Could Cover Crops or Whole Orchard Recycling Help with Orchard Management?
Session Speakers

Gabriele Ludwig, ABC
Tanya Wood, ABC
Greg Wegis, Wegis & Young
Amelie Gaudin, UC Davis
Brent Holtz, UC ANR
Greg Wegis,
Wegis & Young
Implementing cover crop systems in Almond Orchards

J. Mitchell, A. Westphal, M. Yaghmour, C. Zuber, D. Lightle, B. Hanson, N. Williams, A. Hodson, H. Wilson, S. Solis, C. Creze, S. Haring, A. DeVincentis
Orchards alley are underutilized
- Roads
- Floors
Potential to intensify their use to help address
  - **Production** challenges/constraints
  - **Sustainability** targets
Especially postharvest during the winter
  - Tree dormancy
  - Precipitation water is available
It can take many forms

- Orchard’s age and spacing
- Region
  - Precipitation
  - Soil type
  - Temperatures …
- Objectives
- Equipment availability
- Experience and advice
Many growers recognize the potential benefits of winter cover crops but uncertainties remain:

- Water usage?
- Issues at harvest?
- Additional difficulties in management?
  - Weed control
  - Winter sanitation
  - Vertebrate pest management
  - Frost risk
- Cost and uncertainties of economic return

Perceived benefits (n=71)

- Soil health
- Pollinator habitat
- Water infiltration & retention
- Tree nutrition
- Weed control
- Aboveground pest control (NOW)
- Belowground pest control

Lack of information on cover crop management
Perceived operational constraints

- Difficult almond harvest (debris)
- Difficult termination
- Difficult management of stand
- Difficult establishment
- Seeding equipment availability
- Complicated transition towards cover cropping
How can it be successfully implemented in our modern intensive systems? What are the benefits? What to watch out for?
Evaluation across our rainfall gradient

- 2 popular mixes for different objectives
- Perennial resident vegetation, mowed
- Bare soil

1) Soil Mix
(5 species/3 families) at 50 lbs./acre
- 10% Bracco White Mustard (Brassica hirtum)
- 10% Daikon Radish (Raphanus sativus)
- 30% Merced Ryegrass (Lolium perenne)
- 20% Berseem Clover (Trifolium alexandrinum)
- 30% Common Vetch (Vicia sativa)

2) Pollinator Mix
(5 species/1 family) at 8 lbs./acre
- 15% Bracco White Mustard (Brassica hirtum)
- 20% Daikon Radish (Raphanus sativus)
- 15% Nemfix Yellow Mustard (Brassica juncea)
- 15% Common Yellow Mustard (Brassica hirtum)
- 35% Canola (Brassica napus)

Seeded with a no till drill/seeder end of Oct-Nov
1 to 2 or no supplemental irrigation; microsprinklers
2 termination dates (March-April) with herbicide
What have we learned?

<table>
<thead>
<tr>
<th>Soil Mix</th>
<th>Pollinator Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tehama</td>
<td>Tehama</td>
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<tr>
<td>Merced</td>
<td>Merced</td>
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<tr>
<td>Kern</td>
<td>Kern</td>
</tr>
</tbody>
</table>

• Potential Benefits
• What to watch out for
• Best management practices
Selecting the right mix for your objectives

- Different species or classes of cover crops can target different management goals
- Mixtures: many goals, higher chance of good stand
- Treat it as a crop
- Despite identical seeding rates and mix composition, cover crop composition and biomass will likely be different every year and in your different blocks

Katherine Jarvis-Shean, UCCE Orchard Advisor
http://www.sacvalleyorchards.com
Guaranteeing optimal harvest conditions and yields

- It is possible to get clean harvest without conditioner
- Species choice: balanced C/N ratio
  - Legumes are faster in decomposing
- Termination: promptly post bloom using mowing and herbicide was effective
- Flail mow: frequency, height, stage
- If you wish to terminate later in the spring, additional mowing in the summer + irrigation could accelerate the breakdown of residues.

