Energy Efficiency and California Almond Growing

Increases in demand, regulation and political constraints related to fossil fuels have increased the volatility in energy prices and uncertainty of supplies. Moreover, the combustion of fossil fuels has adverse environmental impacts. Energy conservation and efficiency (and the evaluation and use of cost-effective renewable sources) is smart business for decreasing risks and saving money.

Selected statewide results about strengths and opportunities for improvement are displayed and discussed below.

Practice	Response	% of orchards ± 95% confi-dence level	Why not? (% of orchards)		
			Not familiar	Not tried	Have tried
Monitoring Electricity Use					
Electricity use is recorded & tracked beyond filing paid bills	Yes No	39.7 ± 5.4 60.3 ± 5.4			
Of operations recording & tracking electricity use…					
Electricity use is recorded & tracked for operation as a whole	Yes No	84.4 ± 6.4 15.6 ± 6.4	0.0	9.0	6.6
Electricity use is recorded & tracked per orchard	Yes No	77.2 ± 7.4 22.8 ± 7.4	3.3	10.6	8.9
Monitoring Fuel Use					
Fuel use in the operation is recorded & tracked beyond filing paid bills	Yes No	42.5 ± 5.4 57.5 ± 5.4			
Of operations recording & tracking fuel use…					
Fuel use is recorded & tracked for operation as a whole	Yes No	88.0 ± 5.5 12.0 ± 5.5	0.0	3.0	9.0
Fuel use is recorded & tracked per orchard	Yes No	39.3 ± 8.9 60.7 ± 8.9	0.9	41.9	17.9
Energy Audits					
Operation was expert-audited for electricity use efficiency in past 5 years	Yes No	29.2 ± 5.8 70.8 ± 5.8	8.5	50.0	12.3
Operation was expert-audited for fuel use efficiency in past 5 years & used results to develop a fuel management plan & improvements budget	Yes No	15.6 ± 4.9 84.4 ± 4.9	8.5	65.6	10.4
Irrigation Pumps					
Pump motors/engines are regularly maintained	Yes No	90.3 ± 3.5 9.7 ± 3.5	2.2	4.0	3.6
Pumping system was tested for energy efficiency in past 3 years	Yes No	67.2 ± 5.7 32.8 ± 5.7	1.5	21.5	9.8
For orchards with electric pumps, irrigation is done during off-peak hours if possible	Yes No	78.9 ± 4.6 21.1 ± 4.6	1.3	10.1	9.7
For orchards with electric pumps and variable loads, variable-speed drives are installed	Yes No	21.8 ± 5.8 78.2 ± 5.8	7.8	63.2	7.3
Alternative Power Sources					
Solar energy is used to generate electricity or heat	Yes No	14.4 ± 4.6 85.6 ± 4.6	1.8	75.7	8.1
Wind power is used to generate electricity	Yes No	0.5 ± 0.9 99.5 ± 0.9	1.4	92.0	6.1
Operation contracts with electrical utility to purchase electricity from renewable sources	Yes No	10.2 ± 3.9 89.8 ± 3.9	4.9	76.1	8.8

Strengths:

- Growers for a majority of orchards with irrigation pumps ensure energy conservation and efficiency by regular maintenance and testing.
- Growers for a majority of orchards with electric irrigation pumps conserve energy by preferably pumping during off-peak-hours.

Opportunities:

- Growers can improve the energy efficiency of their orchard operations by increasing use of energy audits and by measuring, tracking and managing electricity and fuel use *(more outreach about benefits)*.
- Growers can increase the efficiency of electric irrigation pumping systems by installing variable-speed drives where appropriate *(more outreach about benefits)*.
- Where feasible, growers can reduce reliability on fossil fuels by increasing use of renewable sources for electricity generated on-site and supplied by electric utilities *(more outreach about benefits)*.

