The economics of integrated mite management in almonds

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Five years of tests prove effectiveness and benefits of UC program

An integrated mite management program developed for almonds by the University of California is designed to control spider mites and reduce control costs. Since spider mites are serious pests in a majority of the 395,000 acres of bearing almond orchards in California, this program could have a significant effect on growers' income. Growers now make up to three acaricide applications per season, with an average of about 1.5, according to a survey of growers, University of California Extension personnel, and private pest control advisors.

The mite management program integrates chemical and biological control of spider mites, combining (1) use of selective insecticides to control the navel orangeworm, *Amyelois transitella* (Walker), and peach twig borer, *Anarsia lineatella* Zell, (2) use of lower-than-label rates of selective acaricides, and (3) release of pesticide-resistant predatory mites, *Metaseiulus occidentalis* (Nesbitt), in orchards where native organophosphorus-resistant *M. occidentalis* are lacking or are too rare to achieve control (see *California Agriculture*, July-August 1984).

The integrated mite management (IMM) program often works with native *M. occidentalis*, because they generally are sufficiently resistant to organophosphorus compounds to permit use of azinphosmethyl (Guthion), phosmet (Imidan), and diazinon (Diazinon) to control the navel orangeworm and peach twig borer. Carbaryl (Sevin) and permethrin (Pounce/Ambush) cannot be used without disrupting the native predatory mites.

To use carbaryl, growers can release the laboratory-selected strain of *M. occidentalis* resistant to carbaryl, sulfur, and organophosphorus compounds. This strain has been mass-produced commercially since 1983. It will establish, persist for at least five years in the orchard, and provide substantial spider mite control, while expanding the grower's navel orangeworm control options.

Integrated pest management (IPM) programs are rarely as simple as conventional chemical control. Before adopting an IPM practice, therefore, growers want to be sure that it works and that it generates benefits that exceed its costs. Five years of tests in commercial almond orchards in California have demonstrated that the integrated mite management program is effective. Our purpose here is to compare the economic effects of integrated mite management with those of conventional chemical control.

We have compared the costs of a conventional chemical control program using label rates of propargite (Omite), cyhexatin (Plictran), or hexakis (Vendex) with the costs of an integrated mite management program using lower-than-label rates of these acaricides in conjunction with (1) biological control by native *M. occidentalis* or (2) release of laboratory-selected insecticide-resistant *M. occidentalis*. When the grower uses the integrated mite management program, it is necessary to monitor the orchard to ascertain whether the proper predator-spider mite ratios exist; these monitoring costs have been included.

The evaluation is in two parts: (1) the cost savings to the grower of adopting integrated mite management with and without releases of predator mites and (2) the aggregate economic benefits of the program to the almond industry, taking into consideration the probable rate of adoption and the initial research investment that made the program possible.

Basic assumptions

We made some basic assumptions in estimating the benefits of the integrated mite management program. They are that:

(1) Under the conventional chemical control program, growers spend an average of $75 per acre, including application costs, for 1.5 acaricide treatments per year. (The costs can vary, depending on whether acaricides are applied alone or in a tank mix with navel orangeworm controls. In this study, we have taken a conservative approach and have charged application costs for all acaricides as though applied alone. Costs could be lower if acaricides were applied as a tank mix with other treatments.)

(2) The first-year cost of releasing and monitoring the insecticide-resistant *M. occidentalis* is $30 per acre ($20 for predators plus $10 for monitoring), based on costs supplied by commercial producers, and the predator is able to persist in the orchard for at least five years, based on data from a Bakersfield orchard that received predators in 1979.

