used), subsoiling to break up compacted layers, adding compost as appropriate, listing and final bed preparation.

Most lettuce acreage is pre-irrigated and cultivated prior to planting and also treated prior to planting or after seeding with a pre-emergence herbicide. The most widely used herbicide is pronamide/propyzamide (Kerb) that is applied to the soil surface after planting and then irrigated. Benefin (Balan) is applied as a preemergent herbicide and is either broadcast and incorporated or mulched into beds. In the desert, Balan is broadcast and incorporated by light disking. In the San Joaquin Valley, it is mulched into beds. Bensulide (Prefar) is most commonly used in the desert and occasionally in Salinas for purslane control.

Lettuce growers utilize crop rotation, resistant varieties, weather monitoring, and reduced risk pesticides as standard IPM practices. Crop rotation with Brassica crops (broccoli, cauliflower, cabbage) reduces populations of *Sclerotinia* species that attack lettuce. Varieties resistant to Downy mildew (*Bremia lactucae*) and Corky root (*Rhizomonas suberifaciens*) are planted in all locations where these pests can cause economic losses. Weather monitoring is used to improve timing of fungicide usage for Downy mildew and Anthracnose (*Microdochium panattonianum*). The highly pest specific, reduced risk insecticides are used when the appropriate pests require treatment.

Pest Scouting and Integrated Pest Management

Iceberg and leaf lettuces are intensively scouted for pests from seedling emergence to two to three days before harvest. A licensed Pest Control Advisor (PCA) conducts all monitoring activities. Each individual field is monitored two to three times per week. This frequent monitoring is necessary because of potential migrations of pest insects, the high reproductive rate of some insects, and the potential for optimum disease conditions to significantly change the status of a lettuce field during a 48 to 72 hour timeframe. In addition to changes in pest status, the frequent monitoring is necessary to coordinate spray scheduling with other activities occurring in each field (e.g., hoeing, irrigation and harvest).

An average monitoring consists of randomly sampling 30 to 50 lettuce plants in four to six different locations in each field. Different PCAs use different patterns to randomize the areas sampled and may use different patterns in the same field on different dates. Typical patterns used include an X across the field, four corners plus the middle, or a zigzag from one corner to the opposite corner. Insecticides and curative fungicides are not recommended unless the insect pest or disease is present and is likely to increase to an economic threshold in the lettuce field. Preventative fungicides are recommended only when environmental conditions are conducive to disease development and/or the disease is present in an adjacent lettuce field.

All applications of pesticides in California are under the control of the growers, and/or their Pest Control Advisor (PCA), or Pest Control Operator (PCO). Growers, PCAs, and PCOs work closely to insure that only registered pesticides are used and that they are used in compliance with all state and federal laws, rules and regulations, and labeled recommendations. Communication between growers, PCAs, and PCOs is maintained during the planting and production periods through frequent field visitations by grower representatives and/or their PCAs. The applicator must inform all affected parties in close proximity to the intended treated area (e.g., harvesting crews, weeding crews, irrigators etc.) of their intent to apply pesticides in advance of the application and must also post fields and file post-application paperwork with the appropriate state and/or federal agency. Closed systems are also mandatory for the application of Category 1 (signal word DANGER) pesticides in California.

Worker activities prior to or at planting

Listing/Fertilizer application– (tractor)
Herbicide application – (tractor)
Planting – (tractor)
Insecticide application – (tractor)
Irrigation – sprinkler, furrow or drip

Insect Management

The **seed corn maggot (*Delia platura*), springtails** (Order Collembola), **garden centipedes** (Class Symphyla) and various **cutworms** (*Agrotis ipsilon*, *Peridroma saucia* and *Feltia subserranea*) attack emerging seedlings, and present problems for a small percentage of lettuce acreage primarily on fine soils in the coastal regions. However, stand losses in individual fields can be as high as 50%. The standard practice is to apply Diazinon granular at planting, and it is the only product registered for one or more of these pests at planting, while carbaryl bait is available for cutworm control.

Diazinon and Disyston are registered for the control of soil insects during the planting period. Although the use of these products is limited, it is extremely important to retain registrations for those occasions when soil borne pests create stand problems on lettuce.

Cultural Practices

Cultivation is performed to insure minimum residue of vegetative matter.

Water management is used to maintain optimum moisture levels to manage symphylans and springtails.

Allowing adequate time between crops and weed management in fallow fields may help with springtails, but not with symphylans.

Biological Controls

None.

Chemical Controls

Granular diazinon is registered for the control of soil insects. The granular formulation is very important because it provides uniform distribution, is compatible with other pesticides (i.e., imidacloprid and pronamide), and has a longer residual when compared to liquid formulations. It is not used for cutworms. It provides average control of springtails and symphylans, and gives acceptable to above average control of seed corn maggot. Based on recent discussions with the EPA, it appears that diazinon granular will only be available for a 5-year period.

Disulfoton (Disyston) is registered for the control of soil insects; however, it's use is limited by a long REI of 72 hours. Growers do not want to leave seeds in the ground without water for three days. **t** is more effective than diazinon for springtails and symphylans. It is an acceptable to above average treatment for the lettuce root aphid.

Carbaryl (Sevin) provides excellent control of cutworms as either a bait or liquid formulation.

Two primary **whiteflies** (*Bemisia tabaci* and *B. argentifolii*) transmit viruses that infect lettuce. These insects cause serious problems, primarily in the desert regions, and under high populations reduce lettuce stands, and/or cause severe plant stunting. Feeding by whiteflies also produces sticky honeydew on the leaves upon which a black, sooty mold may develop. Whiteflies also are vectors of Lettuce Infectious Yellows, and related viruses. The management of these two whiteflies, which are restricted to the southern desert valleys, is obtained with applications of imidacloprid (Admire) at planting.

Cultural Practices

Avoid planting lettuce near cotton, alfalfa and/or melons.

Avoid Crop rotations with melons.

Delaying plantings until most cotton has been defoliated; however, this can create a harvest gap. Crop isolation is used, especially by organic growers. Planting away from host crops can help, however, this is difficult to do because it is not often economically possible.

In Arizona, some growers attempt to locate lettuce fields as far away as possible from neighboring crops such as alfalfa, cotton and/or melons to assist in whitefly control.

Biological Controls

None.

Chemical Controls

Imidacloprid (Admire) provides excellent control. Residual activity varies from 45-60 days depending upon soil temperatures. Crops in warm soils reach maturity in 65-70 days and 90-110 days in cool weather. There are limits on the total amount of imidacloprid that can be used per season. This restricts the foliar application rate for Provado, if used following a soil treatment of Admire.

Buprofezin (Applaud) provides excellent control as a foliar treatment.

Greenhouse Whitefly (*Trialeurodes vaporariorum*): This whitefly is a serious problem in the south coastal lettuce production region near Oxnard and Ventura. It has a wide host range, including ornamentals, which makes the use of a crop free period impossible.

Biological Controls

None.

Chemical Controls

Although there are chemicals available for some crops grown in the close proximity to lettuce, there are currently no chemicals that will provide economic control of the greenhouse whitefly in lettuce. CLRB funded research is examining potential control measures for this pest.

Green Peach Aphid (*Myzus persicae*): This aphid causes serious problems primarily in the coastal regions. High populations of this aphid can stunt young plants or transplants. This insect also deposits honeydew, and under high populations causes quality problems in lettuce. It is also the vector of Lettuce Mosaic Virus, one of the most destructive viruses of lettuce in California. This aphid is also a vector of alfalfa mosaic and beet western yellow viruses.

Cultural Practices

Reports from Europe indicate that there is some lettuce germplasm with a moderate tolerance to this aphid. CLRB funded research is examining the source(s) of resistance and exploring the potential to develop germplasm and/or other lettuce cultivars with resistance to this aphid species.

Chemical Controls

Imidacloprid (Admire) provides excellent control. Residual in soil is not long enough to provide season-long control, particularly with the spring crop. There are limits on the total amount of imidacloprid that can be used per season. This restricts the foliar application rate for Provado, if used following a soil treatment of Admire.

Lettuce aphid (*Nasonovia ribis-nigri*): This aphid is a new pest of lettuce having originally been identified in the 1998 production season in the Salinas area. This aphid feeds deep inside the plant on young lettuce leaves as opposed to the green peach and potato aphids that primarily feed on the external portions (i.e., older leaves) of lettuce plants. This aphid also has a tendency to disperse within the plant rather than forming colonies that other aphids (e.g. green peach aphid and potato aphid) might do. Contact aphicides are, for the most part, ineffective and the primary treatments for this aphid are endosulfan, imidacloprid (i.e., soil treatment only), and oxydemeton-methyl with a soil applied treatment of imidacloprid followed by 1 to 2 foliar applications, or 2 to 3 foliar treatments required to maintain acceptable control. CLRB funded research has shown that two new aphicides (e.g., triazamate (Aphistar) and pymetrozine (Fulfill)) provide effective control of this aphid.

Cultural Practices

There are a number of European lettuce cultivars with a high level of resistance to the lettuce aphid. CLRB funded research is examining the source(s) of resistance and exploring the potential to develop germplasm and/or lettuce cultivars with resistance to this aphid species.