Air Quality and California Almond Growing

California agriculture has positive and negative impacts on air quality and climate change. Cropping systems and surrounding landscapes reduce greenhouse gases by sequestering carbon in plants and soil. But, problematic emissions of particulate matter, ozone precursors, and/or greenhouse gases are associated with activities causing dust, fuel combustion, and pesticide and fertilizer use. Air-protective practices are important for environmental stewardship and regulatory compliance, and can increase production efficiencies.

Selected statewide results about strengths and opportunities for improvement are displayed and discussed below.

Practice	Response	% of orchards ± 95% confidence level	Why not? (% of orchards)		
			Not familiar	Not tried	Have tried
Floor Management					
Entire orchard floor & edges are disked or floated each year	Yes No	29.5 ± 4.7 70.5 ± 4.7			
Unpaved Surfaces					
Speed limits are posted on unpaved roads	Yes No	44.0 ± 5.6 56.9 ± 5.6	2.0	41.1	12.9
Vehicle access to unpaved roads is physically restricted	Yes No	58.0 ± 5.5 42.0 ± 5.5	1.3	28.7	12.1
Water, organic dust suppressants, mulches, chips, sand or gravel are applied to unpaved roads/equipment yards	Yes No	66.8 ± 5.1 33.2 ± 5.1	1.2	18.3	13.7
Harvest Operations					
Floors are managed to ensure a smooth, level floor at harvest	Yes No	89.3 ± 3.2 10.7 ± 3.2	1.9	1.1	7.7
Sweeper and pickup machine operators are trained to reduce dust	Yes No	75.0 ± 4.7 25.0 ± 4.7	5.6	8.3	11.1
Sweeper heads are set at manufacturer-recommended heights	Yes No	81.4 ± 4.3 18.6 ± 4.3	5.3	5.0	8.2
Sweeper heads with wire tines (not rubber/plastic) are used	Yes No	56.2 ± 5.6 43.8 ± 5.6	10.7	17.1	16.1
Sweepers designed to minimize passes and reduce dust are used	Yes No	66.1 ± 5.2 33.9 ± 5.2	6.4	17.6	9.9
Conventional pickup machines are driven at reduced speeds near sensitive areas and positioned to discharge debris into orchard	Yes No	85.8 ± 3.8 14.2 ± 3.8	3.8	5.4	5.1
Speeds for separator fans on conventional pickup machines are lowered	Yes No	49.0 ± 5.7 51.0 ± 5.7	10.4	24.8	15.8
Pickup machines designed for reduced dust output are used	Yes No	52.7 ± 5.7 47.3 ± 5.7	6.0	32.9	8.4
Combustion					
Manufacturer-recommended maintenance of engines is followed	Yes No	89.8 ± 3.2 10.2 ± 3.2	3.2	2.9	4.1
Diesel engines have been retrofitted/replaced to Tier 3 or 4 standards	Yes No	50.6 ± 6.0 49.4 ± 6.0	4.5	34.6	10.4
Diesel engines have been retrofitted/replaced with technology using electricity or cleaner-burning fuel (e.g., propane, biodiesel)	Yes No	35.9 ± 5.8 64.1 ± 586	3.8	54.6	5.7
Pest Management					
Low-VOC pesticide formulations are used when available and practical	Yes No	74.8 ± 4.5 25.2 ± 4.5	5.8	7.8	11.6

Strengths

- Growers for a majority of orchards reduce dust by not disking or floating the entire orchard each year, applying water or other dust suppressants to unpaved surfaces, ensuring orchard floors are smooth and level at harvest, training operators of sweepers and pickup machines to limit dust, using sweepers designed to minimize passes and setting sweeper heads at recommended heights, and driving conventional pickup machines at reduced speeds near and discharging debris away from sensitive areas.
- Growers for a majority of orchards reduce emissions from combustion by completing recommended engine maintenance and by either having already transitioned diesel engines to Tier 3 standards or converted them to technology using electricity or cleaner-burning fuel.
- Growers for a majority of orchards reduce emissions of volatile organic compounds (VOCs) from pesticides by applying low-VOC formulations if available and practical.

