The Uses and Benefits of Organophosphate and Carbamate Insecticides in U.S. Crop Production

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1. DISCLAIMER

This paper classifies 23 active ingredients in the organophosphate (OP) class and seven active ingredients in the carbamate class of chemistry as "insecticides." Many of these products are not strictly insecticides, but also act as miticides, aphicides and nematicides. The OP and carbamate pesticide active ingredients that are subject to FQPA rulemaking are not limited to insecticides, but also include certain fungicides, herbicides and plant growth regulators. This paper is limited to the 30 active ingredients. It does not include any analysis of the uses of the fungicides, herbicides or growth regulators.

The usage data used in this report reflects registrations of organophosphates and carbamates in 1995. Several of the active ingredients have been withdrawn from use in the U.S.: sulprofos and fonofos. In addition, all but three of the uses of methamidiphos have been withdrawn.

2. INTRODUCTION

Thirty pesticide active ingredients belonging to the organophosphate (OP) and carbamate classes of chemistry are widely used as insecticides in U.S. production of fruit, vegetable and field crops. These active ingredients, their trade names and major crop uses are identified in Table 1. The organophosphate and carbamate insecticides are used to control insect pests that, otherwise, would lower crop yields significantly. Although alternative chemical and non-chemical controls are available for most of these crops, the organophosphate and carbamate insecticides, generally, are more effective and/or significantly less costly.

In August 1996, the President signed the Food Quality Protection Act (FQPA), which had passed Congress unanimously. FQPA includes significant amendments to the nation's laws regulating pesticide registrations and tolerances in foods. Congress included sections in FQPA that broaden the consideration of health risk factors while reducing the role that pesticide benefits play in granting tolerances. FQPA requires the EPA to reassess all existing pesticide tolerances considering the best available data on aggregate exposure to the pesticide, the cumulative effects from pesticides sharing a common mechanism of toxicity, exposure to children and potential as an endocrine disrupter.

EPA plans to review 33 percent of existing tolerances by August 1999. On August 4, 1997, EPA published a list of its tolerance reassessment priorities and reregistration scheduling priorities. For the August 1999 deadline, EPA intends to reassess those pesticides that appear to pose the greatest risk to the public health. EPA has included pesticides of the organophosphate and carbamate classes of chemistry in this first group of pesticides to be subject to FQPA's requirements. Initially, EPA plans to review the registrations of the organophosphate and carbamate insecticides individually, using FQPA requirements regarding aggregate exposure, protection of children and endocrine effects. Following the individual assessments, EPA plans to conduct a cumulative effects analysis of exposure to all of the active ingredients sharing a common mechanism of toxicity. For this analysis, it is likely that all of the organophosphates will be considered as one group and all of the carbamates as another group. Although the results of the aggregate risk analyses are unknown at this time, it may be that EPA will propose canceling many organophosphate and carbamate insecticide uses in order to reduce the calculated risk to human health to below the acceptable safety standard.

The organophosphate and carbamate insecticides share the ability to depress the levels of cholinesterases enzymes in the blood and nervous systems of insects, animals and humans. Most of the organophosphate and carbamate insecticides are regulated currently by EPA on the basis of threshold effects. FQPA specifically instructs EPA not to consider the benefits of a pesticide when considering threshold human health risks. If the theoretical risk exceeds the safety standard, risk must be reduced by cancellation of uses or otherwise until the standard is met, no matter the cost. However, Congress did not preclude EPA from conducting cost-effective rulemaking. Careful analysis of the individual uses of the organophosphate and carbamate insecticides might identify those crops for which the use of alternatives would be least costly as replacements. On the other hand, EPA may determine that it has no recourse but to propose cancellations of a long list of organophosphate and carbamate insecticide registrations, which may leave many growers without effective alternatives, and be very disruptive to U.S. production of crops. When EPA proposes these regulations, it will be necessary for the Agency to estimate the costs of this rulemaking. However, if pesticide registrants propose to remove registrations voluntarily, it will not be necessary for the EPA to estimate the resulting economic effects. FQPA provides only broad outlines for implementation of the "reasonable certainty of no harm" standard. The impact of FQPA will depend largely on the policies, procedures and default assumptions EPA uses in its implementation. Extremely conservative policies, procedures and assumptions will increase the cost impact of FQPA.

3. OP AND CARBAMATE INSECTICIDE USAGE DATA

The estimates of the usage of organophosphate and carbamate insecticides used in this paper are drawn from the National Pesticide Use Database issued by the National Center for Food and Agricultural Policy (NCFAP) in 1995 [1]. The NCFAP pesticide use database accounts for the use of 200 active ingredients by crop and state. The NCFAP database is the only comprehensive, publicly available pesticide use database for the U.S. and reflects usage patterns circa 1992. The NCFAP database currently is being revised to reflect 1995/96 usage patterns. A key part of the update is an ongoing review of usage estimates for organophosphate and carbamate insecticides, that is being conducted by NCFAP in coordination with EPA, pesticide registrants and commodity organizations. The revised NCFAP usage database will be available in Spring 1998.

The following data summaries are based on the NCFAP usage database issued in 1995 without revision. Tables 2 and 3 show the national usage patterns for the 23 organophosphate and seven carbamate insecticides. National usage for each active ingredient is summarized in terms of the acreage of each crop for which the active ingredient is used in the U.S. As can be seen, acephate is used on 13 crops in the U.S., azinphos methyl on 40 crops, malathion on 61 crops, etc. In all, there are 690 use sites for organophosphate and carbamate insecticides in U. S. crop production. Table 4 lists the number of crop use sites for each organophosphate and carbamate active ingredient. In many cases, different organophosphates and carbamates are used on the same crop. For example, 23 of the organophosphate and carbamate insecticides are used on cotton. Each of the 690 use sites for organophosphate and carbamate insecticides warrants an analysis as to why a particular active ingredient is used on that crop (What are the target pests?) and warrants an analysis of the potential alternatives if the use of the organophosphate or carbamate for that particular crop were canceled.

One readily apparent feature of the national usage pattern for individual organophosphates and carbamates is that there are very few use sites where the active ingredient is used on more than half of U.S. acreage. Of the 690 use sites, only 27 represent more than 50 percent of the nation's acreage of the crop. On the other hand, 442 use sites represent less than 10 percent of the nation's acreage of a crop treated with an individual active ingredient. The NCFAP use estimates reflect normal, average usage patterns. In some cases, risk assessments are conducted with the assumption that 100 percent of the crop acreage is treated with all registered products. The NCFAP data indicate that such assessments are gross overstatements of the normal usage patterns for the organophosphate and carbamate insecticides. On the other hand, insecticide usage can vary tremendously depending on pest pressure and unusual weather patterns. The NCFAP database does not identify the likely maximum usage patterns for these chemicals. While it is accurate to say that few individual products are used on the majority of the acreage of any crop, it may be the case that the majority of the acreage of many crops is treated with one or more organophosphate or carbamate insecticides during the same growing season.

4. OP AND CARBAMATE USAGE ANALYSIS

The organophosphate and carbamate products represent 30 of the 59 active ingredients used as insecticides in U.S. crop production. The other major classes of insecticides used in U.S. crop production are pyrethroids and biological products. Oil is used widely to control insects in tree crops. Of the acres treated with insecticides in U.S. crop production, 70 percent are treated with organophosphate or carbamate insecticides. Tables 5 and 6 list the shares of insecticide treated acres for each crop that is accounted for by organophosphate and carbamate active ingredients. As can be seen for certain crops, organophosphate and carbamate insecticides are the only ones used: barley, canola, dates, flax, oats, rice, rye, safflower, sweet potatoes and wild rice. For 35 crops in the U.S., organophosphate and carbamate insecticides account for more than 70 percent of the insecticide treated acres. Tables 7 and 8 summarize the use of organophosphates and carbamates by state. As can be seen, for most states, the majority of insecticide treated acres are treated with organophosphate and carbamate insecticides.

The total use of organophosphate and carbamate insecticides in U.S. crop production is 83 million pounds. NCFAP estimates that the poundage of insecticides used in U.S. agriculture is 149 million pounds total. However, 51 million pounds of the national usage is accounted for by oil, that is used at a high per pound rate per acre. Organophosphate and carbamate insecticides respectively represent approximately 65 percent and 19 percent of the poundage of insecticides used in U.S. crop production (exclusive of oil).

Tables 9 and 10 show the distribution of poundage of organophosphate and carbamate insecticides used by crop in the U.S. As can be seen, two crops, corn and cotton, account for 54 and 40 percent of national poundage of organophosphate and carbamate insecticides, respectively. Twenty-four crops account for 95 percent of the poundage of organophosphate and carbamate insecticide use while 60 crops, collectively, account for the remaining 5 percent of national use.

5. INDIVIDUAL CROP ANALYSES

For 22 of the crops treated with organophosphate and carbamate insecticides in the U.S. a literature search was conducted to identify the pests and reasons for usage.

Alfalfa:

Weevils, potato leafhoppers and aphids are the three top pests of alfalfa in the U.S. The organophosphate insecticides dimethoate and chlorpyrifos and the carbamate insecticide carbofuran are the most widely used products because of their efficacy against all the major pests. Pyrethroids were introduced for alfalfa insect pest management about 10 years ago. Weevil control with pyrethroids has been uneven. The pyrethroids do not control aphids.