Biological Controls (green peach and lettuce aphids)

A number of natural predators feed on foliar aphids (e.g., green peach and potato aphids) including the following: convergent lady beetle (*Hippodamia convergens*) and lacewings (*Chrysoperla* spp.).

Syrphid fly (Family: Syrphidae) larvae can be effective controls, but only are effective after green peach aphid populations reach high levels. At this time they are not dependable and pose contamination risks, themselves.

A fungus (*Entomophthora aphidis*) can reduce populations of the green peach and potato aphids. However, economic control has not been observed.

Use of predators, and the fungus are limited because of the short time the lettuce crop is in the field, the transitory nature of aphids, high crop quality standards, and a low tolerance for insect contaminated products, especially in packaged salad mixes and the export market.

Cultural Practices (Green peach and lettuce aphids)

Reduce or eliminate weed hosts.

Chemical Controls

Imidacloprid (Admire) provides excellent control. Residual in soil is not long enough to provide season-long control, particularly with the spring crop. There are limits on the total amount of imidacloprid that can be used per season. This restricts the foliar application rate for Provado, if used following a soil treatment of Admire.

Lettuce Root aphid (*Pemphigus bursarius*): This aphid is an occasional problem in the coastal production regions. It occurs in colonies on lettuce roots, and is primarily a problem on transplants. Plants are severely stunted under high population conditions, while moderate populations cause heads to soften and fail to properly mature. The primary materials used for this pest involve either a preplant or postplant/banded application of disulfoton or a treatment at planting of imidacloprid. Oxydemeton-methyl also provides some control of established colonies of this aphid as a foliar treatment.

Cultural Practices

One of the primary means of cultural control of the lettuce root aphid is through the removal of its alternate host, the Lombardy poplar. As a result of a county ordinance, the removal of most Lombardy poplars in Monterey County has reduced the number of outbreaks of this pest. CLRB funded research has shown that some iceberg lettuce germplasm has a high level of resistance to this pest.

Avoid planting lettuce, especially transplants, into fields that were infested with this aphid.

Biological Controls

None

Chemical Controls

Imidacloprid (Admire) provides excellent control. Residual activity varies from 45-60 days depending upon soil temperatures. Crops in warm soils reach maturity in 65-70 days and 90-110 days in cool weather. There are limits on the total amount of imidacloprid that can be used per season. This restricts the foliar application rate for Provado, if used following a soil treatment of Admire.

Disulfoton provides acceptable to above average control. The use of this material is limited by long REI of 72 hours. Growers do not want to leave seeds in the ground without water for three days.

Oxydemeton-methyl provides excellent to acceptable to above average control, but is not registered on leaf lettuce. The REI is long 48 to 72 hours depending on annual rainfall.

INSECT MANAGEMENT GOALS PRIOR TO OR AT PLANTING

Research:

- Develop resistant varieties for major insects.
- Conduct research on alternatives to diazinon and disulfoton for soil insect management.
- Conduct research on alternatives to imidacloprid.

Regulatory:

- Retain the registration for diazinon, particularly the granular soil use.
- Retain the registration for disulfoton (Disyston).
- Retain all REIs at 48 hours or less.
- Retain all PHIs.

Education:

- Educate regulators about cropping practices.

Disease Management

Lettuce drop and *Verticillium* wilt are the two most serious soil borne diseases of lettuce, with lettuce drop found in all production regions and *Verticillium* wilt currently restricted to the coastal regions of Salinas and Watsonville. Research supported by the CLRB has shown that broccoli residues can reduce soil populations of lettuce drop, and additional research is planned with mustard related cover crops to manage this disease. Although pre-plant treatments of Methyl Bromide + chloropicrin, Telone + chloropicrin and chloropicrin alone can reduce soil populations of *Verticillium* wilt, the economics of these treatments limit their use on lettuce. However, registrations for these fumigants should be retained to allow their use on crops grown in rotation with lettuce (i.e., strawberries) to assist in the management of this disease. It is imperative that the research efforts on *Verticillium* wilt be expanded, with funds from sources other than the CLRB, to reduce the spread of this disease and to speed up the development of resistant cultivars.

Lettuce Drop (or **Leaf Drop** in AZ) (*Sclerotinia minor* and *S. sclerotiorum*): Lettuce drop is an extremely important disease of lettuce. Although both species may be present in all lettuce production regions, the soilborne species (*S. minor*) is more prevalent in the coastal production areas while the airborne species (*S. sclerotiorum*) is more prevalent in the San Joaquin Valley and desert regions. *S. minor* populations occur in most production regions and the sclerotia of this species may remain viable in the soil for prolonged periods (e.g., up to 8 to 10 years). Soil applied fungicides such as dicloran, iprodione, and vinclozolin provide some marginal relief from this disease, but timing of applications is extremely critical to achieving economic control. Under normal disease conditions, approximately 66% to 75% of the lettuce acreage is treated for lettuce drop, and even with the use of these fungicides losses from this disease range from 5 to 20%. CLRB funded research is exploring the development of resistant cultivars.

Cultural Practices

Crop rotation with broccoli and mustard cover crops for pre-plant soil incorporation of residues may offer some control.

Deep plowing.

Buried drip irrigation.

Biological Controls

Host plant resistance breeding programs are underway. However, no resistant cultivars are available.

Chemical Controls (*S. minor*)

Chloropicrin provides excellent to acceptable to above average control when used alone. Cost is an issue. Local buffer zones create problems. Permits are required. Limitations are in place on the number of acres that can be treated per day.

Methyl Bromide + Chloropicrin provides excellent to acceptable to above average control. Methyl bromide without chloropicrin is not effective. Cost is an issue. Methyl bromide will not be available after 2005. State mandated buffer zones create problems. Permits are required. Limitations are in place on the number of acres that can be treated per day.

1,3-Dichloropropene (Telone) + Chloropicrin provides excellent to acceptable to above average control. Telone without chloropicrin is not effective. Cost is an issue. State mandated buffer zones create problems. Permits are required. Limitations set by regulation on amounts that can be used in individual townships.

***Verticillium* Wilt** (*Verticillium dahliae*): *Verticillium* wilt is a relative new disease of lettuce and has only been found to date in the Salinas and Watsonville areas. Approximately 200-300 acres are currently identified with very high populations of *Verticillium*. This disease has the potential to be very serious. When a field is infected, the grower may lose the entire field. One of the major problems associated with *Verticillium* is that both strawberries and artichokes are alternate hosts. Soil fumigation with Methyl bromide + chloropicrin, Telone + chloropicrin, and chloropicrin alone offer some hope in the management of *Verticillium*. The costs associated with these treatments, however, essentially eliminate their use on lettuce. Resistant varieties, in combination with the fumigation of crops grown in rotation with lettuce (e.g., strawberries) appear to be the long-term solution to the management of this disease. If this disease continues to spread it will cause very serious yield losses and also impact acres available for planting lettuce. Host plant resistance offers the best long-term solution to managing this disease. CLRB funded research is exploring the development of resistant cultivars.

Cultural Practices

Avoid infested fields.

Biological Controls

None available.

Chemical Controls

Chloropicrin provides excellent to acceptable to above average control. Cost is an issue. State mandated buffer zones create problems. Permits are required. Limitations are in place on the number of acres that can be treated per day.

Methyl Bromide + Chloropicrin provides excellent to acceptable to above average control. Methyl bromide without chloropicrin is not effective. Cost is an issue. Methyl bromide will not be available after 2005. State mandated buffer zones create problems. Permits are required. Limitations are in place on the number of acres that can be treated per day.

1,3-Dichloropropene (Telone) + Chloropicrin provides excellent to acceptable to above average control. Telone without chloropicrin is not effective. Cost is an issue. State mandated buffer zones create problems. Permits are required. Limitations are in place on the number of acres that can be treated per day. Limitations set by regulation on amounts that can be used in townships.

There are a number of viruses that impact the production of lettuce in California and Arizona. Four important virus problems are **Lettuce Mosaic** (LMV), **Lettuce Big-Vein** (LBV), **Lettuce Infectious Yellows** (LIYV), and **Lettuce Die-Back** (LDB). The development of varieties with resistance to these viruses is critical to their management on lettuce. LMV management involves the use of resistant cultivars in combination with an "ELISA" seed testing program that requires all lettuce varieties to be tested prior to planting. LBV is primarily managed through the use of resistant varieties. LIYV is primarily a desert problem and is managed through the use of pre-plant applications of imidacloprid. LDB is primarily a problem on romaine lettuce in areas that are adjacent to rivers or subject to flooding. Resistant cultivars offer the potential to manage this virus, but are not yet commercially available. The CLRB is funding research at both the University of California and the USDA aimed at the continued development and release of germplasm with resistance to viruses on lettuce.

Corky root is caused by a soil borne bacterium that affects root development on lettuce. Under serious conditions, corky root can drastically reduce yields and may require several additional irrigations and/or nitrogen applications in order to salvage a harvestable crop. The only current management technique for this problem is the use of resistant cultivars, and CLRB funded research is aimed at continually searching for this type of resistance.