Opportunities

- Growers can reduce dust by increasing use of posted speed limits for and restricting vehicle access to unpaved roads *(more outreach about benefits where appropriate)*.
- The Almond Board can provide more information on results from ABC-funded research on dust reduction measures that indicate use of sweeper heads with wire tines and lowered separator fan speeds for conventional pickup machines reduce dust from

Irrigation Management and California Almond Growing

Irrigation efficiency in almond farming is essential to achieve yield goals and maximize economic returns, conserve water, and prevent leaching and runoff issues. Numerous relevant practices and technologies exist and continue to evolve. Key areas for maximizing irrigation efficiency are the installation, maintenance, and effective operation of recommended infrastructure, and optimal irrigation scheduling.

Selected statewide results about strengths and opportunities for improvement are displayed and discussed below.

Practice	Response	% of orchards ± 95% confidence level	Why not? (% of orchards)		
			Not familiar	Not tried	Have tried
All Irrigation Systems					
Type	Drip Micro-sprinkler Flood/Furrow Sprinkler	28.2 38.3 17.3 16.2			
Distribution uniformity test was done in past year, or past 5 years if flood/furrow	Yes No	42.7 ± 6.3 57.3 ± 6.3	12.8	30.3	14.1
Infrastructure for Systems with Pumps					
Flow meters are installed according to manufacturer instructions	Yes No	70.2 ± 6.9 29.8 ± 6.9	6.0	20.2	3.6
Of orchards with flow meters…					
Meter readings are recorded per irrigation run	Yes No	42.4 ± 8.1 57.6 ± 8.1	4.2	36.8	16.7
Meters were inspected & calibrated in past 2 years	Yes No	41.1 ± 8.1 58.9 ± 8.1	7.8	36.2	14.9
Pressure gauges are installed to measure pressure drops through filters	Yes No	93.1 ± 3.6 6.9 ± 3.6	2.1	2.7	2.1
Of orchards with pressure gauges…					
Pressure drops are checked per irrigation run & filters cleaned if significant differences occur	Yes No	91.9 ± 3.9 8.1 ± 3.9	2.2	2.2	3.8
Pressure gauges are checked for accuracy at least annually	Yes No	59.6 ± 7.1 40.4 ± 7.1	4.4	25.7	10.4
Backup screen is in place in case of filter failure	Yes No	49.3 ± 8.2 50.7 ± 8.2	16.2	28.2	6.3
Pressure-sustaining device is in place to maintain system pressure during back flushing	Yes No	59.0 ± 8.3 41.0 ± 8.3	16.4	20.1	4.5
Filter status & flushing system is checked at least 2X per season & fixed as needed	Yes No	93.5 ± 3.6 6.5 ± 3.6	0.5	2.7	3.3
Flush water is captured for reuse	Yes No	52.5 ± 7.7 47.5 ± 7.7	5.6	36.4	5.6
Infrastructure for Micro-Irrigation Systems (Drip or Micro-sprinkler)					
System has pressure-compensating emitters to help maintain distribution uniformity	Yes No	64.3 ± 7.9 35.7 ± 7.9	5.6	18.9	11.2
Lines & emitters are checked as least weekly for leaks/clogs	Yes No	93.3 ± 3.8 6.7 ± 3.8	0.6	2.5	3.7
Lines are flushed at least at season's start & once midseason	Yes No	89.1 ± 4.8 10.9 ± 4.8	2.4	2.4	6.1
Irrigation Scheduling (Timing and Amount) for All Systems					
Soil available water holding capacity per irrigation set is known and is used for irrigation scheduling	Yes No	39.7 ± 6.5 60.3 ± 6.5	11.9	35.6	12.8
Management allowed depletion amounts are determined and used for irrigation scheduling	Yes No	44.3 ± 6.7 55.7 ± 6.7	15.6	30.7	9.4
Real-time crop evapotranspiration (at least weekly) is calculated and is used for irrigation scheduling	Yes No	43.9 ± 6.4 56.1 ± 6.4	7.8	34.3	13.9