Apples

San Jose scale and codling moth are two of the key pests which organophosphate insecticides control. The scale is a tiny insect that sucks the plant juices from twigs, branches, fruit and foliage. This pest has become of increasing concern to apple growers in the northwest because of the importance of exports, as phytosanitary regulations ban infested fruit from some countries [46]. The most effective method of control is to use oil plus an organophosphate insecticide, such as malathion, diazinon, phosmet, methidathion or chlorpyrifos during the dormant season [47]. Oil could be used at higher rates without the organophosphates, but increased use of oil could lead to increased plant injury. Fruit infestation with scale can be prevented with summer applications of insecticides (oil cannot be used in the summer). The only insecticides recommended for scale control during the summer are organophosphates – diazinon, chlorpyrifos and methyl parathion. Although it could control scale insects, esfenvalerate (a pyrethroid) is not recommended as a summer spray since it is very toxic to beneficial mites, and its application would be disruptive of the biological of harmful mite species [47].

Codling moth is the key pest of apples in Washington State. Apple losses from this insect alone would each 50 percent in one or two years if no insecticides were applied for control [48]. Its larvae bore deeply into the fruit and feed on seeds. Brown frass, or excrement, extrudes from the hole [47]. Survey data indicate that 96 percent of the growers apply an average of three applications of an organophosphate insecticide (azinphos methyl, phosmet, methyl parathion, chlorpyrifos) for control of codling moth [48]. Available alternatives to the organophosphates tend to be less effective, more expensive or disruptive of IPM programs [48]. Carbaryl and esfenvalerate are toxic to predatory mites and can cause severe mite outbreaks. Codling moth has not been controlled adequately with soft pesticides (such as BT) in the northwest [47]. Generally, efficacy of these compounds, even when applied five to seven times as often as azinphos methyl, do not provide equal control [48]. A synthetic insect pheromone (Isomate C) is available to disrupt codling moth mating. However, mating disruption is a less effective alternative in areas of high codling moth pressure. Growers in this situation usually supplement mating disruption with azinphos methyl.

Artichokes:

In California, the plume moth is the most serious pest of artichokes. The insect feeds on the leaves and tunnels throughout the main stem. Over the past decade the number of insecticide applications has been reduced by half, following the registration of the organophosphate insecticide methidathion, that provides longer residual control than alternatives [13].

Avocados:

The major insect pest of California avocado orchards is Greenhouse thrips. Areas on which thrips have been feeding are browner in color and covered with black specks of their excrement. Fruit scars can result in economic losses of 50 percent [14]. The organophosphate insecticide malathion has been used for several decades and controls the thrips with residual control of up to three weeks. A botanical insecticide is registered, but has no residual control and has to be sprayed two to three times [15]. A parasitic wasp has been introduced but has not proven effective in broad scale biological control.

Blackberries:

The raspberry crown borer is one of the most damaging pests of blackberries in the U.S. The insect damages the underground crown of the perennial blackberry plants. The organophosphate insecticide diazinon is applied as a drench on the row to kill the young larvae prior to their tunneling into the crown [16]. Once inside the crown, they cannot be killed with insecticides.

Blueberries

The blueberry maggot, or blueberry fruit fly, is the major insect pest of blueberries in Maine [49]. Flies emerge from the soil from June through August. Once mated, the females seek ripening blueberries in which to lay eggs. In seven to 10 days the eggs hatch, and the larva (maggot) begins feeding. As the larva feeds and grows, the berry begins to shrink. After two to three weeks the berry is destroyed almost completely. The presence of infested fruit at harvest can result in the condemnation of whole fields of harvested fruit. Maggots became serious problems in Maine blueberries in the 1920's [50]. Dusting with arsenic was the common control method employed in the 1930 - 1950 time period. Currently, blueberry fruit fly emergence is monitored with sticky traps. Action thresholds have been developed to guide the timing and necessity of treatment. The only insecticides recommended by the University of Maine for blueberry maggot control are OP's (malathion, phosmet, azinphos methyl) and a carbamate (carbaryl). Azinphos methyl and phosmet are most widely used because they are the most effective. Some Maine growers who do not use insecticides use the tactic of late harvesting as a means of eliminating some of the maggot infested berries, as these berries tend to drop off the bush as the maggots inside them mature. Research results suggest that this technique may work well in some years, but not in others [51]

Cherries

The most important insect pests in Michigan tart cherry orchards are cherry fruit fly and plum curculio. Both insects directly damage the fruit. Female fruit flies lay their eggs under the skin of the fruit (each female can lay from 50 to 200 eggs). The hatched larvae feed inside the fruit. A Food and Drug Administration rule mandates a zero tolerance for cherry fruit fly maggots in processed cherries. In unsprayed trees a high percentage of fruit is likely to be attacked

The organophosphate insecticides azinphos methyl, phosmet and chlorpyrifos are used widely in Michigan tart cherry orchards because they provide effective control of all the major insect species [45]. Alternatives to the organophosphates include pyrethroids, including esfenvalerate and permethrin. The pyrethroids are less effective and more costly. Unlike the organophosphates, the pyrethroids destroy beneficial mites. With the resulting build-up of damaging mite species, miticide use would have to be increased.

Corn:

Corn rootworm larvae are the primary and most damaging insects pests in corn production. The larvae chew on and tunnel inside or along the roots in summer months. As they feed, the larvae prune roots back to the stalk. Injured plants cannot take up water and nutrients efficiently. Yield losses of up to 55 percent can occur as a result of both root pruning and lodging [3]. For continuous corn production, granular soil insecticides, applied at planting, are the primary method used to control corn rootworm. The three major corn rootworm insecticides are the organophosphates chlorpyrifos and terbufos and the pyrethroid tefluthrin. Chlorpyrifos is used most frequently in the Corn Belt because of its efficacy against both cutworms and rootworms. Terbufos is the market leader in the Western Plains, where the predominant rootworm species is the western corn rootworm, and where rootworm populations are higher. Terbufos also is the market leader in Southern states, where billbugs are problems in corn. Crop rotation has long been an acceptable alternative to insecticide use for control of corn rootworm. However, for the past several years, a new phenomenon has been causing serious rootworm infestations in first-year corn fields in Illinois and

Indiana. Extension personnel believe that the Western corn rootworm beetle has adapted to laying eggs in soybeans, thus minimizing the utility of a corn/soybean rotation for corn rootworm control [4].

Dates:

Four species of beetles are pests of dates in California. In addition to the primary damage caused by feeding, losses result from the presence of excreta, larvae and the moulting skin in the damaged dates. Crop damage is higher during years with above-average rainfall. In the late 1940's, up to 75 percent of the date crop was lost to insect damage in some years [17]. Since 1953, the organophosphate insecticide malathion has been recommended and widely-used for beetle control in California date trees.

Figs:

The major insect pests of California figs are dried fruit beetles, that feed on ripening or overripe fruit. During years of unseasonable rains, fig orchards attract insects from great distances, and populations reach astronomical levels [18]. In order to salvage a portion of the crop after unseasonable rain, fig growers employ the organophosphate insecticides malathion or diazinon.

Grapes:

A Special Local Needs label for the use of the organophosphate insecticide chlorpyrifos for control of grape mealybug exists for California and Washington (approved in 1996/97). Mealybugs feed on grape sugars and proteins and secrete the ingested sugars, leaving behind honeydew, that promotes the growth of sooty mold on the fruit. Grape pickers dislike the mealybug infested grape clusters because the black mold gets all over their clothing and is transferred by their hands from infested bunches to uninfested bunches. Chlorpyrifos, when directed at the vines' trunks and applied in a delayed dormant application, has proven to be the most effective control material against the grape mealybug [19].

Hazelnuts:

Until the 1990's, the organophosphate insecticide chlorpyrifos was used widely for management of the filbert aphid. In addition, sporadic use occurred when leafrollers were an economic threat. In recent years, chlorpyrifos use has declined because of the successful introduction of a parasitoid wasp for biological control of filbert aphids [20]. Leafrollers remain a sporadic pest, and chlorpyrifos is most commonly used for its control currently.

Hops:

Hop aphid is a primary pest of hops in the U.S., and chemicals are used on 100 percent of U.S. hop acreage every year for its control. Hop aphids excrete prolific amounts of honeydew. Sooty mold grows on the honeydew and can render hop cones unmarketable as moldy hops cannot be used for brewing [27]. Until recently, the organophosphate insecticide diazinon was used on 100 percent of U.S. hop acreage for aphid control. However, the recent registration of imidacloprid has resulted in a significant decline in diazinon's use. Diazinon is used currently as an early season spray for aphid control and is also important for resistance management for imidacloprid.

Kiwi:

In California, heavy infestations of scale insects cause premature fruit softening, which is a significant problem for packers storing kiwi fruit [22]. Although widely used to control scale, research indicates that spray oil does not provide adequate control of high populations. In kiwi vineyards with high scale populations, the organophosphate methidathion is used [23]. Methidathion is registered for kiwi under a Special Local Needs registration.

Mint:

The organophosphate insecticides chlorpyrifos and acephate are used to control cutworms in mint fields. Even low populations of cutworms will reduce plant vigor significantly or will kill plants through feeding on roots [24]. Currently, chlorpyrifos is the only insecticide registered for control of mint root borer and garden symphylans. The mint root borer weakens plants by feeding within the rhizomes, making these plants susceptible to winter injury. Garden symphylans is a severe pest in Oregon's Willamette Valley [25]. It feeds on the fine roots of mint and can reduce mint yields in newly planted fields and destroy entire stands of mint.

Olives:

Efforts to control black scale in California olive orchards have encompassed one of the largest biological control programs ever attempted. Beginning in the 1890's, about 70 species of natural controls have been introduced; however, none has proven to be effective [26]. Dormant oil treatments are effective against light to moderate populations. However, for heavy infestations, in the summer months, the organophosphate and carbamate insecticides diazinon and carbaryl are recommended.

