Integrated Pest Management Improvements in California Melons from 2003 to 2016

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EXECUTIVE SUMMARY

Changes in pest management practices in California melon production have minimized crop losses from pests, reduced risks to human health and maintained the economic viability of melons in California.

Based on a comparison of pest management strategic plans developed for the California melon industry in 2003 and 2016, and from pesticide use and other data, melon growers have:

- Reduced the use of carbamate and organophosphate insecticides by 46%
- Reduced the amount of sulfur applied by 75%
- Reduced their use of soil fumigants by 97%

Growers achieved these results by using integrated pest management, or IPM: growing disease-resistant varieties, improving irrigation methods, embracing biological control of insect pests and choosing lower-risk pesticides. Taken together, these changes reduced the risks from melon pest management practices for people, birds and fish from moderate to low.

However, challenges remain. Pesticides used in melon production still pose a moderate risk to pollinators and other invertebrate species, and melon production has declined significantly in some areas of California because of a difficult-to-control insect-vectored virus.

METHODOLOGY

Pest management strategic plans are developed by growers, pest control advisors, researchers and extension educators to document pest challenges and management practices in a particular crop and to identify priorities for research, regulation and education. (They are available at ipmdata.ipmcenters.org.)

These documents are used by federal regulators to understand how pesticides are used in particular crops. However, as snapshots of pest management practices, these plans can also show changes in pest management programs over time. Here, we compare pest management strategic plans from 2003 and 2016 focusing on cantaloupe and honeydew, which account for 90% of the melons grown in California.

In addition to using the pest management strategic plans to document changes, we consulted additional sources to document the impacts of those changes on human and environmental health. These sources include:

- California Department of Pesticide Regulation's pesticide use reporting database. Since 1990, all agricultural pesticide use in the state must be reported to this publicly available database.
- Submissions to the Inter-regional Project 4, known as IR-4, which facilitates registration of pesticides and biopesticides for specialty crops. IR-4 denotes pesticides that have a good fit with IPM when they are narrow-spectrum, conserve natural enemies and provide acceptable control of the target pests.
- Catalogs from the major suppliers of melon seed in California, including HM Clause, Syngenta and Nunhems.
- Data from the National Agriculture Statistics Service, or NASS.

To estimate changes in the risks to human and environmental health associated with changes in pest management practices, we used the Pesticide Risk Mitigation Engine known as ipmPRiME. (This risk-estimation calculator is available at ipmprime.org.) The ipmPRiME tool estimates the likelihood a product will impact an organism based on the species' sensitivity to that material and the level of pesticide exposure. More exposure and higher sensitivity leads to higher risk that an application will exceed the "no observed adverse effect" level. The ipmPRiME tool estimates risks posed by pesticides for acute and chronic toxicity to terrestrial and aquatic vertebrates and invertebrates.

MELON PRODUCTION

Cantaloupe makes up about 70% of California melon production, with honeydew about 20% and a variety of other melons the rest (NASS). Fresno and Imperial counties account for 60% to 70% of the harvested acreage in the state, but acres in production have been dropping.

Between 2003 and 2016, melon production declined from 76,500 acres to 59,800 acres, a 22% decline (NASS). Imperial County saw the largest reduction, with a decline of 45% in harvested acreage. Harvested acreage declined by 34% in Fresno County. The declines are attributed to difficulties producing late-season melons in the southern San Joaquin and Imperial valleys due to large whitefly populations transmitting cucurbit yellow stunting disorder virus, a relatively new pathogen first detected in 2006.

A change in cultural practices from 2003 to 2016 saw subsurface drip irrigation replacing furrow irrigation in some areas. In the San Joaquin Valley, which includes Fresno County, only about 20% of growers used drip in 2003 but by 2016, that use of drip irrigation was considered common. In the Imperial Valley, which includes Imperial County, furrow irrigation remains most common. The shift from furrow to subsurface drip irrigation has important pest management implications.