(3) Monitoring predator-spider mite ratios costs $10 per acre per year in or-

Worksheet for estimating annual benefits of an integrated mite management program

1. Acres requiring treatment	_____ac.
A. Conventional treatment	
2. Cost of acaricide treatment per acre (normal rate for material; include application cost)	$_____
3. Cost of mite monitoring per acre	$_____
4. Total cost of monitoring (multiply value from line 3 by value from line 1)	$_____
5. Total cost of conventional treatment (line 2 times line 1 plus line 4)	$_____
B. Integrated mite management program	
6. Cost of lower-than-label-rate acaricide treatment per acre (low rate for material; include application cost)	$_____
7. Total cost of low-rate treatment (line 6 times line 1)	$_____
8. Cost of mite monitoring per acre	$_____
9. Total cost of monitoring (line 8 times line 1)	$_____
10. Total cost of integrated mite management treatment (line 7 plus line 9)*	$_____
11. Benefits of integrated mite management (line 5 minus line 10)	$_____
12. Benefits per acre (line 11 divided by line 1)	$_____

*If releases of resistant predatory mites are needed, add the cost of mite releases per acre times line 1, divided by the number of years expected between releases, to the amount on line 10 before computing benefits on line 11.

chards where predators are established.

(4) Yearly costs for using lower-than-label rates are $6 per acre for acaricide material plus up to $15 per acre for application. (Lower-than-label rates were estimated to be about 0.1 times the average rate of acaricide application.)

(5) The integrated mite management program will produce yields as good as, but no better than, the conventional chemical control program.

(6) No new equipment or capital investment is involved in adoption of IMM other than the investment in predators where needed, unless the grower does the monitoring using the brush-and-count method.

Grower benefits

Cost-saving budgets were constructed for two situations, in both of which the orchards have spider mite problems that require intervention. In one case, releases of insecticide-resistant *M. occidentalis* are not needed. In the other, there are too few native *M. occidentalis* to achieve effective control, and releases of the insecticide-resistant strain are required.

The cost savings computed under the basic assumptions are $44 per acre for those who use lower-than-label rates of acaricides and have sufficient native predator mites to achieve control (table 1, plan 1). For growers requiring predator releases, the computed cost savings are $24 per acre for the first year and $44 per acre thereafter unless another release of predator mites is needed (table 1, plan 2). Since the predators are known to be able to persist for at least five years, the total of the five-year benefits for the two types of growers has been computed and discounted at a 12 percent rate of interest. These values are $158.62 and $140.76 per acre, respectively, over five years. The values indicate that the grower could afford to invest as much as $158.62 or $140.76 per acre now to receive the cost savings over the next five years and earn 12 percent on the investment.

The integrated mite management program does not require investment in new equipment. Only in the case where the predator mites are needed is a $20 per acre initial investment in predators required. Specially trained people who understand the critical predator-prey ratios must monitor the orchard to ensure that the predators can control the damaging spider mites. This monitoring service, which is necessary to the success of the integrated mite management program, costs $10 per acre annually. Since there is no large "front end" capital investment, the economic risk of adoption is relatively low. Considering the size of the cost savings and the low risk involved, adoption of the integrated mite management program should be attractive to growers.

The accompanying worksheet gives guidelines for comparing costs in specific orchards. For example, if lower-than-label acaricide costs including application are estimated at $15 per acre rather than $21, $15 would be entered in item 6 of the worksheet. Or, if conventional acaricide costs including application and material are $50 per acre rather than $75 as suggested, $50 would be entered in item 2 of the worksheet.

Industry benefits

The decision by an individual grower to adopt the integrated mite management program is based solely on the benefits that grower expects. A conclusion as to whether or not the integrated mite management program has justified the investment in its development is different. Whether the program is economically justified as an industry technology depends on the cost savings per acre and how many acres growers commit to the program.

UC Cooperative Extension IPM personnel estimate that 80 percent of the 395,000 almond-bearing acres have spider mite problems requiring intervention. We evaluated the entire program under three alternative assumptions concerning the rate and extent of adoption: (1) 25 percent of the acreage with spider mite problems committed to the program the first year, but no new acreage added later, (2) 50 percent of the acreage with spider mite problems committed by the end of two years, at 25 percent per year, and (3) 75 percent of the acreage with spider mite problems committed by the end of the first three years, at 25 percent per year. Consequently, the alternatives give a 25, 50, and 75 percent adoption by growers with spider mite problems. It was assumed that 20 percent of the acreage committed to the program would need releases of predator mites each year.

Various agencies, both public and private, made an initial investment through research funds to the second author to develop the program. These funds, which included extramural grant support, 44 percent of the second author's salary and fringe benefits, and salary and fringe benefits for a staff research associate for five years, are documented and were compounded from the date received at an interest rate of 12 percent through July 1984.