Raspberries:

Most raspberries are machine harvested. Any insects shaken loose by machine harvesting contaminate the crop and can result in downgrading the product with a loss of up to $1,400 per acre [27]. Insecticide tests have indicated that the organophosphate insecticide malathion essentially reduces insect contamination of harvested raspberries to zero [28].

Soybeans:

Typically, insecticides are not used in Midwestern soybean fields. Parasites and diseases usually maintain insect populations well below the economic injury level [5]. However, in drought years, such as 1988, when high populations of spider mites develop, 30 percent of Midwestern soybean acreage has been treated, primarily with organophosphate insecticides, including chlorpyrifos and dimethoate in order to prevent substantial yield losses [6]. Insecticide use is more commonplace in Southern U.S. soybean fields, where insects typically arrive on winds from the Tropics. Insect populations in Southern soybean fields have developed a high level of resistance to pyrethroids and the most commonly used insecticides currently in Southeastern soybean fields are the organophosphate methyl parathion and the carbamates carbaryl, methomyl and thiodicarb [7].

Sugarbeets:

The sugarbeet root maggot is the most destructive insect pest of sugarbeets in the U.S. Adult female flies migrate to beet fields and deposit their eggs in the soil around small beet plants. A single female lays up to 200 eggs. The damage to the sugarbeet is done by the larvae. They scrape the root surface with their mouth hooks causing irregular scars that later become darkened from sap escaping from the injured root. Small tap roots can be severed completely, and such plants usually die [8]. Typically 85 to 90 percent of the sugarbeet acreage in the Red River Valley is treated with an application of an organophosphate insecticide (terbufos, chlorpyrifos) for control of the maggot [9]. Research has indicated that uncontrolled maggots can reduce beet yields by 42 percent in comparison to the most effective insecticide control. No commercially viable alternatives to insecticides are available currently to sugarbeet growers [10].

Sugarcane:

The sugarcane borer reduces sugar yield by causing retarded growth and stunted stalks, thus causing losses in plant weight (tonnage). Despite the repeated use of inorganic compounds, sugarcane fields in Louisiana lost about 13 percent of their annual cane yield to the sugarcane borer prior to 1960 [11]. Since the 1960's, azinphos methyl has been the most commonly used insecticide for sugarcane borer control. Two azinphos methyl sprays substituted for 12 annual applications of the inorganic compounds. Currently, azinphos methyl is limited to one application per year and is used typically in combination with a pyrethroid. Applications of the pyrethroid can cause secondary outbreaks of aphids because of disruption of natural controls of aphids.

Sunflowers:

The primary insect pest targeted by ethyl parathion are seed weevils, that feed on pollen and deposit eggs within the developing seeds. The larvae consume the inner meat of the seed and there is considerable difficulty in separating undamaged from weevil-damaged seeds [12]. Pyrethroid insecticides are equally efficacious with ethyl parathion for early season applications; however, for late season applications, when the heads of the sunflower plants are drooping, ethyl parathion is considered more effective because of its volatility that allows penetration into the head from below.

Walnuts:

No adequate cultural or biological controls are currently available for managing codling moth in walnuts [29]. The organophosphate insecticide chlorpyrifos has been the most widely used insecticide since it is effective and is less toxic to beneficial organisms in the orchard [30]. The recent registrations of the insect growth regulators diflubenzuron and tebufenozide for codling moth in walnuts has provided growers with alternatives. However, these products do not control high worm populations and do not affect adult worms [31].

Wild Rice:

The organophosphate insecticide malathion is the only registered insecticide for controlling riceworm in Minnesota wild rice paddies. There are no cultural alternatives. Other chemicals researched have low efficacy. Replicated experiments in 1971 indicated that malathion reduced riceworm populations by 92 percent [32]. A single larva per plant will reduce wild rice yields by 11 percent [37].

6. POTENTIAL IMPACTS OF RULEMAKING

Very few studies exist that project the effects of the potential removal of organophosphate and carbamate insecticides. Five studies recently have included an analysis of the potential impacts of banning certain organophosphate and carbamate insecticides. These estimates are for asparagus, cranberries, apples, rice and cotton.

Asparagus:

Special Local Needs Registrations permit the organophosphate insecticide disulfoton to be applied to asparagus in California and Washington for control of the asparagus aphid. This aphid was first detected in the West in 1979. The aphids feed by sucking plant juices, causing shrinking, dwarfing and death of asparagus shoots [38]. Natural enemies and diseases have kept the aphid under control in the Eastern U.S., but have not proven effective in the West. Washington State University recently concluded that [39]:

> Loss of disulfoton would result in total collapse of the California and Washington asparagus industry unless a replacement compound could be made available within one or two years.

Cranberries:

There are many species of insects that affect the roots, shoots and fruit of the cranberry plant. The University of Wisconsin recently concluded that the loss of organophosphate insecticides would have a major impact on U.S. cranberry production [40]:

> If the four major insecticides, chlorpyrifos, diazinon, azinphos methyl and acephate, were no longer available . . . in most places yields would be significantly reduced since the remaining insecticides are not as effective and cultural or biological alternatives do not provide as good or as fast control as the chemicals. At least half of the crop could be lost to direct pests alone, the first year in East Coast beds, with yield reductions of 15 to 50 percent estimated elsewhere. In subsequent years, pest pressure would be higher, and losses more severe, enough to drive many growers out of business.

Apples

Currently, azinphos methyl and other organophosphates are used to control most of the major insect pests of Michigan apple orchards, including codling moth, apple maggot, plum curculio, leafrollers, leafhoppers and oriental fruit moth. A recent study from Michigan State University estimated that currently eight organophosphate insecticide sprays are applied at a cost of $125/A. The MSU study simulated two replacement strategies for organophosphates. In the first strategy, growers would use eight applications of a pyrethroid – esfenvalerate. However, since the pyrethroid would destroy beneficial mite predators, resulting mite problems would require three applications of miticides. The total cost of this scenario is $201/A. The resulting mite problems would only be partial controllable with the available miticides and increased mite damage would result in losses of 20 percent of marketable yield, as well as shifting 17 percent of the remaining yield from fresh apples to lower priced processing uses [45]. In a second scenario, mating disruption is used to control codling moth. Synthetic pheromones confuse male codling moths and overwhelm their ability to detect pheromone scent from real females. This scenario also relies on three late-season applications of esfenvalerate plus two applications of BT and two miticide applications. The total cost of this scenario is $341/A. Uneven codling moth control is estimated to result in a 10 percent yield reduction compared to current controls with organophosphates and a 27 percent shift from fresh market to processing use.

Rice:

Organophosphates and carbamates are used as insecticides on 28 percent of U.S. rice acreage. Target pests include stinkbugs and rice water weevil. The University of Arkansas recently estimated that without the use of these insecticides, rice yields would decline by 6 to 30 percent [41]. The main non-chemical alternative is water management, to flood or dry out insect pests. Weather variations from year to year would lead to varying impacts.

Cotton

U.S. cotton growers rely on organophosphate and carbamate insecticides to control a wide variety of insect pests – bollworms, budworms, fleahoppers, aphids, boll weevils, lygus bugs, loopers, thrips, leafhoppers, cutworms, whiteflies and armyworms. The USDA has estimated that without carbamates U.S. cotton production would decline by 4 percent, while without organophosphate insecticides the decline in U.S. cotton production would be 8 percent [44]. These estimates assume that growers would use available substitutes.

7. PAST BANS OF OP AND CARBAMATE INSECTICIDES

In recent years, USEPA has banned or suspended several uses of organophosphate and carbamate insecticides. In some cases severe economic effects did not occur, even though a widely used organophosphate insecticide was banned because growers switched to using another organophosphate insecticide as a replacement. Such a replacement will not be allowable under FQPA's assessment of cumulative risks of all the pesticides with a common mechanism of toxicity. In other cases, serious economic effects did occur, prompting the USEPA to restore a suspended use.

Lettuce:

Following the USEPA ban of the organophosphate insecticide ethyl parathion for use in California lettuce fields, growers switched to another organophosphate insecticide diazinon, that increased their insecticide costs by about $50 per acre. Since diazinon had less efficacy in controlling a key pest, the lettuce root aphid, the State of California took the drastic step of cutting down all poplar trees near lettuce fields (The poplar trees are an alternate host for the aphids).

Potatoes:

The carbamate insecticide aldicarb was removed voluntarily for use on potatoes after detection of residues over tolerance. Following research to identify application methods whereby the product could be used without a residue problem, aldicarb was restored for use on potatoes in the Pacific Northwest and Florida. Washington State University estimated the increased cost caused by the loss of aldicarb to the Washington State potato industry. This included the substitution of two or three aerial applications of insecticides for a single aldicarb application at planting [36]. The substituted alternatives did not prove as efficacious in controlling green peach aphid, an insect that transmits a virus that results in a potato disease known as net necrosis. The aggregate loss to the Washington State potato industry from the increase in net necrosis was estimated by Washington State University at $36 million [36].

8. CONTROL OF AFLATOXIN

Several organophosphate insecticides play a key role in reducing toxic contaminant levels in foods by controlling insects that spread aflatoxin. If the organophosphate registrations are removed, growers of peanuts, pistachios and almonds would have less effective insecticides to control the insects that spread aflatoxin. For pesticides with non-threshold effects risk concerns, FQPA instructs EPA to consider whether the removal of pesticide registrations would lead to a greater health risk. For pesticides with threshold human health risk concerns (such as organophosphates and carbamates), FQPA makes no allowance for the possibility that canceling a pesticide use might lead to a greater risk to human health than the risk posed by the pesticide.