Fusarium of lettuce (*Fusarium oxysporum* Schlechtend f.sp. *lactucum forma specialis* nov.) is one of over 40 specialized forms of *Fusarium oxysporum* Schlechtend that attack a wide variety of crop and ornamental plants. This soilborne fungus affects the following crops: celery, asparagus, sweet potatoes, onions, citrus, cabbage, beets, bananas, cucumbers, tomatoes, peas, tobacco, beans, spinach, melons, and cotton.

Each form of *F. oxysporum* is specific to the crop it attacks. The presence of a particular form

of *F. oxysporum* can only be confirmed by analysis of infected tissue at this time. A given soil may have many different forms of *Fusarium*, both pathogenic and non-pathogenic that will show up in culture from a soil sample. *F. oxysporum* is highly persistent fungus and can cause severe vascular wilt symptoms. The vascular tissue inside the roots has a characteristic reddish color and the plant will have stunted growth, turn yellow in color and wilt.

Fusarium survives in soils for long periods of time. It can complete its life cycle on alternate host plants or organic material in the soil. The organism must experience certain conditions to change into the parasitic or disease causing form. The specific conditions have been studied extensively for tomato. The life cycle and conditions particular to *Fusarium* of lettuce have not been studied extensively.

Fusarium of lettuce was first seen in the Huron area in the San Joaquin Valley of California in 1990. It has been documented in fall plantings in subsequent years in Huron. Samples were collected in the Yuma area of southwestern Arizona with *Fusarium* symptoms during fall 2000 and fall 2001. *Fusarium* was confirmed in all samples. The samples were collected from 5 different fields in 3 different locations and from 4 different lettuce varieties. Two of the fields had confirmed disease in both years. Significant yield losses have occurred in some of the infested fields in Yuma, and the disease appears to be spreading rapidly in this area. The presence of *Fusarium* of lettuce has been documented in the Pajaro Valley. The soils in the Salinas Valley have been confirmed to be suppressive for *Fusarium* of tomato, but are very conducive for *Fusarium* of celery.

Control Measures

Fumigants have had limited success in controlling most *Fusarium* wilts. It has been documented that methyl bromide and other fumigants will kill *Fusarium* spores. However, spores may survive in the soil below the fumigation zone. Therefore, researchers have concluded that fumigants only suppress the organism for a period of time.

Crop rotation may kill certain soilborne pathogens (e.g. broccoli residues). However, no specific rotation crop has been found that limits the reproduction of *Fusarium*.

Resistant varieties are the most widely used and successful strategy for soilborne pathogens. Research on the *Fusarium* of lettuce has indicated that there is differential susceptibility of different lettuce varieties. However, breeding for resistance to *Fusarium* is difficult and very long term.

Sanitation has not been a viable option to control the spread of *Fusarium* diseases. *Fusarium* movement through contaminated irrigation water has been documented. The CLRB and the Arizona Iceberg Lettuce Research Commission (AILRC) are conducting research on the management of this disease.

DISEASE MANAGEMENT GOALS PRIOR TO OR AT PLANTING

Research:

- Develop resistant varieties for major diseases,
- Conduct research with new fungicides for lettuce drop and downy mildew management.
- Conduct research on alternatives to fungicides for lettuce drop management.
- Conduct research on *Verticillium* wilt management.
- Conduct research on *Fusarium* wilt management.
- Obtain funds from sources other than the CLRB for research on *Verticillium* wilt.
- Conduct research on improving the efficacy of all fumigants prior to planting.
- Conduct research on Iodomethane and other new fumigants.

Regulatory:

- Obtain a registration for BAS 510 and other new fungicides for lettuce drop management.
- Retain registrations for chloropicrin, Telone + chloropicrin and other new fumigants for *Verticillium*.
- Retain all REIs at 48 hours or less.

Education:

- Educate growers on crop rotation.
- Educate growers on *Verticillium* wilt.
- Educate growers on *Fusarium* wilt.
-

Weed Management Prior to or at Planting in Lettuce

Weed control is essential, as weeds can increase production costs, and cause yield losses in lettuce. Annual broadleaf weeds and grasses are the predominant problems in lettuce fields. The primary losses occur from competition with the crop for nutrients and water during stand establishment and production, and loss of plants during thinning and hand weeding operations. Individual weeds (e.g., burning nettle) can also create problems at harvest, while weed foliage can contaminate lettuce. Weed populations serve as hosts for insects that feed on adjacent lettuce plants and/or transmit viruses. Herbicides are usually applied with ground equipment or through sprinkler systems. Aerial applications are used on occasion, but are primarily restricted to preplant or fallow bed treatments during specific periods (e.g., wet fields) in which ground equipment cannot be used.

There are only a limited number of herbicides available for use in controlling weeds in lettuce. The wide range of production areas and the extreme diversity of weed species allow for many problems in maintaining acceptable control during the production season. No individual

herbicide or combination of materials will control all weed species under all production conditions and soil types.

The high quality standards currently in place in the lettuce industry allow for minimal, if any, contaminated products reaching the market place as whole lettuce heads. Quality standards are even higher for those products destined for sale as packaged salad mixes and for export, where product contamination from any source is not acceptable.

The effective and economical control of annual weeds in lettuce requires an integrated approach that includes cultural and mechanical methods, and the use of selective herbicides. Pronamide/propyzamide (Kerb) is the predominant herbicide used on lettuce along with benefin (Balan) and bensulide (Prefar).

The economics of annual broadleaf weed control involving pronamide/propyzamide has been examined in Monterey County, the primary production area in California. Applying pronamide/propyzamide saved growers $29 to $57 per acre in weed control costs. At very high weed densities, additional hand weeding ranging from $404 to $770 per acre would be necessary to reduce or prevent yield losses. Without pronamide/propyzamide, weed control costs could be as high as $3,301,420 more per year just for Monterey County, and even more under very high weed population densities (3).

It is vital that normal rotational crops not be restricted on herbicide labels, particularly pronamide/propyzamide labels.

Weed control on lettuce is accomplished at three times during the production cycle. Herbicides are applied at or prior to planting, weeds are removed by hand hoeing at thinning as a part of this process, and again during the maturation process, and cultivations are performed in conjunction with thinning, fertilization and at other times during production.

Other herbicides not registered on lettuce play a major role in reducing weed populations with crops grown in rotation with lettuce. The following herbicides play an important role in the reduction of weeds in cole crops and celery: prometryn (Caparol), chlorthal-dimethyl (Dacthal), and oxyfluorfen (Goal).

Seminis Vegetable Seeds and Monsanto have conducted research on the potential use of Roundup Ready lettuce. In addition, the IR-4 has conducted residue trials in preparation for an eventual tolerance for glyphosate on lettuce. It appears that this technology may be useful to the lettuce industry at some point in the future. At this time there are two primary constraints to the commercial availability of Roundup Ready lettuce. They are the acceptability of Roundup Ready lettuce by buyers and consumers in the market place and the availability of commercial cultivars that are tolerant of glyphosate (Roundup). Until these issues are resolved, Roundup Ready lettuce will not be a weed control option in lettuce.

There are no available pest management tools to control perennial weeds in lettuce, and individual species (i.e., yellow nutsedge) can present problems within specific production regions.

Cultural Practices

Pre-irrigate

Cultivate

Cover crops and previous crop weed management

Biological Controls

None available.

Chemical Controls

Fallow Bed

Paraquat dichloride (Gramoxone) - Drift to non-target areas is a potential problem.

Glyphosate (Roundup) - Drift to non-target areas is a potential problem.

Oxyfluorfen (Goal) must be used before planting. Lettuce may not be planted for 90 to 120 days following treatment. Oxyfluorfen is the only option to control *Malva*.

Prior to or at Planting

Pronamide/propyzamide (Kerb) has a 55-day PHI, which i s an issue for leaf lettuce production.

Benefin (Balan) needs to be preplant incorporated. There are plant back restrictions that may limit its use.

Bensulide (Prefar) is more effective under chemigation.

WEED MANAGEMENT GOALS PRIOR TO OR AT PLANTING

Research:

- Conduct research on alternatives to pronamide/propyzamide (Kerb) for weed management.
- Conduct research for perennial weed management.

- Conduct research on eptam or other herbicides to manage nutsedge.
- Explore potential weed resistance with pronamide.

Regulatory:

- Retain the registrations for pronamide/propyzamide (Kerb), benefin (Balan) and bensulide (Prefar).
- Retain the registrations on herbicides for crops grown in rotation with lettuce for prometryn (Caparol), chlorthal-dimethyl (Dacthal), and oxyfluorfen (Goal).
- Retain existing plant back restrictions on pronamide/propyzamide (Kerb).

Education:

- Educate regulators on the economics of weed control.
- Educate regulators and growers on the role of weeds and other hosts as reservoirs of diseases, viruses and vectors.