Strengths:

- Approximately two-thirds of orchards have highly efficient micro-irrigation systems (drip or micro-sprinkler).
- Growers for a majority of orchards with irrigation pumps have installed flow meters and pressure gauges, and frequently inspect and maintain the effective operation of filters and the flushing system.
- Growers for a majority of orchards with micro-irrigation systems have installed pressure-compensating emitters, often check lines and emitters for leaks or clogs, and ensure the timely flushing of lines.

Opportunities:

- Growers can improve irrigation efficiency by increasing the frequency of distribution uniformity tests and calibration and use (monitoring and recording readings) of flow meters, reusing flush water, checking the accuracy of pressure gauges more often, and using backup screens and devices that maintain system pressure during back flushing *(more outreach to ensure awareness and convey benefits)*.
- Growers can improve irrigation scheduling by determining and accounting for soil water holding capacity, management allowed depletion amounts, and real-time crop evapotranspiration *(more outreach to ensure awareness and convey benefits)*.

Pest Management and California Almond Growing

The California Almond community has a long history of implementing integrated pest management (IPM) to increase production efficiencies and decrease pesticide risks. Key has been and continues to be the application of University of California research funded by the Almond Board. Pest challenges occur each year, so it is important that almond growers maintain their reputation of using existing and adopting improved cost-effective, environmentally friendly management practices.

Selected statewide results about strengths and opportunities for improvement related to the IPM tenets of prevention, monitoring, and the effective and safe use of control tactics are displayed and discussed below.

CALIFORNIA ALMOND SUSTAINABILITY PROGRAM™

Practice	Response	% of orchards ± 95% confidence level	Why not? (% of orchards)		
			Not familiar	Not tried	Have tried
Insect, Mite and Disease Monitoring					
Frequency of and Who Does Insect, Mite & Disease Monitoring	Occasional/None Regular non-PCA Regular by PCA	8.0 17.5 74.5			
Of orchards monitored for insects, mites & diseases…					
Pest monitoring records are retained by farm owner/staff to inform management decisions	Yes No	69.4 ± 7.8 30.6 ± 7.8	1.5	22.4	6.7
Monitoring data, university guidelines & practical experience are used to design & implement management strategies	Yes No	86.1 ± 5.8 13.9 ± 5.8	2.2	8.0	3.6
Navel Orangeworm					
Mummy nuts are counted & removed per recommendations during winter to reduce outbreaks of navel orangeworm & brown rot	Yes No	86.2 ± 5.6 13.8 ± 5.6	2.1	3.4	8.3
Hullsplit sprays for navel orangeworm are based on egg-trap counts & degree-days	Yes No	80.2 ± 3.4 19.8 ± 3.4	0.0	12.3	7.5
Web-spinning Spider Mites					
Control tactics for web-spinning spider mites include releases of predatory mites/insects	Yes No	18.9 ± 4.6 81.1 ± 4.6	3.8	62.9	14.4
Weeds					
Weed species and infestation levels are monitored & recorded to inform the management strategy and type and timing of controls	Yes No	65.7 ± 7.9 34.3 ± 7.9	2.1	24.3	7.9
Monitoring records include growth stages & potential herbicide resistance	Yes No	45.7 ± 8.3 54.3 ± 8.3	2.9	35.7	15.7
Field equipment is cleaned after working weedy areas to prevent transferring weeds among orchards	Yes No	45.8 ± 8.9 54.2 ± 8.9	0.8	36.7	16.7
General Pesticide Risk Management					
Frequency of dormant sprays in past 5 years	0 1-2 3-4 5	39.6 31.2 13.9 15.3			
Pesticide application equipment is calibrated prior to use each year & after equipment repair/modification	Yes No	95.6 ± 3.5 4.4 ± 3.5	0.7	2.2	1.5
Air blast spray patterns are adjusted for average tree size & shape	Yes No	94.8 ± 3.8 5.2 ± 3.8	0.7	0.7	3.7
Air blast spray coverage is periodically checked using water-sensitive paper	Yes No	39.8 ± 8.5 60.2 ± 8.5	3.9	29.7	26.6
Air blast spraying is stopped when making row turns & does not resume until nozzles are adjacent to first trees	Yes No	97.7 ± 2.6 2.3 ± 2.6	0.0	1.5	0.8
Spraying near waterways/other sensitive sites is discontinued when winds blow in their direction	Yes No	93.3 ± 4.8 6.7 ± 4.8	0.0	1.9	4.8
Ultra-low-volume spray equipment or target-sensing sprayers are used to reduce spray volumes or amounts of pesticides	Yes No	30.8 ± 7.9 69.2 ± 7.9	5.4	40.8	23.1