Aflatoxins are powerful, tasteless, odorless and colorless mycotoxins that are chemical metabolites produced by certain strains of *Aspergillus* fungi. Aflatoxins are mutagenic, carcinogenic, teratogenic, and acutely toxic to most animals and humans. They can cause animals, including humans, to lose their appetites, decrease their feed efficiency and/or cause death. Aflatoxins inhibit the body's immune system and reduce the effects of vaccines. Concern exists for possible adverse effects from long-term exposure to low levels of aflatoxins in food [35]. In the U.S., the aflatoxins are the only mycotoxins that are specifically regulated by FDA. The allowable residue level of aflatoxin is 20 ppb total aflatoxins, with the exception of milk that has a action level of .5ppb [34].

Almonds:

Aflatoxins are associated with almond kernels damaged by navel orangeworm larvae. Research has shown that the most direct means of controlling aflatoxin contamination of almonds is to reduce insect damage [33]. The current recommendation for insect control in almond orchards is to spray almond trees every year in the winter with a dormant spray of oil and organophosphate insecticides [2].

Pistachios:

Navel orangeworm infected kernels account for 84 percent of aflatoxin in pistachios according to research conducted by the University of California [21]. The organophosphate insecticide azinphos methyl is the preferred compound for navel orangeworm control because of its longer residual and effectiveness in the control of hatching navel orangeworms.

Peanuts:

Peanuts are frequently contaminated by aflatoxin if the pods develop during hot conditions, and/or if the pods are partially eaten by an insect – the lesser cornstalk borer. This eating provides a point of entry for the aflatoxin producing fungi. Research has found a 94 percent correlation between damage caused by the lesser cornstalk borer and the number of aflatoxin producing fungi [42]. The organophosphate insecticide chlorpyrifos reduces the insect population by about 80 percent while the most efficacious non-organophosphate insecticide reduces the populations by about 40 percent [43].

CONCLUSIONS

The organophosphate and carbamate classes of insecticides are extremely important for insect control for many crops grown in the U.S. Collectively, these two classes of chemistry are applied to 70 percent of the acreage treated with insecticides in the U.S. For 11 crops the organophosphate and carbamate products are the only ones used currently. Two crops, corn and cotton, account for 50 percent of the poundage of organophosphate and carbamate insecticides used in U.S. crop production. Twenty-four crops account for 95 percent of the poundage of organophosphate and carbamate insecticides while 60 crops, collectively, account for the remaining 5 percent of national use.

For many small acreage fruit, nut and vegetable crops, the organophosphate and carbamate insecticides have been the main means of controlling key pests for several decades. Although considerable research has been conducted to find alternatives for crops like kiwi, date, figs, avocados, wild rice and olives, the organophosphate and carbamate products remain the primary means of controlling key pests.

Although only a few projections have been made regarding the potential impacts of banning the organophosphate and carbamate insecticides, the available reports for cranberries, rice and asparagus indicate that severe declines in production likely would occur.

Although FQPA does not allow EPA to consider the benefits of a pesticide's use when acute dietary risks are the concern, a prudent course of action would be for the Agency to conduct cost effective rulemaking. For example, it may be prudent to preserve organophosphate registrations for pistachios, peanut and almonds in order to prevent increased amounts of aflatoxin. Likewise, a careful examination of each use site for organophosphates and carbamates would indicate to the Agency which crops are most dependent and have fewest alternatives. Although the outcomes of the risk analyses of EPA's proposals are unknown at this time, it may be that U.S. growers, potentially, could lose many organophosphate and carbamate uses because of these concerns.

As a result, U.S. growers of many crops may lose the most effective pesticides to control key pests, and crop losses may occur. Resistance to the remaining insecticides may accelerate. It is likely that USEPA would face a large number of emergency exemption requests to replace lost organophosphate or carbamate uses.

An alternatives database needs to be developed to help guide EPA decision making. For each use of organophosphates and carbamates, the key pests and control efficacies of available alternatives need to be identified.

Aggregate economic analysis needs to be undertaken so that policy makers and regulators can gain an appreciation of the magnitude of the impacts that may result from FQPA implementation.

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TABLE 1

Organophosphate and Carbamate Insecticides Used in U.S. Crop Production

Active Ingredient	Trade Name(s)	Major Crop Uses
Organophosphates		
Acephate	Orthene, Payload	Cotton, Lettuce, Tobacco
Azinphos Methyl	Guthion, Sniper	Cotton, Apples, Sugarcane
Chlorpyrifos	Lorsban	Corn, Cotton, Alfalfa
Diazinon	D-Z-N	Alfalfa, Lettuce, Corn
Dicrotophos	Bidrin	Cotton
Dimethoate	Cygon	Alfalfa, Cotton, Wheat
Disulfoton	Di-syston	Corn, Cotton, Wheat
Ethion	Ethion	Citrus
Ethoprop	Mocap	Potatoes, Tobacco, Peanuts
Ethyl Parathion		Alfalfa, Sorghum, Sunflowers
Fenamiphos	Nemacur	Tobacco, Cotton, Grapes
Fonofos	Dyfonate	Corn, Peanuts, Potatoes
Malathion	Cythion	Alfalfa, Cotton, Sorghum
Methamidophos	Monitor	Cotton, Potatoes, Tomatoes
Methidathion	Supracide	Almonds, Citrus, Plums
Methyl Parathion	Penncap M	Corn, Cotton, Wheat
Naled	Dibrom, Legion	Cotton, Grapes, Citrus
Oxydemeton Methyl	Metasystox R	Cotton, Broccoli, Cauliflower
Phorate	Thimet	Corn, Cotton, Potatoes
Phosmet	Imidian	Apples, Alfalfa, Potatoes
Profenofos	Curacron	Cotton
Sulprofos	Bolstar	Cotton
Terbufos	Counter	Corn, Sorghum, Sugarbeets
Carbamates		
Aldicarb	Temik	Cotton, Peanuts, Sugarbeets
Carbaryl	Sevin	Alfalfa, Apples, Corn
Carbofuran	Furadan	Alfalfa, Corn, Rice
Formetanate HCL	Carzol	Citrus, Apples, Nectarines
Methomyl	Lannate	Cotton, Sorghum, Peanuts
Oxamyl	Vydate	Cotton, Apples, Potatoes
Thiodicarb	Larvin	Cotton, Soybeans, Sweet Corn

TABLE 2 ORGANOPHOSPHATE INSECTICIDE USE

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
ACEPHATE				
	CAULIFLOWER	60324	13	7546
	CELERY	34649	44	15222
	COTTON	11120700	15	1697085
	CRANBERRIES	28600	34	9806
	DRY BEANS	1802394	2	44645
	GREEN BEANS	304152	28	86243
	GREEN PEAS	385617	1	4930
	LETTUCE	272242	59	161308
	MINT	153542	50	77119
	PEANUTS	1651000	10	167610
	SOYBEANS	58414278	<1	94600
	SWEET PEPPERS	77481	41	31444
	TOBACCO	784770	96	752652
AZINPHOS-METHYL				
	ALFALFA	24276084	<1	13099
	ALMONDS	390000	31	120900
	APPLES	497903	72	360067
	APRICOTS	17800	4	712
	BARLEY	7338164	<1	900
	BLACKBERRIES	5045	12	581
	BLUEBERRIES	56153	39	21982
	BRUSSEL SPROUTS	3000		30
	CABBAGE	87688	9	8098
	CANTALOUPES	112749	3	2990
	CAULIFLOWER	60324		549
	CELERY	34649	4	1376
	CHERRIES	99543	29	28950
	CITRUS	878300		7796
	COTTON	11120700	16	1769000
	CRANBERRIES	28600	43	12306
	CUCUMBERS	145697	<1	662
	EGGPLANT	4633	1	39
	GRAPES	764921		6839
	GREEN ONIONS	22300	3	630
	GREEN PEAS	385617	<1	575
	HAZELNUTS	26800	17	4556
	MELONS	25600	18	4680
	NECTARINES	27100	8	2168
	ONIONS	151676	1	1844
	PEACHES	183815	34	62070
	PEARS	72226	79	57370
	PECANS	444823	2	10966
	PISTACHIOS	51800	39	20202
	PLUMS	135095	7	9851

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	POMEGRANATES	3449	6	207
	POTATOES	1326000	15	197079
	RASPBERRIES	13266	8	1109
	SPINACH	38560	3	1224
	SQUASH	53457	1	332
	STRAWBERRIES	57778	11	6222
	SUGARCANE	857300	25	211800
	SWEET PEPPERS	77481	2	1773
	TOMATOES	413361	3	11558
	WALNUTS	183996	24	43440
CHLORPYRIFOS				
	ALFALFA	24276084	6	1367296
	ALMONDS	390000	31	120900
	APPLES	497903	57	283227
	ASPARAGUS	89653	35	31376
	AVOCADOS	81300	3	2187
	BEETS	11640	2	282
	BROCCOLI	120427	36	43489
	BRUSSEL SPROUTS	3000	90	2700
	CABBAGE	87688	27	23585
	CAULIFLOWER	60324	56	33661
	CHERRIES	99543	7	6934
	CITRUS	878300	23	201405
	COLLARDS	11328	12	1371
	CORN	78156196	9	6801980
	COTTON	11120700	10	1070892
	CRANBERRIES	28600	44	12471
	DRY BEANS	1802394	<1	774
	GRAPES	764921		9870
	GREEN BEANS	304152	<1	1125
	GREEN PEAS	385617	2	7388
	HAZELNUTS	26800	39	10452
	HOPS	39553	11	4386
	MINT	153542	27	42069
	NECTARINES	27100	17	4607
	ONIONS	151676	19	28676
	PEACHES	183815	28	51622
	PEANUTS	1651000	37	610240
	PEARS	72226	13	9334
	PECANS	444823	39	173614
	PLUMS	135095	7	9938
	RADISHES	37253	19	6989
	SEED CROPS	1516139	3	44267
	SOD	152438	6	9612
	SORGHUM	12183011	5	607571
	SOYBEANS	58414278	1	298300
	STRAWBERRIES	57778	15	8954
	SUGARBEETS	1411000	22	314140
	SUNFLOWERS	2044491		15096