Vertebrate Pest Management Prior to or at Planting in Lettuce

Bird damage to lettuce is a severe problem in several areas of California. The major damaging species is the **horned lark**, *Eremophila alpestris* (L.), which uproots seedlings, grazes seedling leaves, and eats seeds. Statistics are lacking on exact losses, however millions of dollars are believed to be lost from bird depredations annually. In some cases, growers have reported entire crops destroyed by horned larks (5).

Controls

Horned larks are protected under federal law and special permits are required to haze or kill them. Several control methods can be used to reduce horned lark damage to lettuce, but the effectiveness of each depends on the persistence of the grower. Frightening devices requires several hours of hazing each day and do not work. Amplification of recorded tapes of distress and alarm calls have been used without much success. The equipment is expensive and several units may be required per acre (5).

Ground squirrels and other small mammals (e.g., **rabbits, gophers**, and **mice**) can be a significant problem when fields back up to open areas. Anti-coagulant baits offer some control of individual species.

II. PEST MANAGEMENT AT OR JUST AFTER THINNING THROUGH THE INITIATION OF HEAD FORMATION

Worker activities at or just after thinning through the initiation of head formation:

Irrigation

Cultivating (tractor)
Hoeing, including thinning and weeding
Pesticide/Fertilizer applications (tractor)
Scouting

Insect Management

The green peach aphid and the lettuce aphid are the two most important aphid species affecting lettuce production. The green peach aphid feeds primarily on the surface areas of lettuce and is the vector of Lettuce Mosaic Virus. The lettuce aphid feeds primarily deep within the lettuce heads. Management of the green peach and lettuce aphids is obtained primarily through the use of pre-plant treatments of imidacloprid (Admire) and foliar applications of acephate (Orthene), imidacloprid (Provado), endosulfan (Thiodan), where not constrained by environmental regulations, and oxydemeton-methyl (Meta-Systox R). The same treatments provide management of this aphid on leaf lettuce; however, acephate (Orthene) and oxydemeton-methyl (Meta-Systox R) are not registered on leaf lettuce thus greatly reducing management options for aphids on these types of lettuce. It should be noted that the pre-plant treatments will not provide season long control of either aphid, and also are not applied to all acres of lettuce. Thus it is imperative that foliar treatments be available to manage these insects from thinning to head formation.

Green Peach Aphid (*Myzus persicae*): This aphid causes serious problems primarily in the coastal regions. High populations of this aphid can stunt young plants or transplants. This insect also deposits honeydew, and under high populations causes quality problems in lettuce. It is also the vector of Lettuce Mosaic Virus, one of the most destructive viruses of lettuce in California.

Cultural Practices

Reports from Europe indicate that there is some lettuce germplasm with a moderate tolerance to this aphid. CLRB funded research is examining the source(s) of resistance and exploring the potential to develop germplasm and/or other lettuce cultivars with resistance to this aphid species.

Weed management on adjacent bank areas for alternate hosts may reduce aphid infestations.

Biological Controls (green peach and lettuce aphids):

A number of predators feed on foliar aphids (e.g., green peach and potato aphids) including the following: convergent lady beetle (*Hippodamia convergens*) and lacewings (*Chrysoperla* spp.).

Syrphid fly (Family: Syrphidae) larvae can be effective controls, but only arrive after green peach aphid populations are high. At this time they are not dependable and pose contamination risks, themselves.

A fungus (*Entomophthora aphidis*) can reduce populations of the green peach and potato aphids. However, economic control has not been observed.

Use of predators, and the fungus, however, are limited because of the short time the lettuce crop is in the field, the transitory nature of aphids, high crop quality standards, and a low tolerance for insect contaminated products, especially in packaged salad mixes and the export market.

Cultural Practices

Reduce or eliminate weed hosts, especially mustards and members of the goosefoot family.

Chemical Controls

Imidacloprid (Provado) provides excellent control. There are limits on the total amount of imidacloprid that can be used per season. This restricts the foliar application rate for Provado, if used following a soil treatment of Admire.

Acephate (Orthene) provides excellent control, but is not registered on leaf. It has a long PHI of 21 days.

Diazinon provides acceptable to above average control. It has a questionable continued registration under FQPA/FIFRA.

Dimethoate provides acceptable to above average control. It has a questionable continued registration under FQPA/FIFRA. It has a 7-day PHI on head lettuce and a 14-day PHI on leaf.

Endosulfan (Thiodan) provides excellent control; however it has numerous environmental concerns, which limit regions where it can be used. It is not commonly used in Monterey and Santa Cruz Counties.

Malathion provides acceptable to above average control.

Methomyl (Lannate) provides acceptable to above average control. It has a 10-day PHI and a long REI of 48 hours.

Oxydemeton-methyl (Meta-systox R) provides excellent control, but is not registered on leaf lettuce. The 28-day PHI is long, and restricts use, especially for desert regions. The REI is long 48 to 72 hours depending on annual rainfall.

Potato aphid (*Macrosiphum euphorbiae*): This aphid is a sporadic problem but is causing increasing problems in the coastal regions and the deserts. Like the green peach aphid, this insect deposits honeydew, and under high populations causes quality problems on lettuce. Feeding damage, and resultant honeydew, is usually located deeper into the head than the green peach aphid thus causing increased problems at harvest. If necessary, up to 2 total annual treatments are applied, primarily in the coastal regions.

Cultural Practices

Weed management on adjacent bank areas for alternate hosts, especially mustards and members of the goosefoot family.

Chemical Controls

Imidacloprid (Provado) provides excellent control. There are limits on the total amount of imidacloprid that can be used per season. This restricts the foliar application rate for Provado, if used following a soil treatment of Admire.

Acephate (Orthene) provides excellent control, but is not registered on leaf. It has a long PHI of 21 days.

Diazinon provides acceptable to above average control. It has a questionable continued registration under FQPA/FIFRA.

Dimethoate provides excellent control. It has a questionable continued registration under FQPA/FIFRA. It has a 7-day PHI on head lettuce and a 14-day PHI on leaf.

Endosulfan (Thiodan) provides excellent control, however it has numerous environmental concerns, which limit regions where it can be used. It is not commonly used in Monterey and Santa Cruz Counties.

Malathion provides acceptable to above average control.

Methomyl (Lannate) provides acceptable to above average control. It has a 10-day PHI and a long REI of 48 hours.

Oxydemeton-methyl (Meta-systox R) provides excellent control, but is not registered on leaf lettuce. The PHI varies from 14-28 days, and the 28-day PHI is long, and restricts use, especially for desert regions. The REI is long, 48 to 72 hours, depending on annual rainfall.

Lettuce aphid (*Nasonovia ribis-nigri*): This aphid is a new pest of lettuce having originally been identified in the 1998 production season in the Salinas area. This aphid feeds deep inside the plant on young lettuce leaves as opposed to the green peach and potato aphids that primarily feed on the external portions (i.e., older leaves) of lettuce plants. This aphid also has a tendency to disperse within the plant rather than forming colonies that other aphids (e.g. green peach aphid and potato aphid) might do. Contact aphicides are, for the most part, ineffective and the primary treatments for this aphid are endosulfan, imidacloprid (i.e., soil treatment only), and oxydemeton-methyl with a soil applied treatment of imidacloprid followed by 1 to 2 foliar applications, or 2 to 3 foliar treatments required to maintain acceptable control.

CLRB funded research has shown that two new aphicides (e.g., triazamate (Aphistar) and pymetrozine (Fulfill)) provide effective control of this aphid.

Cultural Practices

Reports from Europe indicate that there are some lettuce cultivars with a degree of resistance to the lettuce aphid. CLRB funded research is examining the source(s) of resistance and exploring the potential to develop germplasm and/or iceberg and other lettuce cultivars with resistance to this aphid species.

Biological Controls

None available.

Chemical Controls

Imidacloprid (Admire) provides excellent control. Imidacloprid (Provado) provides acceptable to above average control. There are limits on the total amount of imidacloprid that can be used per season. This restricts the foliar application rate for Provado, if used following a soil treatment of Admire.

Acephate (Orthene) provides acceptable to above average control, but is not registered on leaf. It has a long PHI of 21 days.

Diazinon provides average control. It has a questionable continued registration under FQPA/FIFRA.

Dimethoate provides acceptable to above average control. It has a questionable continued registration under FQPA/FIFRA. It has a 7-day PHI on head lettuce and a 14-day PHI on leaf.

Endosulfan (Thiodan) provides acceptable to above average control, however it has numerous environmental concerns, which limit regions where it can be used. It is not commonly used in Monterey and Santa Cruz Counties.

Malathion provides average control.

Methomyl (Lannate) provides average control. It has a 10-day PHI and a long REI of 48 hours.

Oxydemeton-methyl (Meta-systox R) provides excellent control, but is not registered on leaf lettuce. The PHI varies from 14-28 days, and the 28-day PHI, especially for desert regions. The REI is long 48 to 72 hours depending on annual rainfall

Lygus Bug (*Lygus hesperus*) is a seasonal problem on lettuce, and is primarily a problem in the coastal regions during the late spring - early summer. Damage to lettuce foliage occurs as the result of feeding and leaf wounds (punctures), which can have a significant affect on lettuce quality, due in part to a toxin released during the feeding process. Very low populations of lygus bugs can cause serious quality problems at harvest, and significant leaf damage may result in individual heads being unmarketable. The primary materials used for this insect are Acephate (Orthene), cypermethrin (Ammo), diazinon, dimethoate, permethrin (Ambush, Pounce), malathion, and methomyl (Lannate). When necessary, up to 2 total treatments may be applied in the coastal regions on an annual basis.