Strengths:

- Growers for a majority of orchards employ the key IPM tenet of pest monitoring (92% of orchards regularly monitored) and record-keeping, and use results and expert guidelines to support management decisions.
- As part of optimal navel orangeworm management, growers for a majority of orchards count and remove mummy nuts during winter and base necessary hullsplit sprays on egg-trap counts and degree-days.
- Growers for a majority of orchards decrease pesticide risks by not applying dormant sprays annually (nearly 40% apply no dormant sprays), timely calibration of spray equipment and adjusting spray patterns based on average tree size and shape, and discontinuing sprays during row turns and near sensitive sites when winds blow in their direction.

Opportunities:

- Growers can improve operations by ensuring monitoring records include weed growth stages and resistance concerns, and cleaning field equipment after working weedy areas *(more outreach about benefits where appropriate)*.
- Growers can further mitigate pesticide risks and enhance production efficiencies by confirming coverage with water-sensitive paper and considering use of ultra-low spray equipment or target-sensing sprayers *(more outreach by application technologists about benefits)*.

Nutrient Management and California Almond Growing

The increasing costs for fertilizers and high-profile issues associated with nutrient contamination of water resources substantiate the importance of nutrient use efficiency in almond production. With nutrient use increasingly scrutinized, it is important that growers implement recommended practices as warranted by expert research and understandings. Stewardship practices for nutrient use often are grouped according to 4Rs – right source, right amount, right timing, and right place.

Selected statewide results about strengths and opportunities for improvement are displayed and discussed below.