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SWEET CORN	761045	14	105265
	SWEET POTATOES	84768	53	45164
	TOBACCO	784770	37	291640
	TOMATOES	413361	4	16480
	WALNUTS	183996	58	106790
	WHEAT	62407000	1	692200
DIAZINON				
	ALFALFA	24276084	<1	107400
	ALMONDS	390000	24	93600
	APPLES	497903	5	23898
	APRICOTS	17800	62	11036
	BEETS	11640	35	4076
	BLACKBERRIES	5045	12	606
	BLUEBERRIES	56153	11	6333
	BROCCOLI	120427	20	24189
	BRUSSEL SPROUTS	3000	90	2700
	CABBAGE	87688	16	14136
	CANTALOUPES	112749	12	13590
	CARROTS	109640	16	17659
	CAULIFLOWER	60324	21	12474
	CELERY	34649	14	4768
	CHERRIES	99543	12	11991
	CITRUS	878300	3	25811
	COLLARDS	11328	19	2142
	CORN	78156196	<1	84570
	COTTON	11120700	<1	11050
	CRANBERRIES	28600	48	13847
	CUCUMBERS	145697	4	5607
	DRY PEAS	249191	2	4767
	EGGPLANT	4633	4	189
	FIGS	14400	17	2448
	GRAPES	764921	5	37353
	GREEN BEANS	304152	4	11705
	GREEN ONIONS	22300	5	1170
	GREEN PEAS	385617	4	15791
	HAZELNUTS	26800	6	1608
	HOPS	39553	63	25018
	HOT PEPPERS	22700	<1	97
	LETTUCE	272242	34	92263
	MELONS	25600	36	9240
	NECTARINES	27100	45	12195
	OLIVES	30100	2	602
	ONIONS	151676	14	20966
	PARSLEY	1550	4	62
	PEACHES	183815	11	19998
	PEARS	72226	15	10669
	PECANS	444823		6547
	PLUMS	135095	28	38394
	POTATOES	1326000	1	7896

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	PUMPKINS	33833	<1	79
	RADISHES	37253	4	1347
	RASPBERRIES	13266	17	2311
	SOD	152438	<1	356
	SORGHUM	12183011	<1	24621
	SPINACH	38560	16	6063
	SQUASH	53457	4	2363
	STRAWBERRIES	57778	12	7065
	SUGARBEETS	1411000	5	68350
	SWEET CORN	761045	3	26303
	SWEET PEPPERS	77481	4	2912
	SWEET POTATOES	84768	9	7323
	TOBACCO	784770	3	21410
	TOMATOES	413361	9	36136
	WALNUTS	183996	7	13449
	WATERMELONS	258197	2	5961
	WHEAT	62407000	<1	200
DICROTOPHOS				
	COTTON	120700	22	2468909
DIMETHOATE				
	ALFALFA	24276084	5	1212050
	APPLES	497903	15	75067
	BARLEY	7338164	<1	13390
	BROCCOLI	120427	22	26780
	CABBAGE	87688	25	21788
	CANTALOUPES	112749	11	11885
	CAULIFLOWER	60324	19	11494
	CHERRIES	99543	9	9159
	CITRUS	878300	12	108584
	COLLARDS	11328	25	2882
	CORN	78156196	1	523922
	COTTON	11120700	14	1604002
	CUCUMBERS	145697	2	2394
	DRY BEANS	1802394	4	68488
	DRY PEAS	249191	2	5567
	GRAPES	764921	<1	3410
	GREEN BEANS	304152	13	40422
	GREEN PEAS	385617	27	103506
	HOT PEPPERS	22700	3	682
	LETTUCE	272242	49	134616
	MELONS	25600	35	8884
	OATS	4524882	<1	17350
	ONIONS	151676	<1	228
	PEARS	72226	2	1694
	PECANS	444823	16	72333
	POTATOES	1326000	2	31456
	SAFFLOWER	112665	19	21043
	SEED CROPS	1516139	<1	4411

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SORGHUM	12183011	5	561384
	SOYBEANS	58414278	<1	76200
	SPINACH	38560	6	2324
	SQUASH	53457	3	1786
	SWEET CORN	761045	<1	380
	SWEET PEPPERS	77481	22	16780
	TOMATOES	413361	8	34089
	WATERMELONS	258197	6	15963
	WHEAT	62407000	2	140060
DISULFOTON				
	ASPARAGUS	89653	35	31732
	BARLEY	7338164		43090
	BROCCOLI	120427	11	13038
	BRUSSEL SPROUTS	3000	84	2520
	CABBAGE	87688	3	2848
	CAULIFLOWER	60324	27	16544
	CORN	78156196	<1	214800
	COTTON	11120700	6	616058
	DRY BEANS	1802394	<1	5957
	DRY PEAS	249191	2	4972
	GREEN BEANS	304152	11	32626
	GREEN PEAS	385617	<1	858
	LETTUCE	272242	6	16861
	OATS	4524882	<1	2950
	PEANUTS	1651000	7	118380
	PECANS	444823	4	19778
	POTATOES	1326000	6	80195
	SORGHUM	12183011	2	208968
	SOYBEANS	58414278	<1	13800
	SWEET PEPPERS	77481	3	2000
	TOBACCO	784770	2	13230
	TOMATOES	413361		5560
	WATERMELONS	258197	<1	12
	WHEAT	62407000		697100
ETHION				
	APPLES	497903		3898
	AVOCADOS	81300	2	1680
	CITRUS	878300	29	257114
	MELONS	25600		360
	ONIONS	151676	8	12300
	PECANS	444823	2	9128
ETHOPROP				
	CABBAGE	87688		575
	CUCUMBERS	145697	1	836
	GREEN BEANS	304152	4	10936
	PEANUTS	1651000		24600
	POTATOES	1326000	11	148532
	SUGARCANE	857300	5	39190

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SWEET CORN	761045	3	26281
	SWEET POTATOES	84768	15	12565
	TOBACCO	784770	13	101907
ETHYL PARATHION				
	ALFALFA	24276084	3	736400
	BARLEY	7338164		46380
	CANOLA	39206	<1	121
	CORN	78156196	1	461540
	COTTON	11120700	3	345400
	OATS	4524882	<1	7350
	RYE	386366		3462
	SORGHUM	12183011	6	710754
	SOYBEANS	58414278	<1	249300
	SUNFLOWERS	2044491	24	488885
	WHEAT	62407000	1	381730
FENAMIPHOS				
	BROCCOLI	120427	14	16490
	BRUSSEL SPROUTS	3000	13	390
	CABBAGE	87688	6	4905
	CAULIFLOWER	60324	13	7819
	CITRUS	878300		12335
	COTTON	11120700		83974
	GRAPES	764921	8	59004
	KIWI	7100	9	639
	NECTARINES	27100	3	813
	PEACHES	183815		1267
	PEANUTS	1651000		19780
	RASPBERRIES	13266	6	765
	TOBACCO	784770	29	225942
FONOFOS				
	ASPARAGUS	89653	5	4690
	BEETS	11640	3	372
	BROCCOLI	120427	2	2627
	CABBAGE	87688		728
	CAULIFLOWER	60324	6	3422
	CORN	78156196	3	2248570
	DRY BEANS	1802394	<1	3079
	GREEN BEANS	304152	6	18073
	HOT PEPPERS	22700	3	682
	MINT	153542	21	32202
	ONIONS	151676	2	2721
	PEANUTS	1651000	10	157040
	POTATOES	1326000	4	47780
	RADISHES	37253	5	1823
	SEED CROPS	1516139	<1	4022
	SORGHUM	12183011	<1	1680
	STRAWBERRIES	57778	<1	62
	SUGARBEETS	1411000		17980

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SUGARCANE	857300	<1	393
	SWEET CORN	761045	4	31408
	SWEET PEPPERS	77481	4	3230
	SWEET POTATOES	84768	17	14355
	TOBACCO	784770	1	8106
	TOMATOES	413361	4	16680
MALATHION				
	ALFALFA	24276084	2	564000
	APPLES	497903	10	51975
	ASPARAGUS	89653	6	5710
	AVOCADOS	81300	<1	336
	BARLEY	7338164	1	41310
	BEETS	11640		174
	BLACKBERRIES	5045	28	1419
	BLUEBERRIES	56153	32	17959
	BROCCOLI	120427	6	7781
	CABBAGE	87688		928
	CANOLA	39206	<1	81
	CANTALOUPES	112749	9	9730
	CARROTS	109640	6	6839
	CAULIFLOWER	60324	3	1687
	CELERY	34649	7	2580
	CHERRIES	99543	16	16414
	CITRUS	878300	<1	3700
	COLLARDS	11328	2	185
	CORN	78156196	<1	15720
	COTTON	11120700	7	795517
	CRANBERRIES	28600	1	378
	CUCUMBERS	145697	2	2290
	DATES	5200	75	3900
	DRY PEAS	249191	3	7953
	EGGPLANT	4633	3	121
	FIGS	14400		144
	GARLIC	25377		230
	GRAPES	764921		7382
	GREEN BEANS	304152		1783
	GREEN ONIONS	22300	9	1980
	GREEN PEAS	385617		4572
	HOT PEPPERS	22700		146
	LETTUCE	272242	4	11694
	MELONS	25600	13	3420
	MINT	153542	8	12772
	OATS	4524882	1	26559
	OKRA	3226	21	689
	ONIONS	151676	10	15519
	PEACHES	183815	2	4443
	PEANUTS	1651000	<1	2590
	PECANS	444823	3	11987
	POTATOES	1326000	<1	858