With the development costs documented, we calculated the net present value as of 1985 of the industry cost savings over five years for the three alternative rates of adoption. The net present values are the sums of the annual cost savings benefits discounted at a 12 percent interest rate minus the initial research investment costs compounded at a 12 percent rate from date of allocation up to 1985. These values represent how much more could have been invested and still earn 12 percent on the initial research investment. (To allow for inflation, all costs were inflated by 5 percent per year compounded.)

The net present values for 25, 50, and 75 percent adoption by growers with acreage with spider mite problems, using a 12 percent interest rate, are $11,626,684, $21,255,816, and $28,239,860, respectively. These are re-

TABLE 1. Grower cost savings analysis for integrated mite management in almonds

Item					Amount
PLAN #1 (no releases of predator mites necessary)					
Cost of conventional treatment (includes material plus application/acre)					$ 75.00
Minus low acaricide rate treatment (includes material plus application/acre)					(21.00)
Minus cost of mite monitoring/acre					(10.00)
Cost reduction/acre					$ 44.00
Value of cost savings/acre					**Present value* at 12%**
Year #1	**Year #2**	**Year #3**	**Year #4**	**Year #5**	
$44.00	$44.00	$44.00	$44.00	$44.00	$ 158.62
PLAN #2 (release of predator mites necessary)					
Cost of conventional treatment (includes material plus application/acre)					$ 75.00
Minus low acaricide rate treatment (includes material plus application/acre)					(21.00)
Minus cost of mite monitoring per acre					(10.00)
Minus cost of first year predator releases/acre					(20.00)
First year cost reduction/acre					$ 24.00
Second and following year cost reduction/acre					$ 44.00
Value of savings per acre					**Present Value* at 12%**
Year #1	**Year #2**	**Year #3**	**Year #4**	**Year #5**	
$24.00	$44.00	$44.00	$44.00	$44.00	$ 140.76

*Present value $= \frac{\text{Savings \#1}}{1.12} + \frac{\text{Savings \#2}}{(1.12)^2} + \frac{\text{Savings \#3}}{(1.12)^3} + \frac{\text{Savings \#4}}{(1.12)^4} + \frac{\text{Savings \#5}}{(1.12)^5}$

Where the savings are the same each year, this is the same as the present value of an annuity.

turns above an initial research cost of $823,877. (Total funds allocated to the research from 1976 to 1984 were $537,661. Since society was deprived of the use of these funds for other purposes, compound interest at the rate of 12 percent was charged through 1984. The costs do not reflect the efforts of the UC Extension personnel or the collaborators who cooperated in developing the presence-absence monitoring system [see Zalom *et al.*, *California Agriculture* May-June 1984]. UC Cooperative Extension costs for education and implementation during 1984-85 are also excluded.)

The returns result in benefit-cost ratios of 15, 26, and 35, respectively, which translate into an annual return of 280 to 370 percent on the initial research investment. If the program is used longer than five years, additional benefits to the initial research investment will accrue, although costs for ongoing education and adaptation will continue.

A program like this has much to recommend it, since it is not expected to increase crop yields. Therefore, in the short run, the cost-saving benefits accrue to the growers directly and totally.

The integrated mite management program is unique in that it incorporates, as a component, a laboratory-selected predator. An additional unique feature is the fact that a large portion of the development costs can be documented to determine the economic justification of the endeavor.

By June 1985, an informal survey of pest control advisors and UC Cooperative Extension personnel suggested that nearly 25 percent of the growers with spider mite problems had already adopted the program. In 1984 and 1985, at least 12,000 acres of almonds received releases of the laboratory-selected strain of *M. occidentalis.* Cost savings expected from the first increment of adoption have therefore already been achieved. The outlook is that, by 1987, up to 60 to 70 percent of growers with spider mite problems will have adopted the program, and the projected industry cost savings will be reality.