Practice	Response	% of orchards ± 95% confidence level	Why not? (% of orchards)		
			Not familiar	Not tried	Have tried
Source of Nutrients					
Sources of nitrogen	Fertilizer Manure Compost Cover Crops	85.4 9.1 22.5 10.3			
Of orchards using compost, manure and/or N-fixing cover crops…					
Calculations of total nitrogen applied include contributions from these sources	Yes No	43.5 ± 7.3 56.5 ± 7.3	8.5	34.5	13.6
Nitrogen content of irrigation well water was analyzed in past 3 years	Yes No	57.8 ± 6.1 42.2 ± 6.1	5.1	25.4	11.7
Of orchards where tests verify well water used for irrigation contains nitrogen…					
Calculations of total nitrogen applied include nitrogen from well water	Yes No	56.3 ± 6.8 43.7 ± 6.8	8.7	25.7	9.2
Amount of Nutrients					
Calculated fertilizer rates are based on yield estimates & nutrient amounts removed by hulls, shells & nuts	Yes No	81.1 ± 4.2 18.9 ± 4.2	4.9	7.3	6.7
Plant tissues are sampled and tested annually before applying nutrients to inform fertility management decisions	Yes No	89.2 ± 3.4 10.8 ± 3.4	2.8	2.8	5.1
Plant tissues used for nutrient tests are sampled using recommended procedures	Yes No	87.8 ± 3.6 12.2 ± 3.6	2.2	4.8	5.1
Results of nutrient tests are mapped to guide precision fertilizer applications	Yes No	19.8 ± 4.6 80.2 ± 4.6	5.8	63.8	10.6
Method and Timing of Nutrient Applications					
Nitrogen is applied by broadcasting	Yes No	45.5 ± 5.4 54.5 ± 5.4			
Nitrogen is applied by fertigation	Yes No	74.2 ± 4.7 25.8 ± 4.7			
Nutrient applications are timed primarily to spring growth & crop demand	Yes No	94.1 ± 2.6 5.9 ± 2.6	1.2	0.6	4.0
Nitrogen is applied 3 or more times each year	Yes No	71.7 ± 4.9 28.3 ± 4.9			
Placement of Nutrients					
Variable-rate nutrient applications are made to account for intra-orchard variation	Yes No	49.0 ± 5.6 51.0 ± 5.6	2.6	34.6	13.7
To prevent N leaching/runoff, fertilizer applications are timed to irrigation/ rainfall where possible to optimally position N in root zone	Yes No	91.7 ± 3.0 8.3 ± 3.0	1.5	4.6	2.2
To prevent N leaching/runoff, the depth of irrigation water is managed to position nutrients in root zone	Yes No	73.4 ± 4.9 26.6 ± 4.9	2.6	16.0	8.0
Nutrient Management Plan and Budget					
A written nutrient management plan & budget guides annual practices	Yes No	37.5 ± 5.3 62.5 ± 5.3	5.6	46.7	10.2

Strengths:

- Growers for a majority of orchards annually sample and test plant tissues to inform fertility management decisions, take samples using recommended procedures, and calculate fertilizer rates based on yield estimates and nutrients removed with harvest.
- Growers for a majority of orchards optimize root uptake of nutrients by using fertigation, timing applications to crop demand, and making split-applications (3 or more per year).
- To position nutrients in the root zone and prevent nitrogen leaching or runoff, growers for a majority of orchards time fertilizer applications to irrigation or rainfall and manage the depth of soil penetration by irrigation.

Opportunities:

- Growers can improve nutrient use efficiency by ensuring nitrogen additions from irrigation, compost, manure, and cover crops are accounted for; and by effectively using variable-rate applications to account for intra-orchard variation *(more outreach about benefits)*.
- Growers can improve nutrient use efficiency by using management plans and budgets *(more outreach about benefits and requirements)*.