INSECT CONTROL

Growers saw significant improvement between 2003 and 2016 in the control of leafhoppers and soil insect pests and reduced the use of broadly toxic carbamate and organophosphate insecticides to control them. These insects – which included beet- and other leafhopper species, as well as cutworms, seedcorn maggots, darkling beetles, wireworms, flea beetles and western spotted and western striped cucumber beetles – were priority problems in 2003 but considered well-controlled in 2016.

What's driven the change is neonicotinoid insecticides.

Neonicotinoids were not widely used in 2003 but have now largely supplanted carbamates and organophosphates in California melon production (Figure 1). Four neonicotinoid insecticides (dinotefuran, thiamethoxam, imidacloprid, acetamiprid) are listed for control of these pests, and the 2016 plan identified better efficacy and improved conservation biological control as advantages of these materials. (Others include increased water solubility and lower mammalian toxicity.) Efficacy tables in the 2016 plan show the neonicotinoid insecticides provide similar or better control of the insects listed above, as well as enhancing control of several foliar-feeding pests, such as whiteflies, thrips and aphids, which are not effectively controlled by the older materials. (Table 1)

Lepidopteran pests, such as loopers, armyworms and cutworms, are also better controlled now than in 2003 when they were identified as priority pests. Research partnerships with IR-4 that emerged from the 2003 strategic plan delivered several reduced-risk products (methoxyfenozide, indoxacarb, chlorantraniliprole) that are highly effective against these pests (ir4app.rutgers.edu/Ir4FoodPub/prnum.aspx?prnum=07357, =08339, =10204).

Because lepidopteran pests are better controlled, further research on pesticides to control them was not identified as a priority in the 2016 plan.

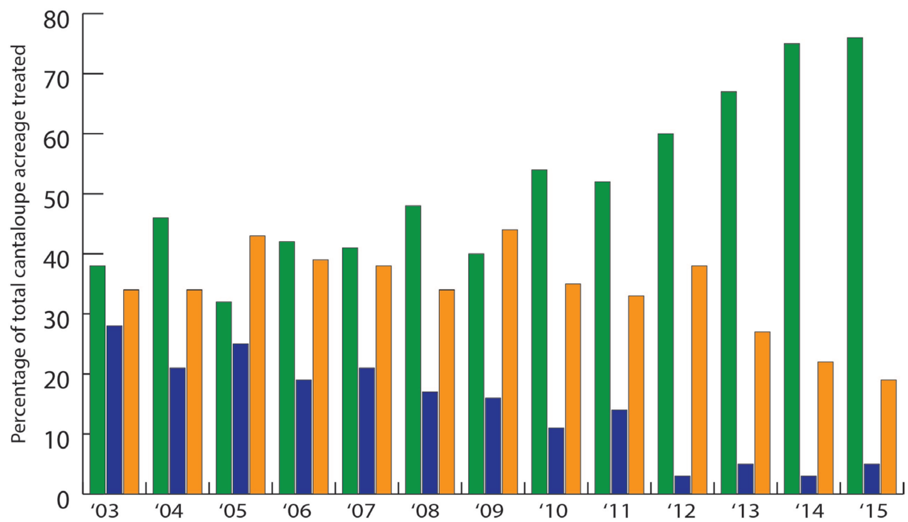

Figure 1. Use of neonicotinoids (green bars) organophosphates (blue bars) and carbamates (orange bars) in cantaloupe production for the control of leafhoppers and soil insect pests from 2003-2015. Sources: PUR data for insecticide use and NASS for harvested acreage.

Table 1. Efficacy of selected insecticides against soilborne targets, leafhoppers and insect vectors of melon viruses.

	Cutworm	Leaf-hopper	Seed corn maggot	Wire-worms	Cucumber beetle	Darkling beetle	Flea beetle	Aphid	Whitefly	Thrips
Imidacloprid	Poor	Excellent	Good	Good	Fair	Good	Not rated	Excellent	Good	Excellent
Dinotefuran	Poor	Good	Poor	Poor	Good	Good	Good	Good	Good	Fair
Acetamiprid	Poor	Good	Poor	Poor	Fair	Poor	Good	Excellent	Excellent	Poor
Diazinon	Poor	Excellent	Poor	Poor	Poor	Poor	Good	Good	Poor	Poor
Carbaryl	Excellent	Fair	Poor	Poor	Excellent	Good	Fair	Poor	Poor	NA
Methomyl	Good	Good	Good	Good	Not rated	Good	Good	Fair	Fair	NA

Performance ratings taken from the 2003 and 2016 strategic plans.