No negative impacts on yields
Trends toward yield increase in very compacted orchards
Keeping water use low: maximize use of rainfall

Kc, ET

Soil moisture
Keeping irrigation water use low

- Seed ahead of the first rain
- No significant differences in soil moisture or tree water status in the spring
- Very close ET values for winter cover crop and bare soils
  - Cumulative difference is approximately 1 inch (25 mm)
- Water is used to create biomass that provides other benefits
- Function of establishment, growth and species
Infiltration and trafficability

Pictures: D.Doll
Merced, February 2017
Infiltration and water retention - 2 years:

- Infiltration: Improved infiltration during the cover crop
- Higher capacity for winter rainfall to penetrate the soil
  - Reduced risks of runoff
  - Water conservation
- Conditions tend to revert back to original infiltration rates post-cover crop: Long term improvements
- Improved aggregation with vegetative covers
  - Water infiltration
  - Dust

C. Creze, A Gaudin
Improvements in soil health take time….  

• Cover crop biomass production is a key factor
• Soil biology responds rather quickly, site/mix dependent  
  • + Microbial biomass N  
  • Carbon cycling enzymes  
  • Shifts in soil food web (enrichment in bacterial feeding nematodes)
• Some cover crop species can help limit reproduction of pest nematodes (Greenhouse)  
  • Cover crops that suppress RLN do not necessarily suppress RN  
  • Large variability between species i.e.: clover types, Rose Clover
• Increases in SOM have not yet been seen

C. Creze, Andreas Westphal, Amanda Hodson
NOW: Sanitation effectiveness?

• Trafficability can be improved in the winter to facilitate sanitation
• NOW mortality may increase in mummies in cover crops
• At the same time, cover crops could interfere with sanitation efficacy
  • More difficult to blow/sweep nuts from rows with a dense stand of cover crop
• Offset? We don’t know!
  – Shaking and sanitation is still necessary and feasible
  – Sanitation before planting the cover crop is an option
  – Combine cover crop mowing with flail-mowing of the mummies
Regrowth? Maximizing weed control

• Competition for resources

• Found weed suppression when the cover crop emerges early and is really abundant
  • Decrease weed diversity
  • Weed germination and emergence are not affected
  • Suppress growth

• No differences between mixes thus far

• Early seeding of a mixture ahead of winter rain

Mowing
Herbicide
Dry conditions
Avoiding increases in frost risks

- Cover crops can reduce soil-to-tree heat transfer and therefore, increase damage during sensitive frost nights
- Topsoil temperatures were cooler under cover crops
- We observed no ambient air temperature differences at 3 and 5 feet:
  - Suggests that cover cropped orchards may not experience higher frost risks

**One year data**

- Mowing and irrigating for frost control can be done anytime
- Consider a low-growing cover such as sub-clover for instance

C. Creze, Dani Lightle
Feeding pollinators

• Both mixes tested provided forage resources to bees during and after almond bloom
• Brassica appears more attractive than other species in these mixes.

• Achieving blooming synchrony is not trivial – early planting, mowing strategy (sanitation..)
• Little to no competition for pollination with Almond while having the potential to provide useful habitat to improve bee health
## Economic feasibility

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>Increased Yield</td>
</tr>
<tr>
<td>Planting (labor)</td>
<td>Soil erosion control</td>
</tr>
<tr>
<td>Termination (labor)</td>
<td>Nutrient cycling</td>
</tr>
<tr>
<td>Depreciation of machinery</td>
<td>Weed control</td>
</tr>
<tr>
<td>Opportunity cost of time spent learning to grow cover crops</td>
<td>Increased soil organic matter</td>
</tr>
<tr>
<td></td>
<td>Reduced surface water runoff</td>
</tr>
<tr>
<td></td>
<td>Soil-carbon storage</td>
</tr>
<tr>
<td></td>
<td>Discounted beehives (almonds only)</td>
</tr>
</tbody>
</table>

![Benefit-cost ratio graph](image)
Last thoughts

- Many interacting factors – there are opportunities for optimization according to your objective(s)
- High flexibility in its implementation
- Start small, learn from trial and error
- Every year will be different
- Inform yourself
  - Other growers
  - Farm advisors and UCCE resources
  - NRCS

Be patient, it’s a medium/long term investment (so are your trees)
Thanks to the research team, growers, industry partners and funding agencies
Check out our posters
Pollinators: POLL20, POLL13
NOW: ENTO22
Soil: STEWCROP7
Weeds: HRT12

Thank you
agaudin@ucdavis.edu
web: gaudin.ucdavis.edu
Whole Orchard Recycling - Update

by

Brent A. Holtz, Ph.D.
UC Farm Advisor in San Joaquin County

Sponsored by the Almond Board of California and the California Department of Food and Agriculture
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Burning before the clean air act of 2002

Grinding orchards for co-generation plants
Can whole orchards be incorporated into the soil when they are removed and not burned in the field or in a co-generation plant?