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	PUMPKINS	33833	6	1954
	RADISHES	37253	<1	51
	RASPBERRIES	13266	47	6175
	RICE	3130000	4	136460
	RYE	386366	<1	7
	SORGHUM	12183011	2	190170
	SPINACH	38560	5	2031
	SQUASH	53457	2	1247
	STRAWBERRIES	57778	19	11044
	SUGARBEETS	1411000	2	32870
	SUNFLOWERS	2044491		30200
	SWEET CORN	761045	<1	414
	SWEET PEPPERS	77481	<1	315
	TOBACCO	784770	1	6291
	TOMATOES	413361	2	6317
	WALNUTS	183996	5	8426
	WATERMELONS	258197		3740
	WHEAT	62407000	<1	133500
	WILD RICE	24198	27	6533
METHAMIDOPHOS				
	ALFALFA	24276084	<1	48000
	BEETS	11640	4	417
	BROCCOLI	120427	11	13146
	BRUSSEL SPROUTS	3000	82	2460
	CABBAGE	87688	25	22018
	CANTALOUPES	112749	19	21690
	CAULIFLOWER	60324	5	2978
	CELERY	34649	21	7362
	COTTON	11120700	4	445665
	CUCUMBERS	145697	1	2024
	EGGPLANT	4633	26	1215
	HOT PEPPERS	22700		244
	LETTUCE	272242	4	11198
	MELONS	25600	16	4044
	POTATOES	1326000	23	310941
	SUGARBEETS	1411000	4	51000
	SWEET PEPPERS	77481	6	4472
	TOMATOES	413361	31	126152
	WATERMELONS	258197	6	14814
METHIDATHION				
	ALFALFA	24276084	<1	28800
	ALMONDS	390000	16	62400
	APPLES	497903	3	14735
	APRICOTS	17800	10	1780
	ARTICHOKES	9400	90	8460
	CHERRIES	99543	2	2350
	CITRUS	878300	4	32728
	COTTON	11120700	<1	22100

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	KIWI	7100	13	923
	NECTARINES	27100	19	5149
	OLIVES	30100		301
	PEACHES	183815	12	22949
	PEARS	72226	5	3773
	PECANS	444823		6290
	PLUMS	135095	22	29645
	SAFFLOWER	112665	42	47623
	SUNFLOWERS	2044491	<1	1932
	TOBACCO	784770	<1	85
	WALNUTS	183996	10	18100
METHYL PARATHION				
	ALFALFA	24276084	2	535964
	APPLES	497903	21	105016
	ARTICHOKES	9400	7	658
	BARLEY	7338164	<1	4350
	BROCCOLI	120427	2	1810
	BRUSSEL SPROUTS	3000	4	120
	CABBAGE	87688	6	4866
	CANTALOUPES	112749		780
	CARROTS	109640	2	1800
	CAULIFLOWER	60324	1	436
	CELERY	34649		494
	CHERRIES	99543	9	8633
	COLLARDS	11328	10	1107
	CORN	78156196	2	1356520
	COTTON	11120700	24	2619464
	CUCUMBERS	145697	<1	287
	DRY BEANS	1802394	<1	8317
	DRY PEAS	249191	<1	264
	GRAPES	764921	2	12220
	GREEN BEANS	304152	11	34444
	GREEN PEAS	385617		3316
	LETTUCE	272242	1	3890
	NECTARINES	27100	7	1897
	OATS	4524882	<1	13350
	ONIONS	151676	19	28114
	OTHER HAY	28111089	<1	37500
	PEACHES	183815	22	41077
	PEARS	72226	2	1284
	PECANS	444823	4	17168
	PLUMS	135095	2	2444
	POTATOES	1326000	3	36387
	RICE	3130000	10	304300
	SOYBEANS	58414278	<1	257100
	SPINACH	38560	3	1137
	STRAWBERRIES	57778	<1	50
	SUGARBEETS	1411000		12000
	SUNFLOWERS	2044491	6	130970

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SWEET CORN	761045	10	74663
	SWEET PEPPERS	77481	1	616
	TOMATOES	413361	1	3090
	WATERMELONS	258197	5	12540
	WHEAT	62407000	1	620100
NALED				
	ALFALFA	24276084	<1	16200
	BROCCOLI	120427	4	4850
	BRUSSEL SPROUTS	3000	33	990
	CABBAGE	87688	10	8557
	CANTALOUPES	112749		640
	CAULIFLOWER	60324	3	1735
	CELERY	34649	6	2076
	CITRUS	878300	2	17269
	COLLARDS	11328	6	669
	COTTON	11120700	<1	44200
	DRY BEANS	1802394	<1	1539
	DRY PEAS	249191	<1	515
	GRAPES	764921	10	78672
	GREEN BEANS	304152	<1	1035
	GREEN PEAS	385617	<1	427
	SAFFLOWER	112665	20	22150
	SEED CROPS	1516139	1	12065
	STRAWBERRIES	57778	6	3464
	SUGARBEETS	1411000	<1	5350
	WALNUTS	183996	1	1810
OXYDEMETON-METHYL				
	BEETS	11640	1	157
	BROCCOLI	120427	56	66863
	BRUSSEL SPROUTS	3000	90	2700
	CABBAGE	87688	10	8591
	CANTALOUPES	112749	12	13365
	CAULIFLOWER	60324	56	33672
	CORN	78156196	<1	1320
	COTTON	11120700	2	217626
	CUCUMBERS	145697	2	2922
	EGGPLANT	4633	3	146
	GREEN BEANS	304152	<1	552
	GREEN PEAS	385617	<1	1904
	HAZELNUTS	26800	3	804
	HOT PEPPERS	22700	3	779
	LETTUCE	272242	4	9725
	MELONS	25600	33	8460
	MINT	153542	13	20014
	ONIONS	151676	2	3214
	POTATOES	1326000	<1	1074
	PUMPKINS	33833	4	1359
	RASPBERRIES	13266	8	1071

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SEED CROPS	1516139	2	32172
	SORGHUM	12183011	<1	10367
	SQUASH	53457	6	2975
	STRAWBERRIES	57778	7	4020
	SUGARBEETS	1411000	1	14350
	SWEET CORN	761045	<1	2910
	SWEET PEPPERS	77481	2	1200
	WALNUTS	183996	1	1810
	WATERMELONS	258197	3	8796
PHORATE				
	CORN	78156196	2	1808790
	COTTON	11120700	4	418294
	DRY BEANS	1802394	<1	5981
	GREEN BEANS	304152	4	12393
	HOPS	39553	1	565
	PEANUTS	1651000	9	141780
	POTATOES	1326000	30	394090
	SORGHUM	12183011	1	113240
	SUGARBEETS	1411000	4	52490
	SUGARCANE	857300	10	84170
	SWEET CORN	761045	3	25661
	WHEAT	62407000	<1	196150
PHOSMET				
	ALFALFA	24276084	1	130900
	ALMONDS	390000	4	15600
	APPLES	497903	26	130173
	APRICOTS	17800	1	178
	BLUEBERRIES	56153	3	1623
	CHERRIES	99543	12	12064
	DRY PEAS	249191	9	22281
	GRAPES	764921	5	41327
	GREEN PEAS	385617	5	19115
	KIWI	7100	5	355
	NECTARINES	27100	18	4878
	PEACHES	183815	17	30579
	PEARS	72226	33	24007
	PLUMS	135095	9	11613
	POTATOES	1326000	4	48685
PROFENOFOS				
	COTTON	120700	16	1788574
SULPROFOS				
	COTTON	120700	6	636885
TERBUFOS				
	CORN	78156196	9	7205810
	SORGHUM	12183011	2	276430
	SUGARBEETS	1411000	30	424180

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SWEET CORN	761045	7	53400

TABLE 3 CARBAMATE INSECTICIDE USE

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
ALDICARB				
	CITRUS	878300	12	104712
	COTTON	11120700	25	2738993
	DRY BEANS	1802394		19249
	PEANUTS	1651000	48	788210
	PECANS	444823	4	18654
	SORGHUM	12183011	<1	45000
	SUGARBEETS	1411000	11	157550
	SWEET POTATOES	84768	3	2799
	TOBACCO	784770	9	70686
CARBARYL				
	ALFALFA	24276084		360683
	ALMONDS	390000		3900
	APPLES	497903	36	179894
	APRICOTS	17800	9	1602
	ASPARAGUS	89653	30	26669
	BARLEY	7338164	<1	9060
	BEETS	11640	17	1964
	BLACKBERRIES	5045	33	1645
	BLUEBERRIES	56153	50	27836
	BROCCOLI	120427	4	4341
	CABBAGE	87688	4	3200
	CANOLA	39206	<1	121
	CANTALOUPES	112749	7	8198
	CARROTS	109640	4	4291
	CAULIFLOWER	60324	4	2265
	CELERY	34649	3	1200
	CHERRIES	99543	12	11890
	CITRUS	878300	2	17086
	COLLARDS	11328	4	421
	CORN	78156196	<1	353170
	COTTON	11120700	<1	22100
	CRANBERRIES	28600	39	11146
	CUCUMBERS	145697	14	20446
	DRY BEANS	1802394	1	11684
	DRY PEAS	249191	3	6270
	EGGPLANT	4633	5	212
	FLAX	164000	1	1400
	GRAPES	764921	14	103314
	GREEN BEANS	304152	23	68932
	GREEN PEAS	385617	2	6136
	HAZELNUTS	26800	4	1072
	LETTUCE	272242	1	2473
	MELONS	25600	70	18000
	NECTARINES	27100	18	4878