Cultural Practices

None available

Biological Controls

None available

Chemical Controls

Acephate (Orthene) provides average to acceptable to above average control, but is not registered on leaf lettuce. It has a long PHI of 21 days.

Diazinon provides acceptable to above average control. It has a questionable continued registration under FQPA/FIFRA.

Dimethoate provides acceptable to above average control. It has a questionable continued registration under FQPA/FIFRA. It has a 7-day PHI on head lettuce and a 14 day PHI on leaf.

Endosulfan provides excellent control.

Malathion provides average control.

Methomyl (Lannate) provides acceptable to above average control. It has a 10-day PHI and a long REI of 48 hours.

The pyrethroids (cypermethrin (Ammo), permethrin (Ambush, Pounce) provide excellent to acceptable to above average control, while l-cyhalothrin (Warrior), esfenvalerate (Asana), and tralomethrin (Stryker/Scout) provide acceptable to above average to average control.

Western Flower Thrips (*Frankliniella occidentalis*) is an insect that causes problems on a small percentage of the lettuce acreage in California and is more of a problem in the desert

and Arizona. Damage occurs in the form of leaf stippling and rib discoloration that affects quality at harvest. Thrips also cause problems as contaminants, especially on lettuce exported to Japan. The primary materials used for this insect are acephate (Orthene), cypermethrin (Ammo), methomyl (Lannate), and permethrin (Ambush, Pounce).

Cultural Practices

Weed control in adjacent areas.
Avoid planting in close proximity to alfalfa.

Biological Controls

None available.

Chemical Controls

The timing of applications is critical, and treatments should be made early when populations are low, or in the afternoon when adults are active.

Acephate (Orthene) provides below average control, and is not registered on leaf lettuce.

Methomyl (Lannate) provides acceptable to above average control at high rates. It has a 10 day PHI and a long REI of 48 hours. It is not commonly used.

The pyrethroids Cypermethrin (Ammo), esfenvalerate (Asana), and Permethrin (Ambush, Pounce) provide average to acceptable to above average to average control.

Spinosad (Success) provides acceptable to above average control. It is costly.

Lepidopterous Larvae:

Alfalfa Looper (*Autographa californica*): This insect can cause serious damage to lettuce in all areas, but is more of a problem in the desert regions. It is particularly a problem near harvest when larvae enter heads causing internal damage and deposit frass.

Beet Armyworm (*Spodoptera exigua*): This insect causes serious damage to lettuce, and is more prevalent during fall production in the desert regions. Reduced stands can result from high larval populations.

Cabbage Looper (*Trichoplusia ni*): This insect can cause serious damage to lettuce in all regions. It is particularly a problem near harvest when larvae enter heads causing internal damage and deposit frass.

Corn Earworm (*Helicoverpa zea*): This insect can cause serious damage to lettuce in all areas, but is more of a problem in the desert regions. It is particularly a problem near harvest when larvae enter heads causing internal damage and deposit frass.

Cultural Practices

None available

Biological Controls

Various parasites, but none are effective at low population densities.

Chemical Controls

Acephate (Orthene) provides acceptable to above average to average control of alfalfa and cabbage loopers. It provides below average control of the corn earworm and is not used for beet armyworm. Acephate is not registered on leaf lettuce and has a long PHI of 21 days.

Bacillus thuringiensis provides acceptable to above average to average control alfalfa looper and cabbage looper but with a slow kill. It provides average control for beet armyworm and corn earworm. It requires multiple applications.

Carbaryl (Sevin) provides average control of all four pests.

Pyrethroids ((e.g., cypermethrin (Ammo), esfenvalerate (Asana), permethrin (Ammo, Pounce), l-cyhalothrin (Warrior)), provide varying degrees of control from excellent to average for all four pests.

Endosulfan (Thiodan) provides acceptable to above average of the alfalfa and cabbage loopers, and average control of the corn earworm. It is not effective on the beet armyworm. It has numerous environmental concerns, which limit regions where it can be used. It is not commonly used in Monterey and Santa Cruz Counties.

Malathion provides poor control for all four pests.

Methomyl (Lannate) provides acceptable to above average to average control of the beet armyworm and the corn earworm. It is not effective on alfalfa and cabbage loopers.

Spinosad (Success) provides excellent to acceptable to above average control of the beet armyworm and corn earworm. Control of alfalfa looper is acceptable to above average to average. Control of cabbage looper is below average.

Thiodicarb (Larvin) – Provides excellent control of the alfalfa and cabbage loopers and acceptable to above average control of the beet armyworm and the corn earworm. It is incompatible with Maneb.

Emamectin benzoate (Proclaim) provides excellent control of these pests. It is not registered on leaf lettuce.

Indoxacarb (Avaunt) provides excellent control of alfalfa and cabbage loopers and the corn earworm. It provides average to acceptable to above average control of the beet armyworm.

Tebufenozide (Confirm) provides acceptable to above average control of all four pests, but is slow acting. It is used mainly for beet armyworm control.

Leafminers:

A number of species of leafminers affect lettuce production. The **Pea Leafminer** (*Liriomyza langei*) is the predominant species in the coastal regions, with *L. trifolii* and other species affecting lettuce in other production areas. Populations of leafminers have increased in recent years, especially in the coastal regions and on fall harvested lettuce in the San Joaquin Valley. The larvae of leafminers mine lettuce leaves and cause serious problems with stand reductions at the cotyledon stage and crop quality and crop contamination at harvest. Although very low larval populations may be accepted on lettuce harvested in cartons, lettuce leaves contaminated with the larvae of this insect are not suitable for use in either packaged salad mixes or for export.

The primary materials for control of the larval stage of this insect are abamectin and cyromazine, with plant back restrictions currently limiting the use of cyromazine.

Reductions in adult fly populations may be achieved with foliar treatments of acephate (Orthene), cypermethrin (Ammo), diazinon, and permethrin (Ambush, Pounce). However, these chemicals do not provide economic control of adults and do not control fly larvae. The control of adult flies is, at best, not an effective management technique. For example, under normal adult fly population conditions, achieving 90% control, which most of the aforementioned materials do not provide, still could result in populations in the range of 1/4 to 1/2 million flies per acre.

Under normal population conditions, the larval treatments would be applied a total of 1 to 2 times and the adult materials a total of 1 to 3 times. Under high population pressure, total treatments would increase to 2 to 3 for larval control and 2 to 4 for adults. Leafminers are managed primarily through the use of abamectin (Agri-Mek) for the control of the larval form of this pest; however, this product is not registered on leaf lettuce. Although cyromazine (Trigard)

is registered on lettuce its use is curtailed by a 300-day plant back for cole crops that, for all intents and purposes, eliminates use on lettuce. Management of adult leafminers has been attempted with applications of pyrethroid pesticides, however control has not been acceptable.

Cultural Practices

Plow down all susceptible host crops as soon as possible.
Sticky traps are not effective for control.

Biological Controls

None are commercially available for lettuce.

Chemical Controls

Abamectin (Agri-Mek) provides acceptable to above average control of larvae, but is not registered on leaf lettuce. Its efficacy appears to be decreasing. The FQPA risk cup is full, which appears to prevent its use on leaf lettuce.

Acephate provides average control of adult insects only.

Azadirachtin (Neem) provides average control and is organically acceptable. It does not control adults or larvae, but only restricts development of pupae.

Cypermethrin provides average control of adult insects only.

Cyromazine (Trigard) provides excellent to acceptable to above average control of leafminer larvae. Its use is limited due to a 300-day plant back restriction, making it unusable for cole crop rotation.

Diazinon and dimethoate provide average control of adults only.

Spinosad (Success) - This material offers suppression of adults and larvae at high rates.

Tralomethrin provides average control of adults only.

INSECT MANAGEMENT GOALS AT OR JUST AFTER THINNING THROUGH THE INITIATION OF HEAD FORMATION

Research:

- Develop effective, economical management techniques for aphids with emphasis on

the lettuce aphid.
- Develop effective, economical management techniques and impact of population levels for lygus.
- Develop effective, economical management techniques and impact of population levels for thrips.
- Develop effective, economical management techniques for the major worm pests.
- Develop effective, economical management techniques for leafminers.
- Continue research on host plant resistance.

Regulatory:
- Remove the 300-day plant back restriction for cyromazine (Trigard) by establishing tolerances on cole crops.
- Obtain a registration for oxydemeton-methyl (Meta-Systox R) on leaf lettuce.
- Obtain a registration for acephate (Orthene) on leaf lettuce.
- Obtain a registration for abamectin (Agri-Mek) on leaf lettuce.
- Obtain a registration for emamectin benzoate (Proclaim) on leaf lettuce.
- Retain organophosphates for aphids, lygus, thrips, and worms.
- Retain all REIs at 48 hours or less.
- Retain all PHIs at existing times.