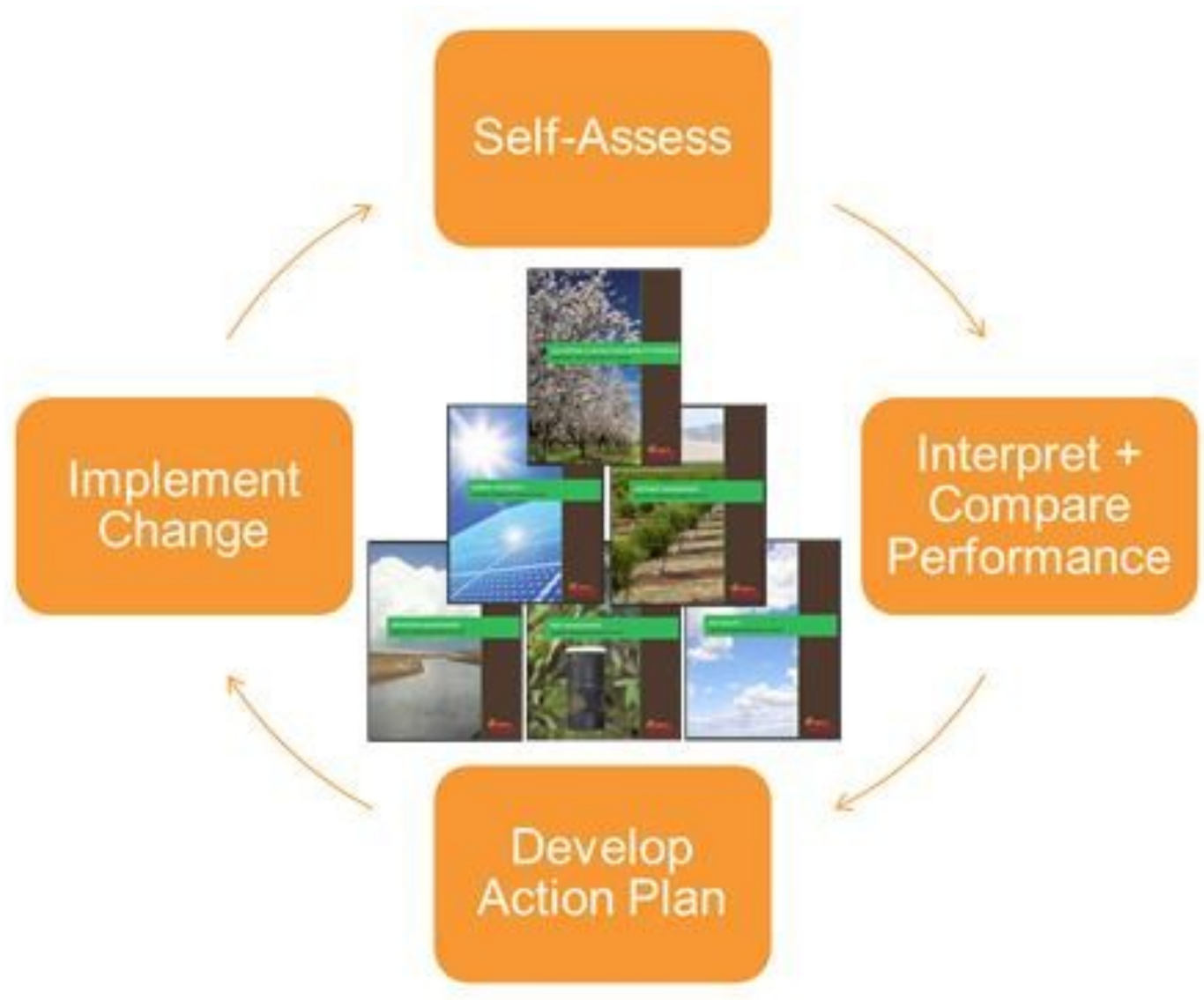
California Almond Sustainability Program

Presented by the Almond Board of California

There is no single sustainable way to grow almonds in California as each location has different resources and issues. However, documenting growers' thoughtfulness and efforts to be good stewards of the environment is critical to ensuring that almonds remain a crop of choice to grow in California. Thus, the Almond Board's California Almond Sustainability Program, based on grower self-assessments and facilitated by SureHarvest, has completed its third year.

Growers and handlers participate by attending workshops and assessing their management practices using a workbook of modules designed by peer growers and handlers, university experts, and other authorities. Current modules cover Irrigation Management, Energy Efficiency, Nutrient Management, Air Quality, and Pest Management. The ability to self-assess online was added this year.

The California Almond Sustainability Program is centered around the Cycle of Continuous Improvement, allowing growers to assess their practices, compare with grower peers, develop and implement new management practices, and reassess periodically.



Information gathered through the assessments will be used to tell the good story of California Almond production to regulators and select markets. This communication will show that almond producers use practices that make practical and economic sense while also protecting the people and environment of California.

Participation To Date:

- 882 Growers have participated in workshops
- 527 self-assessments have been submitted
- Resulting in 73,127 acres assessed

With increased participation, it is now possible to start assessing what practices almond growers are using for their operations. A statistical analysis of the results to date found that results are representative of what almond growers are doing across the state with 95% confidence. Selected results for each module are detailed in the associated five posters.