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	OATS	4524882	1	23300
	OKRA	3226	32	1044
	OLIVES	30100	11	3311
	ONIONS	151676	1	1377
	OTHER HAY	28111089	1	384900
	PEACHES	183815	25	45090
	PEANUTS	1651000	8	129090
	PEARS	72226	3	1818
	PECANS	444823	23	101654
	PISTACHIOS	51800	17	8806
	PLUMS	135095	5	6482
	POTATOES	1326000	3	36636
	PUMPKINS	33833	38	12952
	RASPBERRIES	13266	5	628
	SAFFLOWER	112665	1	1108
	SOD	152438	<1	216
	SORGHUM	12183011	2	218582
	SOYBEANS	58414278	1	332800
	SQUASH	53457	11	6012
	STRAWBERRIES	57778	17	9787
	SUGARBEETS	1411000	4	55300
	SUNFLOWERS	2044491	1	28266
	SWEET CORN	761045	4	27152
	SWEET PEPPERS	77481	13	10034
	SWEET POTATOES	84768	18	15658
	TOBACCO	784770	2	13286
	TOMATOES	413361	18	76470
	WALNUTS	183996	1	1810
	WATERMELONS	258197	13	32809
	WHEAT	62407000	<1	77850
CARBOFURAN				
	ALFALFA	24276084	9	2193880
	ARTICHOKES	9400	60	5640
	BARLEY	7338164	<1	7200
	CANTALOUPES	112749	1	849
	CORN	78156196	3	2697340
	CRANBERRIES	28600		168
	CUCUMBERS	145697	9	13671
	GRAPES	764921	3	26266
	HOT PEPPERS	22700	12	2674
	OATS	4524882	<1	6113
	POTATOES	1326000	16	213173
	PUMPKINS	33833	6	2016
	RICE	3130000	14	434000
	SEED CROPS	1516139	<1	649
	SORGHUM	12183011	4	460560
	SOYBEANS	58414278	<1	13800
	SQUASH	53457	5	2496
	STRAWBERRIES	57778	5	2999

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SUGARBEETS	1411000	4	57980
	SUGARCANE	857300	6	53254
	SUNFLOWERS	2044491	1	29713
	SWEET CORN	761045	6	47838
	SWEET PEPPERS	77481	2	1343
	TOBACCO	784770	5	41537
	WATERMELONS	258197	3	8102
	WHEAT	62407000	<1	29700
FORMETANATE HCL				
	ALFALFA	24276084	<1	9600
	APPLES	497903	13	65638
	CITRUS	878300	16	137325
	NECTARINES	27100	89	24119
	PEACHES	183815	3	5826
	PEARS	72226	12	8489
	PLUMS	135095	1	1222
METHOMYL				
	ALFALFA	24276084	1	209824
	APPLES	497903	21	106918
	ASPARAGUS	89653	15	13255
	BARLEY	7338164	<1	7200
	BEETS	11640	6	683
	BLUEBERRIES	56153	18	10066
	BROCCOLI	120427	13	15057
	BRUSSEL SPROUTS	3000	1	30
	CABBAGE	87688	36	31391
	CANTALOUPES	112749	8	9358
	CARROTS	109640	7	7429
	CAULIFLOWER	60324	30	18260
	CELERY	34649	64	22247
	CITRUS	878300	3	27137
	COLLARDS	11328	19	2207
	CORN	78156196	<1	270870
	COTTON	11120700	9	990364
	CUCUMBERS	145697	17	24677
	DRY BEANS	1802394		10776
	DRY PEAS	249191		1501
	EGGPLANT	4633	44	2051
	GARLIC	25377	13	3220
	GRAPES	764921	15	112019
	GREEN BEANS	304152	19	56735
	GREEN ONIONS	22300	11	2430
	GREEN PEAS	385617	4	13834
	HOT PEPPERS	22700		292
	LETTUCE	272242	48	130302
	MELONS	25600	11	2700
	MINT	153542	10	16087
	NECTARINES	27100	45	12195

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	OATS	4524882	<1	5438
	ONIONS	151676	16	24854
	OTHER HAY	28111089	<1	62500
	PARSLEY	1550	19	294
	PEACHES	183815	7	13000
	PEANUTS	1651000	16	262270
	PEARS	72226	2	1756
	PECANS	444823	3	14683
	POMEGRANATES	3449	66	2276
	POTATOES	1326000	3	36554
	PUMPKINS	33833	6	2094
	RADISHES	37253	34	12800
	RASPBERRIES	13266	<1	9
	SORGHUM	12183011	2	263645
	SOYBEANS	58414278	<1	69000
	SPINACH	38560	25	9504
	SQUASH	53457	22	11696
	STRAWBERRIES	57778	19	10977
	SUGARBEETS	1411000	6	83100
	SWEET CORN	761045	28	212956
	SWEET PEPPERS	77481	52	40557
	SWEET POTATOES	84768	1	450
	TOBACCO	784770	12	95228
	TOMATOES	413361	28	115390
	WATERMELONS	258197	16	41094
	WHEAT	62407000	<1	93600
OXAMYL				
	APPLES	497903	21	102938
	CANTALOUPES	112749	30	34110
	CARROTS	109640	2	2242
	CELERY	34649	36	12438
	COTTON	11120700	11	1256154
	CUCUMBERS	145697	9	13410
	EGGPLANT	4633	30	1384
	GARLIC	25377	1	230
	MELONS	25600	47	12000
	MINT	153542	33	50845
	ONIONS	151676	1	1155
	PEACHES	183815	1	1920
	PEARS	72226	2	1360
	POTATOES	1326000	3	40709
	PUMPKINS	33833	3	1159
	SQUASH	53457	9	4892
	SWEET PEPPERS	77481	18	14152
	TOMATOES	413361	10	40554
	WATERMELONS	258197	2	6344
THIODICARB				
	COTTON	11120700	16	1766971

ACTIVE INGREDIENT	CROP	ACRES PLANTED	% ACRES TREATED	ACRES TREATED
	SOYBEANS	58414278	<1	274200
	SWEET CORN	761045	12	93961

TABLE 4

Crop Use Sites for Organophosphate and Carbamate Insecticides

Active Ingredient	**Number of Crop Uses**
Organophosphates	
Acephate	13
Azinphos Methyl	40
Chlorpyrifos	44
Diazinon	59
Dicrotophos	1
Dimethoate	37
Disulfoton	24
Ethion	6
Ethoprop	9
Ethyl Parathion	11
Fenamiphos	13
Fonofos	24
Malathion	61
Methamidophos	19
Methidathion	19
Methyl Parathion	42
Naled	20
Oxydemeton Methyl	30
Phorate	12
Phosmet	15
Profenofos	1
Sulprofos	1
Terbufos	4
Subtotal	(505)
Carbamates	
Aldicarb	9
Carbaryl	64
Carbofuran	26
Formetanate HCL	7
Methomyl	57
Oxamyl	19
Thiodicarb	3
Subtotal	(185)
TOTAL	**690**

TABLE 5 ORGANOPHOSPHATE INSECTICIDE USE BY CROP

CROP	% OF INSECTICIDE TREATED ACRES
ALFALFA	54
ALMONDS	38
APPLES	43
APRICOTS	35
ARTICHOKES	16
ASPARAGUS	52
AVOCADOS	31
BARLEY	86
BEETS	64
BLACKBERRIES	36
BLUEBERRIES	52
BROCCOLI	59
BRUSSEL SPROUTS	75
CABBAGE	42
CANOLA	63
CANTALOUPES	24
CARROTS	41
CAULIFLOWER	49
CELERY	23
CHERRIES	58
CITRUS	30
COLLARDS	31
CORN	68
COTTON	46
CRANBERRIES	72
CUCUMBERS	12
DATES	100
DRY BEANS	28
DRY PEAS	82
EGGPLANT	12
FIGS	58
GARLIC	4
GRAPES	15
GREEN BEANS	55
GREEN ONIONS	40
GREEN PEAS	55
HAZELNUTS	41
HOPS	26
HOT PEPPERS	41
KIWI	44
LETTUCE	37
MELONS	29
MINT	55
NECTARINES	24
OATS	66
OKRA	32

CROP	% OF INSECTICIDE TREATED ACRES
OLIVES	10
ONIONS	46
OTHER HAY	8
PARSLEY	3
PEACHES	41
PEANUTS	47
PEARS	26
PECANS	38
PISTACHIOS	28
PLUMS	37
POMEGRANATES	8
POTATOES	53
PUMPKINS	8
RADISHES	31
RASPBERRIES	37
RICE	50
RYE	100
SAFFLOWER	99
SEED CROPS	63
SOD	94
SORGHUM	67
SOYBEANS	37
SPINACH	22
SQUASH	10
STRAWBERRIES	28
SUGARBEETS	73
SUGARCANE	65
SUNFLOWERS	72
SWEET CORN	30
SWEET PEPPERS	29
SWEET POTATOES	81
TOBACCO	84
TOMATOES	28
WALNUTS	64
WATERMELONS	24
WHEAT	65
WILD RICE	100