Education:
- Educate registrants and regulators to design studies to support reasonable plant back restrictions.
- Educate growers on cultural practices and chemical techniques to manage insects, aimed at reducing pesticide usage.

Disease Management

There are four (4) primary foliar diseases of lettuce: Downy mildew; Powdery mildew; Anthracnose; and Bacterial leaf spot.

Downy mildew is the primary foliar disease on lettuce. At one time there were three foliar fungicides available to manage this disease, however; research funded by the CLRB has shown that, due to resistance, metalaxyl/mefenoxam (Ridomil) is no longer effective in all lettuce production regions and fosetyl-al (Aliette) is not effective in some regions. Resistant varieties in combination with fungicides offer the most promise for the management of downy mildew.

Downy Mildew (*Bremia lactuca*): This is the most serious foliar disease of lettuce in California. It is found in all areas, but is more prevalent in the coastal regions. Resistant cultivars have been developed through CLRB funded plant breeding programs. Unfortunately, this disease has the ability to overcome this type of resistance, and many of the originally

resistant cultivars are no longer useful. Maneb is the fungicides of choice for downy mildew control, with the number of foliar applications per acre per season ranging from none up to 4 in the coastal regions and from none up to 2 in the desert. Metalaxyl/mefenoxam use has declined due to the ability of the fungus to become resistant to this fungicide, and recent research has indicated that insensitivity to fosetyl-al also exists. Ground applications are the preferred method for applying fungicides. However, aerial treatments are also used, especially under wet field conditions. CLRB funded research has shown that the use of downy mildew resistant cultivars in combination with weather forecasting and models related to leaf wetness, rainfall, irrigation, and other downy mildew infection parameters has resulted in improvements in application efficiency and a reduction in fungicide use.

Cultural Practices

Resistant cultivars.

Weather forecasting/Modeling is limited by reluctance of growers to adopt because of investment in crop and risk of crop loss. The initial cost of equipment is restrictive.

Drip irrigation.

Biological Controls

None available.

Chemical Controls

Acibenzolar-S-Methyl (Actigard/Blockade) provides acceptable to above average control. There are limitations on varieties and areas in which use is allowed.

Azoxystrobin (Quadris) provides average control and is expensive.

Copper provides below average control and may not be mixed with fosetyl-al.

Fosetyl-al (Aliette) provides average control and has resistance and potential phytotoxicity issues related to its use with copper.

Harpin protein (Messenger) provides average control.

Mefenoxam, formerly metalaxyl (Ridomil) offers average to unacceptable control due to resistance.

Maneb provides acceptable to above average to average control. It has a long PHI of 14

days. Only 4 applications per crop are allowed.

Neem oil (Trilogy) provides below average control.

Powdery mildew (*Erysiphe cicoracearum*): Powdery mildew is primarily a problem in the desert production regions during the winter months. This is weather dependent. Sulfur is the primary treatment for powdery mildew control. Current management involves the use of various sulfur type materials, all of which only offer partial control with potential crop injury. CLRB funded research has shown that 2-3 new fungicides offer promise for the powdery mildew management and they should be registered.

Cultural Practices

Drip irrigation.

Biological Controls

None available.

Chemical Controls

Harpin protein (Messenger) provides average control.

Neem oil (Trilogy) provides average control.

Sulfur provides average to acceptable to above average to average control, but must be used preventatively. There is potential phytotoxicity with sulfur, especially following multiple applications.

The following chemicals provide below average to unacceptable control of powdery mildew: acibenzolar-s-methyl (Actigard/Blockade); azoxystrobin (Quadris); *Bacillus subtilis* (Serenade); fosetyl-al (Aliette); and maneb.

Anthracnose (*Microdochium panattonianum*) is a foliar disease that is extremely devastating during prolonged wet periods. Anthracnose has not been an economic problem in lettuce production for a number of years; however, the extreme wet weather that occurred in the spring of 1998 resulted in a severe onset of this disease, especially in the coastal production regions, with losses in individual fields as high as 100%.

Cultural Practices

Avoid planting into previously infected fields.

Avoid using overhead irrigation.

Keep bed tops dried.

Biological Controls

None.

Chemical Control

Acibenzolar-S-Methyl (Actigard/Blockade) provides average control. There are use limitations on varieties and areas in which use is allowed.

Azoxystrobin (Quadris) provides acceptable to above average control and is the fungicide of choice for the control of this disease.

Maneb provides average control as a protective treatment.

The following chemicals provide below average control of anthracnose: Harpin protein and Neem oil.

Bacterial Leaf Spot (*Xanthomonas campestris* pv. *vitians*) can be a serious foliar disease of lettuce, especially in the coastal production regions in the spring of the year, and during periods of prolonged wetness.

Cultural Practices

Avoid planting into previously infected fields.

Destroy infested plant residues to allow decomposition prior to planting lettuce.

Avoid using overhead irrigation.

Biological Controls

None available.

Chemical Controls

Bacillus subtilis (Serenade) provides acceptable to above average control.

The following chemicals provide below average to unacceptable control of powdery mildew: azoxystrobin (Quadris); copper hydroxide; Harpin protein; maneb; and Neem oil.

DISEASE MANAGEMENT GOALS AT OR JUST AFTER THINNING THROUGH THE INITIATION OF HEAD FORMATION

Research:

- Continue development of resistant varieties for major diseases.
- Develop effective, economical management techniques for downy mildew.
- Develop effective, economical management techniques for powdery mildew.
- Develop effective, economical management techniques for anthracnose.
- Develop effective, economical management techniques for bacterial leaf spot.
- Develop effective, economical management techniques for lettuce drop.

Regulatory:

- Revise the label for acibenzolar-S-Methyl (Actigard/Blockade) to allow use on all types of lettuce in all production regions.
- Obtain registrations for new fungicides for downy mildew.
- Obtain registrations for new fungicides for powdery mildew.
- Obtain registrations for new fungicides for anthracnose.
- Obtain registrations for new fungicides for bacterial leaf spot.
- Obtain a registration for BAS 510 and other new fungicides for lettuce drop.
- Retain individual B_2 carcinogens (e.g., Maneb).

Education:

- Educate growers on crop rotation.

Weed Management

The thinning operation, when combined with cultivation, provides an opportunity to remove all existing weeds from the bedtop and furrow areas. The use of a pre-emergent herbicide prior to, or at, planting influences the time and economics associated with the thinning operation. Weed control between thinning and head formation is usually accomplished with 1-2 cultivations.

Cultural Practices

Hoeing/thinning
Cultivation (tractor)

Manage weeds in adjacent areas and in rotational crops.

Biological Controls

None available.

Chemical Controls

Clethodim (Prism) is only effective on grassy weeds.

Sethoxydim (Poast) is only effective on grassy weeds. It is not effective on annual bluegrass.

WEED MANAGEMENT GOALS AT OR JUST AFTER THINNING THROUGH THE INITIATION OF HEAD FORMATION

Research:

- Develop selective post emergent broadleaf herbicides.
- Continue to investigate non-chemical, robotic means of weed control.

Regulatory:

- Retain the registrations for pronamide/propyzamide (Kerb), benefin (Balan) and bensulide (Prefar).
- Retain the registrations on rotational crops for prometryn (Caparol), chlorthal-dimethyl (Dacthal), linuron (Lorox) and oxyfluorfen (Goal).

Education:

- Educate regulators on the economics of weed control.
- Educate regulators and growers on the role of weeds and other hosts as reservoirs of diseases, viruses and vectors.

III. PEST MANAGEMENT FROM THE INITIATION OF HEAD FORMATION THROUGH HARVEST

Worker activities from the initiation of head formation through harvest

Irrigation
Hoeing
Pesticide/fertilizer applications (tractor)
Scouting
Cultivation (tractor)
Harvesting

Insect Management

It is imperative that insects be maintained at low levels during this period to ensure a high quality product at harvest. This is especially true for product scheduled for export, as some countries have extremely strict requirements for imported products.

The following general comments relate to information previously presented in this report:

Aphids

The **green peach, potato**, and **lettuce aphids** can present problems from the initiation of head formation to harvest.

Chemical Controls

The following previously referenced materials: Imidacloprid (Provado); diazinon; dimethoate; endosulfan; malathion; methomyl; and oxydemeton-methyl (see pages 26-29), are available depending upon labeled use restrictions. Acephate is not included at this time, as the 21-day PHI essentially eliminates its availability.

Lygus bug

Chemical Controls

The following previously referenced materials: pyrethroids; diazinon; dimethoate; malathion; and methomyl; (see pages 29-30), are available depending upon labeled use restrictions. Acephate is not included at this time, as the 21-day PHI essentially eliminates its availability.

Western Flower Thrips

Chemical Controls

The following previously referenced materials: pyrethroids; methomyl; and spinosad (see page 30), are available depending upon labeled use restrictions. Acephate is not included at this time, as the 21-day PHI essentially eliminates its availability.