DISEASE CONTROL

Diseases are a significant cause of crop loss in melons, and although there have been significant IPM advances in disease control since 2003, new challenges have emerged.

Powdery mildew control improved from 2003 to 2016 because of the switch to drip irrigation and the availability of resistant varieties. This improved control of powdery mildew can be seen in the reduction in the use of sulfur to treat it. More than 251,000 pounds of sulfur were used on cantaloupe in California in 2003, with the majority applied in Fresno, Imperial and Riverside counties. By 2016, the amount of sulfur applied dropped to 64,000 pounds, a nearly 75% reduction (PUR data).

The impact of irrigation management in powdery mildew control can be seen by comparing Fresno County, which largely switched to drip, with Imperial County, which largely continued to use furrow irrigation. In Fresno County, sulfur use dropped 95%, from 62,000 to 3,000 pounds, while in Imperial County, use dropped just 75%, from 152,000 to 37,000 pounds.

Both counties benefited from newly available resistant varieties, and host-plant resistance in the cantaloupe germplasm against powdery mildew races 1 and 2 is now common in a majority of the cultivars available to California growers. Resistant varieties are also widely available for Verticillium and Fusarium. Despite that availability, the diseases continued to be priorities in the 2016 strategic plan as growers worried that newly evolving races of the pathogens could break the existing resistance and that resistance traits were not as widely available in honeydew or other melon types.

An area that has not seen significant improvement is insect-vectored viruses. The 2003 strategic plan identified viruses vectored by aphids and cucumber beetles as significant causes of crop losses, and the 2016 plan added cucurbit yellow stunting disorder virus transmitted by whitefly to the list. The 2016 strategic plan noted that neonicotinoid insecticides alone do not provide sufficient control of the insects to control the viruses, especially in the case of whitefly. Management strategies therefore include exclusion techniques such as row covers, weed management to remove alternate hosts and sources of whiteflies, and cucurbit-free periods either through an arranged regional host-free period or true winter season.

Despite these tools, late-season melon production in the Imperial Valley is challenging or impossible because of whitefly and cucurbit yellow stunting disorder virus.

WEED CONTROL

Another area the change to subsurface drip irrigation is seen is in the use of preplant herbicides. The preplant herbicides used by growers in both 2003 and 2016 were trifluralin, bensulide and metam-sodium, which although listed as a herbicide in the pest management strategic plans, is a soil fumigant also used to control soilborne pathogens, nematodes and insects.

In Fresno County, which embraced drip irrigation, metam-sodium used dropped 97 percent, from 710,000 pounds applied to cantaloupe in the years 2003 through 2008, down to 21,000 pounds used from 2009 through 2015 (PUR data).

There was no corresponding reduction in Imperial County, where furrow irrigation remained standard. There, the most common preplant herbicide was bensulide and use hovered around 10,000 pounds a year (ranging from a low of 6,500 pounds in 2010 to a high of 13,500 pounds in 2011). There was no significant change in trifluralin use in either county and use of other common herbicides, including glyphosate, clethodim and oxyfluorfen, also remained unchanged (PUR data).

While the reduction in metam-sodium use was attributed to the switch to drip irrigation in the 2016 strategic plan, other factors may have contributed. New buffer zone regulations to protect field workers may have contributed. Variable efficacy of metam-sodium related to new application techniques may also have limited the utility of this material and hence its use. The rate at which metam-sodium is currently being applied in melon production has doubled, a change attributed to the new shank-injection application method.

The switch to drip irrigation did result in increased vertebrate pest issues for growers, who report coyotes, rabbits and voles damaging irrigation line to access water. Fencing has been an effective exclusion strategy.