The "% of insecticide treated acres" represents the sum of acres treated with carbamates as a % of the sum of acres treated with all insecticides

TABLE 6 CARBAMATE INSECTICIDE USE BY CROP

CROP	% OF INSECTICIDE TREATED ACRES
ALFALFA	32
ALMONDS	0
APPLES	19
APRICOTS	4
ARTICHOKES	10
ASPARAGUS	28
AVOCADOS	0
BARLEY	14
BEETS	31
BLACKBERRIES	23
BLUEBERRIES	41
BROCCOLI	5
BRUSSEL SPROUTS	0
CABBAGE	12
CANOLA	37
CANTALOUPES	17
CARROTS	22
CAULIFLOWER	8
CELERY	25
CHERRIES	7
CITRUS	13
COLLARDS	10
CORN	11
COTTON	19
CRANBERRIES	17
CUCUMBERS	51
DATES	0
DRY BEANS	8
DRY PEAS	14
EGGPLANT	26
FIGS	0
FLAX	100
GARLIC	65
GRAPES	14
GREEN BEANS	27
GREEN ONIONS	25
GREEN PEAS	7
HAZELNUTS	3
HOPS	0
HOT PEPPERS	46
KIWI	0
LETTUCE	11
MELONS	25
MINT	20
NECTARINES	31
OATS	34

CROP	% OF INSECTICIDE TREATED ACRES
OKRA	48
OLIVES	35
ONIONS	11
OTHER HAY	91
PARSLEY	14
PEACHES	12
PEANUTS	44
PEARS	3
PECANS	16
PISTACHIOS	12
PLUMS	3
POMEGRANATES	88
POTATOES	13
PUMPKINS	45
RADISHES	39
RASPBERRIES	2
RICE	50
RYE	0
SAFFLOWER	1
SEED CROPS	0
SOD	2
SORGHUM	25
SOYBEANS	26
SPINACH	16
SQUASH	28
STRAWBERRIES	17
SUGARBEETS	26
SUGARCANE	10
SUNFLOWERS	6
SWEET CORN	33
SWEET PEPPERS	30
SWEET POTATOES	19
TOBACCO	13
TOMATOES	26
WALNUTS	1
WATERMELONS	34
WHEAT	3
WILD RICE	0

The "% of insecticide treated acres" represents the sum of acres treated with carbamates as a % of the sum of acres treated with all insecticides

TABLE 7 ORGANOPHOSPHATE INSECTICIDE USE BY STATE

STATE	% OF INSECTICIDE TREATED ACRES
ALABAMA	50
ARIZONA	40
ARKANSAS	44
CALIFORNIA	43
COLORADO	62
CONNECTICUT	43
DELAWARE	57
FLORIDA	33
GEORGIA	44
IDAHO	52
ILLINOIS	78
INDIANA	68
IOWA	78
KANSAS	46
KENTUCKY	58
LOUISIANA	54
MAINE	46
MARYLAND	27
MASSACHUSETTS	44
MICHIGAN	65
MINNESOTA	58
MISSISSIPPI	48
MISSOURI	53
MONTANA	44
NEBRASKA	66
NEVADA	37
NEW HAMPSHIRE	29
NEW JERSEY	41
NEW MEXICO	69
NEW YORK	49
NORTH CAROLINA	49
NORTH DAKOTA	59
OHIO	71
OKLAHOMA	66
OREGON	59
PENNSYLVANIA	48
RHODE ISLAND	29

STATE	% OF INSECTICIDE TREATED ACRES
SOUTH CAROLINA	38
SOUTH DAKOTA	70
TENNESSEE	58
TEXAS	52
UTAH	45
VERMONT	29
VIRGINIA	57
WASHINGTON	53
WEST VIRGINIA	50
WISCONSIN	76
WYOMING	77

The "% of insecticide treated acres" represents the sum of acres treated with carbamates as a % of the sum of acres treated with all insecticides

TABLE 8 CARBAMATE INSECTICIDE USE BY STATE

STATE	% OF INSECTICIDE TREATED ACRES
ALABAMA	29
ARIZONA	15
ARKANSAS	23
CALIFORNIA	12
COLORADO	12
CONNECTICUT	24
DELAWARE	14
FLORIDA	19
GEORGIA	32
IDAHO	22
ILLINOIS	9
INDIANA	10
IOWA	5
KANSAS	17
KENTUCKY	26
LOUISIANA	21
MAINE	19
MARYLAND	18
MASSACHUSETTS	25
MICHIGAN	17
MINNESOTA	7
MISSISSIPPI	18
MISSOURI	24
MONTANA	24
NEBRASKA	12
NEVADA	22
NEW HAMPSHIRE	27
NEW JERSEY	27
NEW MEXICO	22
NEW YORK	27
NORTH CAROLINA	35
NORTH DAKOTA	17
OHIO	12
OKLAHOMA	10
OREGON	11
PENNSYLVANIA	18
RHODE ISLAND	17

STATE	% OF INSECTICIDE TREATED ACRES
SOUTH CAROLINA	35
SOUTH DAKOTA	18
TENNESSEE	22
TEXAS	21
UTAH	31
VERMONT	42
VIRGINIA	31
WASHINGTON	11
WEST VIRGINIA	24
WISCONSIN	7
WYOMING	23

The "% of insecticide treated acres" represents the sum of acres treated with carbamates as a % of the sum of acres treated with all insecticides

TABLE 9 ORGANOPHOSPHATE INSECTICIDE USE

CROP	% OF NATIONAL USE (POUNDS)
CORN	34
COTTON	20
ALFALFA	5
TOBACCO	5
POTATOES	
PEANUTS	3
CITRUS	3
SORGHUM	3
WHEAT	3
APPLES	3
SUGARBEETS	2
SUNFLOWERS	1
SUGARCANE	1
PEACHES	
ALMONDS	
PECANS	
SWEET CORN	
WALNUTS	1
SOYBEANS	1
DRY BEANS	<1
CHERRIES	<1
COLLARDS	<1
CRANBERRIES	<1
DATES	<1
DRY PEAS	<1
GARLIC	<1
HAZELNUTS	<1
EGGPLANT	<1
FIGS	<1
CUCUMBERS	<1
BROCCOLI	<1
APRICOTS	<1
ARTICHOKES	<1
ASPARAGUS	<1
AVOCADOS	<1
BARLEY	<1
BEETS	<1
CANTALOUPES	<1
BLUEBERRIES	<1
CELERY	<1
BRUSSEL SPROUTS	<1
CABBAGE	<1
MINT	<1
CANOLA	<1
GRAPES	<1
CARROTS	<1
CAULIFLOWER	<1

CROP	% OF NATIONAL USE (POUNDS)
BLACKBERRIES	<1
SPINACH	<1
PUMPKINS	<1
RADISHES	<1
RASPBERRIES	<1
RICE	<1
RYE	<1
SAFFLOWER	<1
LETTUCE	<1
SOD	<1
PISTACHIOS	<1
SQUASH	<1
STRAWBERRIES	<1
SWEET PEPPERS	<1
SWEET POTATOES	<1
TOMATOES	<1
WATERMELONS	<1
SEED CROPS	<1
OATS	<1
GREEN ONIONS	<1
GREEN PEAS	<1
HOPS	<1
HOT PEPPERS	<1
KIWI	<1
MELONS	<1
POMEGRANATES	<1
NECTARINES	<1
PLUMS	<1
OKRA	<1
OLIVES	<1
ONIONS	<1
OTHER HAY	<1
PARSLEY	<1
PEARS	<1
GREEN BEANS	<1
WILD RICE	<1

TABLE 10 CARBAMATE INSECTICIDE USE

CROP	% OF NATIONAL USE (POUNDS)
COTTON	23
CORN	17
ALFALFA	9
PEANUTS	7
SORGHUM	4
SWEET CORN	4
PECANS	3
APPLES	3
SUGARBEETS	3
SOYBEANS	3
CITRUS	3
POTATOES	2
GRAPES	2
OTHER HAY	2
TOBACCO	2
WHEAT	1
SWEET PEPPERS	
LETTUCE	
PASTURE	
RICE	1
PEACHES	1
GREEN BEANS	1
TOMATOES	1
COLLARDS	<1
CUCUMBERS	<1
DRY BEANS	<1
DRY PEAS	<1
EGGPLANT	<1
CRANBERRIES	<1
BRUSSEL SPROUTS	<1
ALMONDS	<1
APRICOTS	<1
ARTICHOKES	<1
ASPARAGUS	<1
BARLEY	<1
BEETS	<1
BLACKBERRIES	<1
CAULIFLOWER	<1
BROCCOLI	<1
CHERRIES	<1
CABBAGE	<1
CANOLA	<1
CANTALOUPES	<1
NECTARINES	<1
CARROTS	<1
HAZELNUTS	<1
CELERY	<1

CROP	% OF NATIONAL USE (POUNDS)
BLUEBERRIES	<1
POMEGRANATES	<1
WATERMELONS	<1
WALNUTS	<1
SWEET POTATOES	<1
SUNFLOWERS	<1
SUGARCANE	<1
STRAWBERRIES	<1
SQUASH	<1
SPINACH	<1
SOD	<1
SEED CROPS	<1
SAFFLOWER	<1
RASPBERRIES	<1
MELONS	<1
PUMPKINS	<1
FLAX	<1
PLUMS	<1
PISTACHIOS	<1
PEARS	<1
PARSLEY	<1
ONIONS	<1
OLIVES	<1
OKRA	<1
OATS	<1
MINT	<1
HOT PEPPERS	<1
GREEN PEAS	<1
GREEN ONIONS	<1
GARLIC	<1
RADISHES	<1