Lepidopterous Larvae

Chemical Controls

The following previously referenced materials: *Bacillius thuringiensis*; pyrethroids; endosulfan; methomyl; thiodicarb; spinosad; emamectin benzoate; indoxacarb; and tebufenozide (see

pages 30-32), are available depending upon labeled use restrictions. Acephate is not included at this time, as the 21-day PHI essentially eliminates its availability.

Leafminers

Chemical Controls

The following previously referenced materials: azadirachtin; abamectin; cyromazine; and spinosad (see pages 32-33), are available depending upon labeled use restrictions.

Cultural Practices for all Insects

Stripping contaminated foliage at harvest - reduces yield.

Biological controls

None available.

INSECT MANAGEMENT GOALS FROM THE INITIATION OF HEAD FORMATION TO HARVEST

Research:

- Develop resistant varieties for major insects.
- Develop effective, economical management techniques for aphids with emphasis on the lettuce aphid.
- Develop effective, economical management techniques and impact of population levels for lygus.
- Develop effective, economical management techniques and impact of population levels for thrips.
- Develop effective, economical management techniques for the major worm pests.
- Develop effective, economical management techniques for leafminers.

Regulatory:

- Retain all REIs at 48 hours or less.
- Retain all PHIs.
- Remove the plant-back restriction for cyromazine (Trigard).
- Obtain a registration for oxydemeton-methyl (Meta-Systox R) on leaf lettuce.
- Obtain a registration for acephate (Orthene) on leaf lettuce.
- Obtain a registration for abamectin (Agri-Mek) on leaf lettuce.
- Retain organophosphates for aphids, lygus, thrips, and worms.

Education:

- Educate registrants and regulators to design studies to support reasonable plant back restrictions.
- Educate growers on cultural practices and chemical techniques to manage insects,

aimed at reducing pesticide usage.

Disease Management

Management of foliar diseases from the initiation of head formation to harvest is also critical, as individual diseases (e.g., downy mildew, powdery mildew, anthracnose, and bacterial leaf spot can create problems during shipping and in the market place.

The following general comments relate to information previously presented in this report:

Downy Mildew

Chemical Controls

The following previously referenced materials: acibenzolar-s-methyl (Actigard/Blockade); azoxystrobin (Quadris), fosetyl-al, and maneb are available depending upon resistance related issues and labeled use restrictions.

Powdery mildew

Chemical Controls

The following previously referenced materials: *Bacillus subtilis*; Harpin protein; neem oil; and sulfur are available depending upon labeled use restrictions.

Anthracnose

Chemical Controls

The following previously referenced materials: acibenzolar-s-methyl (Actigard/Blockade); azoxystrobin (Quadris), and maneb are available depending upon labeled use restrictions

Bacterial Leaf spot

Chemical Controls

The only product that would aid in the management of this disease at this time would be *Bacillius subtilis*.

DISEASE MANAGEMENT GOALS FROM THE INITIATION OF HEAD FORMATION TO HARVEST

Research:

- Retain all REIs at 48 hours or less.
- Retain all PHIs.
- Develop effective, economical management techniques for downy mildew.
- Develop effective, economical management techniques for powdery mildew.
- Develop effective, economical management techniques for anthracnose.
- Develop effective, economical management techniques for bacterial leaf spot.

Regulatory:

- Revise the label for acibenzolar-s-methyl (Actigard/Blockade) to allow use on all types of lettuce in all production regions.
- Obtain registrations for new fungicides for downy mildew.
- Obtain registrations for new fungicides for powdery mildew.
- Retain individual B_2 carcinogens (e.g., Maneb).

Education:

- Educate growers on crop rotation.

Weed Management

Weeds must be removed from lettuce fields prior to harvest as they can become contaminants during harvest and individual species (i.e., stinging nettle) can create problems with the harvesting crew. Management during this period is primarily obtained with a hand hoeing operation conducted within 2-4 weeks of harvest.

Cultural Practices

Hoeing

Biological Controls

None available.

Chemical Controls

None, as is too late for effective control.

WEED MANAGEMENT GOALS FROM THE INITIATION OF HEAD FORMATION TO HARVEST

Research:

- Conduct research on alternatives to pronamide/propyzamide (Kerb) for weed management.
- Conduct research for perennial weed management.

Regulatory:

- Retain the registrations for pronamide/propyzamide (Kerb), benefin (Balan) and bensulide (Prefar).
- Retain the registrations for prometryn (Caparol), chlorthal-dimethyl (Dacthal), and oxyfluorfen (Goal).

Education:

- Educate regulators on the economics of weed control.
- Educate regulators and growers on the role of weeds and other hosts as reservoirs of diseases, viruses and vectors.

REFERENCES

Cited References

(1) California Agricultural Resource Directory - 2001.
(2) United State Department of Agriculture - Vegetables - 2001 Summary - January 2002.
(3) California Lettuce Research Board Reports.
(4) Personal Communication - CLRB members and/or their PCAs.
(5) Compendium of Lettuce Diseases.
(6) USDA, NASS Arizona Agricultural Statistics Service, July 2001. http://www.nass.usda.gov/az/
(7) Arizona Agricultural Statistics Service. 2001. 1998 Arizona Agricultural Statistics Bulletin; USDA, NASS Arizona Agricultural Statistics Service, July 2001. http://www.nass.usda.gov/az/
(8) Kerns, D.L. et al. 1999. Guidelines for Head Lettuce Production in Arizona, IPM series, #12. University of Arizona, Cooperative Extension. Extension bulletin AZ1099. http://ag.arizona.edu/crops/vegetables/cropmgt/az1099.html
(9) Arizona Agricultural Statistics Bulletin, July 2000. Arizona Agricultural Statistics Service. http://www.nass.usda.gov/az/
(10) Arizona Agricultural Statistics Service. 1999. 1998 Arizona Agricultural Statistics Service, July 2000. http://www.nass.usda.gov/az/
(11) Teegerstrom, T. et al. 1998-99 Arizona Vegetable Crop Budgets. Western Arizona. University of Arizona, Cooperative Extension. Extension bulletin AZ1105.

Other References

AZ Iceberg Lettuce Crop Profile
AZ Leaf Lettuce Crop Profile
CA Iceberg Lettuce Crop Profile
CA Leaf Lettuce Crop Profile

Table 1

LETTUCE INSECT PESTS

MANAGEMENT TOOL	CUTWORMS	SEED CORN MAGGOT	SPRINGTAILS/ SYMPHYLANS	GREEN PEACH APHID	LETTUCE APHID	ROOT APHID	POTATO APHID	ALFALFA LOOPER	BEET ARMYWORM	CABBAGE LOOPER	CORN EARWORM	LYGUS BUG	LEAF-MINERS (ADULTS)	LEAF-MINERS (LARVAE)	WHITE-FLIES	WESTERN FLOWER THRIPS	COMMENTS
ACEPHATE *ORTHENE*				1	2		1	2-3		2-3	4	2-3	3			4	Not labeled on leaf
AVERMECTIN *AGRI-MEK*														2			Not labeled on leaf
AZADIRACHTIN *NEEMIX*				4	5		4							3	4	4	
B. thuringiensis *DIPEL*								2	3	2	3						
BUPROFEZIN *APPLAUD*															1		
CARBARYL *SEVIN*	1							3	3	3	3	2					
CYPERMETHRIN *AMMO*	2							1	3	1	1	1	3			2	
CYROMAZINE *TRIGARD*														1-2			300 day plantback restriction to Brassica
DIAZINON		2	3	2	3		2					2	3				Expect to lose label for head lettuce in 1 year, and granular and leaf lettuce in 5 years
DIMETHOATE				2	2		1					2	3			3	probable loss of registration
DISULFOTON *DI-SYSTON*			2			2											60 day PHI limits use on leaf, 72 hr REI
EMAMECTIN BENZOATE *PROCLAIM*								1	1	1	1						Not labeled on leaf, ground application only
ENDOSULFAN *THIODAN*				1	2		1	2	4	2	3	1					Limited by environmental concerns
ESFENVALERATE *ASANA*								1	3	1	1	2				3	Not labeled on leaf
GARLIC *ALLITYN*	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
INDOXACARB *AVAUNT*								1	2-3	1	1						Not labeled on leaf
IMIDACLOPRID *ADMIRE*				1	1	1	1								1		
IMIDACLOPRID *PROVADO*				1	2		1										
L-CYHALOTHRIN *WARRIOR*								1	3	1	2	2					

EFFICACY RATING SYMBOLS: 1=Excellent (95-100% control); 2=Acceptable to above average (85-94% control); 3=Average (75-84% control); 4=Below average (60-74% control); and 5=Unacceptable/Poor (<60% control)