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'Melogold', a new pummelo-grapefruit hybrid

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The second offspring of a pummelo-grapefruit cross — 'Melogold' — is now being released. In 1958, an essentially acidless pummelo, CRC 2240 (*Citrus grandis* Osbeck), which imparts low acidity to its progeny, was crossed as seed parent with a seedy, white tetraploid (having twice the normal number of chromosomes) grapefruit (*C. paradisi* Macf.). The small population from this cross consisted of one tetraploid and six triploids (having 1½ times the normal number of chromosomes), which were field-planted in 1962. Two of the triploids had particularly favorable characteristics and were propagated for further testing. One of these was released in 1980 as 'Oroblanco' (*California Agriculture,* November-December 1980). The second, 6C26,18, is the cultivar 'Melogold'.

Observations have been made and data collected at Riverside (intermediate, interior climate) since 1967. Additional test trees were planted at the University of California Lindcove Field Station at Exeter (also intermediate, interior), the UC South Coast Field Station at Irvine (cool, humid area), and the U.S. Date and Citrus Station, Indio (hot desert climate). Some fruit has been available for testing at these locations since 1975.

'Melogold' appears to be best adapted to the inland citrus areas of California. At Lindcove, the season of production is from early November through February, just slightly earlier than 'Oroblanco'. At Riverside, maturity is from early December into March. 'Melogold' is suitable as a breakfast or salad fruit.

Description

In general characteristics, 'Melogold' resembles the present white-fleshed grapefruit cultivars but is more pummelo-like than 'Oroblanco'. Fruit are larger than 'Marsh' grapefruit and 'Oroblanco' at all test locations. Weight at Riverside from 1967 through 1975 averaged 470 grams (17 ounces) for 'Melogold', 360 grams (13 ounces) for 'Oroblanco', and 280 grams (10 ounces) for 'Marsh'. At Lindcove, from 1975 through 1983 with younger trees, fruit weight averaged 700 grams (25 ounces), 520 grams (18 ounces), and 450 grams (16 ounces), respectively, for the three cultivars.

Fruit shape is comparable to 'Marsh' and 'Oroblanco' with a slight tendency for more stem-end taper. Exterior peel color is slower to develop than in 'Marsh' grapefruit but is comparable late in the season. Exterior peel texture is smooth to slightly pebbled. Average peel thickness is slightly greater than in 'Marsh' but, as a percentage of fruit diameter, is equal to 'Marsh' and thinner than 'Oroblanco'.

Interior color and texture are the same as in 'Oroblanco'. As with 'Oroblanco', the central core hollow is greater than in 'Marsh' at maturity. The flesh is tender and juicy, separating well from the segment membranes. Percent juice has been equal to 'Marsh' and slightly higher than 'Oroblanco'.

'Melogold' may have a slight bitterness, particularly early and late in the harvest season. In taste tests, 'Melogold' was always preferred by a wide margin over 'Marsh' but usually was a very close second to 'Oroblanco'. In flavor, 'Melogold' differs from both 'Oroblanco' and grapefruit and is more like pummelo.

The total soluble solids, titratable acid, and solids-to-acid ratios of 'Melogold', 'Oroblanco', and 'Marsh', have been recorded since 1967 at Riverside and 1975 at Lindcove (tables 1 and 2). Riverside data for 'Melogold' and 'Oroblanco' through 1976 are from the original seedling trees or the first-budded trees on Troyer citrange (*Citrus sinensis* [L.] Osbeck × *Poncirus trifoliata* [L.] Raf.) rootstock. The slightly lower solids and acids in 1975 through 1978 are from younger trees also on Troyer citrange. All trees in Lindcove are also on Troyer citrange.

In comparison with 'Oroblanco', solids have consistently been slightly lower at Riverside but have sometimes been slightly higher at Lindcove. Acidity has also been consistently slightly lower than that of 'Oroblanco' at Riverside but has fluctuated at Lindcove. As with 'Oroblanco', 'Melogold' had much lower acidity than 'Marsh' did on all sampling dates through the season at all test locations.

In the 1981-82 season at Lindcove (table 2), the low acidity with moderate solids produced a much higher ratio than in 'Marsh' at all sampling dates. Fruit from the Coachella Valley and South Coast Field Station also had low acidity and moderate solids, even early in the season.