PROTECTING BENEFICIAL INSECTS

In melon production, pollination is required for proper fruit set and yield and honey bees are commonly used. Neonicotinoids pose a moderate risk to invertebrates, including honey bees. While the risk estimated by the ipmPRIME tool is similar to older materials like organophosphates, carbamates and pyrethroids (Table 2), anecdotal evidence suggests that application methods, including chemigation and seed treatment, may increase the risk to honey bees. Other research suggests methoxyfenozide, indoxacarb, flubendiamide, and chlorantraniliprole may pose a moderate risk to pollinators in general and honey bees specifically.

Because of the need for pollination services and risks posed by these newer insecticides, the 2016 strategic plan identified the need to develop and publish best management practices for protecting pollinator health in California melon production.

Conservation biological control maintains populations of beneficial insects – predators, parasitoids and competitors – to control the growth of pest populations. Broad-spectrum insecticides like organophosphates, carbamates and pyrethroids reduce or eliminate these biological controls, which can lead to rapid pest population growth and crop losses.

The 2016 strategic plan listed organophosphate, carbamate and pyrethroid insecticides as harmful to a variety of insect predators and incompatible with conservation biological control. Neonicotinoids were listed as less harmful and more compatible. The effects of methoxyfenozid indoxacarb and chlorantraniliprole on biological control organisms were unknown to the 2016 strategic plan participants, but literature suggests there is moderate risk to biological control organisms associated with these materials.

IN CALIFORNIA MELON PRODUCTION, OVERALL RISKS HAVE BEEN SIGNIFICANTLY REDUCED

In the years between 2003 and 2016, the California melon industry reduced the risks to people and the environment from its pest management practices significantly.

Large reductions in the use of soil fumigants and broad-spectrum insecticides drove this reduction. The overall estimated risk of exceeding the no observable adverse effect level for terrestrial and aquatic vertebrates – people, birds and fish – from insecticides applied to control soil insects and leafhoppers dropped from moderate (0.1 < risk < 0.5) to low (below 0.1) (Table 2). While the overall reduction in metam-sodium use in cantaloupe also reduced the risks for all species, including humans, the higher rates now being applied have a high (0.8 to 1.0) risk of exceeding the no observable adverse effect level for terrestrial and aquatic vertebrates and invertebrates. (These ipmPRIME risk estimates assume no mitigation tactics are used.)

The risk to honeybees and other terrestrial and aquatic invertebrates in melon production remains moderate (0.1 and 0.5) (Table 2), due to the use of neonicotinoid insecticides. However, those products present lower risks to human and overall environmental health compared to organophosphates and carbamates, so the shift away from those older insecticides has reduced the overall risks from melon production in California.

Table 2. Estimated risk associated with pesticides used to control leafhoppers and soil insect pests in cantaloupe production in California, based on ipmPRIME tool.

	2003	2005	2007	2009	2011	2013	2015
Human	0.27	0.23	0.21	0.14	0.14	0.06	0.05
Small mammal	0.04	0.03	0.02	0.02	0.04	0.03	0.01
Avian acute	0.16	0.13	0.11	0.08	0.08	0.06	0.04
Avian reproductive	0.10	0.09	0.08	0.06	0.07	0.05	0.03
Fish	0.16	0.13	0.09	0.04	0.03	0.02	0.01
Terrestrial invertebrates	0.28	0.30	0.44	0.47	0.48	0.47	0.47
Aquatic invertebrates	0.42	0.43	0.45	0.42	0.42	0.42	0.40

Presented in the table are average risks associated with insecticide applications used to control leafhoppers and soil insects in that year. Insecticides used to control leafhoppers and soil insect pests were reported by the PMSP participants and include diazinon, dinotefuran, imidacloprid, acetamiprid, methomyl and carbaryl. The average risk was calculated using the risk value for each application listed in the PUR database and weighted by area. Weighted values were summed over all applications and insecticides within a year. These risk values should be considered as maximal risk, and no mitigation tactics used to avoid risk were included in the calculations.

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