Table 4

LETTUCE ANNUAL WEEDS

MANAGEMENT TOOL	BURNING NETTLE	COMMON GROUNDSEL	PRICKLY LETTUCE	SOW THISTLE	COMMON PURSLANE	MUST-ARDS	LITTLE MALLOW	CHENO-PODIUMS	PIG-WEEDS	NIGHT-SHADES	BARNYARD GRASS	VOLUNTEER CEREALS	ANNUAL BLUEGRASS	SHEPHERD'S PURSE	GROUND CHERRY	PINEAPPLE WEED	NUT-SEDGES	KNOT-WEED	COMMENTS
BENEFIN *BALAN*	4	5	5	5	2	4-5	5	2	2	4	1	3	1	4	5	5	5	1	
BENSULIDE *PREFAR*	2	5	5	5	1-3	4-5	5	2	1	4	1	4	1	4	5	5	5	2-3	
GLYPHOSATE *ROUNDUP*	5	1	1	1	2	1	4	1	1	1	1	1	1	4	1	1	5	3	Fallow bed application
METAM-SODIUM	1	1	1	1	1	1	4	1	1	1	1	1	2	1	1	1	5	2	
BROMIDE + CHLOROPICRIN	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	2-3	1	
OXYFLUORFEN *GOAL*	2	1	1	1	1	1	1	1	1	1	3	4	3	3	1-3	3-4	5	4-5	plantback/Fallow bed application
PARAQUAT *GRAMOXONE*	4	1	3	3	1	1	4	1	1	1	3	4	3	1	1-2	3	5	4	Fallow bed application
PROPYZAMIDE *KERB*	2	4	4	4	2	2	4	3-4	4	2	2	2	1	2	1-3	3-4	5	2	
SETHOXYDIM *POAST*	5	5	5	5	5	5	5	5	5	5	1	2	5	5	5	5	5	5	
CLETHODIM *PRISM*	5	5	5	5	5	5	5	5	5	5	1	2	1-2	5	5	5	5	5	
EFFICACY RATING SYMBOLS: 1=Excellent (95-100% control); 2=Acceptable to above average (85-94% control); 3=Average (75-84% control); 4=Below average (60-74% control); and 5=Unacceptable/Poor (<60% control)																			

Table 1

LETTUCE INSECT PESTS

MANAGEMENT TOOL	CUTWORMS	SEED CORN MAGGOT	SPRINGTAILS/ SYMPHYLANS	GREEN PEACH APHID	LETTUCE APHID	ROOT APHID	POTATO APHID	ALFALFA LOOPER	BEET ARMYWORM	CABBAGE LOOPER	CORN EARWORM	LYGUS BUG	LEAF-MINERS (ADULTS)	LEAF-MINERS (LARVAE)	WHITE-FLIES	WESTERN FLOWER THRIPS	COMMENTS
MALATHION				2	3		2	5	5	5	5	3					
METHOMYL *LANNATE*				2	3		2	4	2	4	2-3	2				2	
OXYDEMETON-M *METASYSTOX-R*				1	1	1-2	1										Not labeled on leaf
PERMETHRIN *AMBUSH/POUNCE*	2							1-2	3	1-2	2-4	1-2	5			3-4	
PIP-BUTOXIDE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
PYRETHRINS *PYGANIC*	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
ROTONONE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
SPINOSAD *SUCCESS*								2-3	1-2	4	1-2		3	3		2	
TEBUFENOZIDE *CONFIRM*								2	2	2	2						
THIDIOCARB *LARVIN*								1	2	1	2						
TRALOMETHRIN *STRYKER/SCOUT*	3							1	3	1	1	2	3				
EFFICACY RATING SYMBOLS: 1=Excellent (95-100% control); 2=Acceptable to above average (85-94% control); 3=Average (75-84% control); 4=Below average (60-74% control); and 5=Unacceptable/Poor (<60% control)																	

EFFICACY RATING SYMBOLS: 1=Excellent (95-100% control); 2=Acceptable to above average (85-94% control); 3=Average (75-84% control); 4=Below average (60-74% control); and 5=Unacceptable/Poor (<60% control)

Table 2 LETTUCE INSECT PREDATORS AND PARASITES

MANAGEMENT TOOL	LADY BEETLES (LARVAE)	LACEWINGS (LARVAE)	SYRPHID FLIES (LARVAE)	PARASITIC WASPS (ADULTS)	TACHINID FLIES (ADULTS)	BIG-EYED BUGS (ADULTS)	MINUTE PIRATE BUGS (ADULTS)	ASSASSIN BUGS (ADULTS)	COMMENTS
ACEPHATE *ORTHENE*	P	P	P	P	P	P	P	P	
AVERMECTIN *AGRI-MEK*	E	E	E	E	E	E	E	E	
AZADIRACHTIN *NEEMIX*	G	G	G	E	E	E	E	E	
B. thuringiensis *DIPEL*	E	E	E	E	E	E	E	E	
BUPROFEZIN *APPLAUD*	E	E	E	E	E	E	E	E	
CARBARYL *SEVIN*	P	P	P	P	P	P	P	P	
CYPERMETHRIN *AMMO*	P	P	P	P	P	P	P	P	
CYROMAZINE *TRIGARD*	E	E	E	E	E	E	E	E	
DIAZINON	P	P	P	P	P	P	P	P	
DIMETHOATE	P	P	P	P	P	P	P	P	
DISULFOTON *DI-SYSTON*	P	P	P	P	P	P	P	P	
EMAMECTIN BENZOATE *PROCLAIM*	E	E	E	E	E	E	E	E	
ENDOSULFAN *THIODAN*	P	P	P	P	P	P	P	P	
ESFENVALERATE *ASANA*	P	P	P	P	P	P	P	P	
GARLIC *ALLITYN*	E	E	E	E	E	E	E	E	
INDOXACARB *AVAUNT*	E	E	E	E	E	E	E	E	
IMIDACLOPRID *PROVADO/ADMIRE*	E	E	E	E	E	E	E	E	
L-CYHALOTHRIN *WARRIOR*	P	P	P	P	P	P	P	P	

E=Excellent survivability; G=Good survivabiltiy; P=Poor survivability

Table 2 LETTUCE INSECT PREDATORS AND PARASITES

MANAGEMENT TOOL	LADY BEETLES (LARVAE)	LACEWINGS (LARVAE)	SYRPHID FLIES (LARVAE)	PARASITIC WASPS (ADULTS)	TACHINID FLIES (ADULTS)	BIG-EYED BUGS (ADULTS)	MINUTE PIRATE BUGS (ADULTS)	ASSASSIN BUGS (ADULTS)	COMMENTS
MALATHION	P	P	P	P	P	P	P	P	
METHOMYL *LANNATE*	P	P	P	P	P	P	P	P	
OXYDEMETON-M *METASYSTOX-R*	P	P	P	P	P	P	P	P	
PERMETHRIN *AMBUSH/POUNCE*	P	P	P	P	P	P	P	P	
PIP-BUTOXIDE	G	G	G	G	G	G	G	G	
PYRETHRINS *PYGANIC*	G	G	G	G	G	G	G	G	
ROTONONE	G	G	G	G	G	G	G	G	
SPINOSAD *SUCCESS*	G	G	P	G	G	E	E	E	
TEBUFENOZIDE *CONFIRM*	E	E	E	E	E	E	E	E	
THIDIOCARB *LARVIN*	E	E	E	E	E	E	E	E	
TRALOMETHRIN *STRYKER/SCOUT*	P	P	P	P	P	P	P	P	
E=excellent tolerance, G=good tolerance, F=fair tolerance, P=poor tolerance									

E=Excellent survivability; G=Good survivabiltiy; P=Poor survivability

Table 3

LETTUCE DISEASES

MANAGEMENT TOOL	ANTHRACNOSE	BOTTOM ROT	FUSARIUM WILT	PYTHIUM	DOWNY MILDEW	LETTUCE DROP (SOIL)	VERTICILLIUM WILT	POWDERY MILDEW	BACTERIAL LEAF SPOT	COMMENTS
1,3-DICLOROPROPENE *TELONE*		?	5			5	5			
1,3-DICLOROPROPENE + *CHLORPICRIN*		2	2-3			1-2	1-2			
ACIBENZOLAR-S-METHYL *BLOCKADE*	3				2			4		
AZOXYSTROBIN *QUADRIS*	2	3			3			4	4	
B*ACILLUS SUBTILIS SERENADE*		4				5		4	2	
CHLOROPICRIN			2-3			1-2	1-2			
COPPER HYDROXIDE					4				4	Potential crop injury
DICLORAN *BOTRAN*		3-4				2-4				
FOSETYL-AL *ALIETTE*					3			4		DM "R" documented
HARPIN PROTEIN *MESSENGER*	4	3	5		3	3-4		3	5	
IPRODIONE *ROVRAL*		3				4				
MANEB	3				2-3			5	5	
MEFENOXAM *RIDOMIL GOLD*				3	3-5					DM "R" documented
METHYL BROMIDE		?	5			?	5			No longer available after 2005
METHYL BROMIDE + CHLORPICRIN		2	2-3			1-2	1-2			
NEEM OIL *TRILOGY*	4				4			3	4	
SULFUR								2-3		Potential Crop injury
VINCLOZOLIN *RONILAN*		4				3				No longer available after 2005
EFFICACY RATING SYMBOLS: 1=Excellent (95-100% control); 2=Acceptable to above average (85-94% control); 3=Average (75-84% control); 4=Below average (60-74% control); and 5=Unacceptable/Poor (<60% control); ?=unknown efficacy										