Can we return this organic matter to our orchard soils without negatively effecting the next orchard that will be planted?
When we remove an orchard we grind up 25-30 years worth of photosynthesis and carbon and nutrient accumulation and haul it away. 25-30 years of organic matter is lost from our system, estimated at 60 tons per acre for an almond orchard.
The Iron Wolf
The Iron Wolf
a 100,000 lb (45,000 kg) rototiller

http://ucanr.edu/?blogpost=16603 &blogasset=74534
Two Treatments:
Orchard Grinding with Iron Wolf
Pushing and Burning Trees
In a natural forest system—Tree nutrients come from either decomposing logs or ashes from forest fires.
no of tree sites counting buffers: 286
2009 First leaf trees growing in grinding plot

2010 Second leaf trees

No difference in tree circumference

The grinding did not stunt the second generation orchard
2011 Third leaf trees growing in grinding plot

2012 Fourth leaf trees growing in grinding plot
In 2010, Burn treatments had significantly more organic matter (OM), carbon (C), and Cation Exchange Capacity (CEC) in the top 10-15 cm of soil.

Burning appears to release nutrients back into the orchard soil more rapidly than decomposition.
### Soil Analysis

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grind</td>
<td>Burn</td>
<td>Grind</td>
<td>Burn</td>
</tr>
<tr>
<td>Ca (meq/L)</td>
<td>4.06 a</td>
<td>4.40 b</td>
<td>2.93 a</td>
<td>3.82 b</td>
</tr>
<tr>
<td>Na (ppm)</td>
<td>19.43 a</td>
<td>28.14 b</td>
<td>13.00 a</td>
<td>11.33 b</td>
</tr>
<tr>
<td>Mn (ppm)</td>
<td>11.83 a</td>
<td>8.86 a</td>
<td>12.78 a</td>
<td>9.19 b</td>
</tr>
<tr>
<td>Fe (ppm)</td>
<td>32.47 a</td>
<td>26.59 b</td>
<td>27.78 a</td>
<td>22.82 b</td>
</tr>
<tr>
<td>Mg (ppm)</td>
<td>0.76 a</td>
<td>1.52 b</td>
<td>1.34 a</td>
<td>1.66 a</td>
</tr>
<tr>
<td>B (mg/L)</td>
<td>0.08 a</td>
<td>0.07 a</td>
<td>0.08 a</td>
<td>0.08 b</td>
</tr>
<tr>
<td>NO₃-N (ppm)</td>
<td>3.90 a</td>
<td>14.34 b</td>
<td>8.99 a</td>
<td>11.60 a</td>
</tr>
<tr>
<td>NH₄-N (ppm)</td>
<td>1.03 a</td>
<td>1.06 a</td>
<td>2.68 a</td>
<td>2.28 a</td>
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<tr>
<td>pH</td>
<td>7.41</td>
<td>7.36</td>
<td>6.96 a</td>
<td>7.15 b</td>
</tr>
<tr>
<td>EC (dS/m)</td>
<td>0.33 a</td>
<td>0.64 b</td>
<td>0.53</td>
<td>0.64</td>
</tr>
<tr>
<td>CEC (meq/100g)</td>
<td>7.40 a</td>
<td>8.47 b</td>
<td>8.04</td>
<td>7.88</td>
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<tr>
<td>OM %</td>
<td>1.22 a</td>
<td>1.38 b</td>
<td>1.24</td>
<td>1.20</td>
</tr>
<tr>
<td>C (total) %</td>
<td>0.73 a</td>
<td>0.81 a</td>
<td>0.79 a</td>
<td>0.73 a</td>
</tr>
<tr>
<td>C-Org-LOI</td>
<td>0.71 a</td>
<td>0.80 b</td>
<td>0.72</td>
<td>0.70</td>
</tr>
<tr>
<td>Cu (ppm)</td>
<td>6.94 a</td>
<td>6.99 a</td>
<td>7.94 a</td>
<td>7.54 a</td>
</tr>
</tbody>
</table>

**Blue Pair** = grinding significantly less than burning

**Yellow pair** = grinding significantly greater than burning
## Soil Analysis

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<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
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<tr>
<td></td>
<td>Grind</td>
<td>Burn</td>
<td>Grind</td>
</tr>
<tr>
<td>Ca (meq/L)</td>
<td>3.78 a</td>
<td>3.25 b</td>
<td>7.55 a</td>
</tr>
<tr>
<td>Na (ppm)</td>
<td>2.74 a</td>
<td>1.90 b</td>
<td>3.41 a</td>
</tr>
<tr>
<td>Mn (ppm)</td>
<td>26.35 a</td>
<td>5.71 b</td>
<td>14.46 a</td>
</tr>
<tr>
<td>Fe (ppm)</td>
<td>32.56 a</td>
<td>20.38 b</td>
<td>38.58 a</td>
</tr>
<tr>
<td>Mg (ppm)</td>
<td>2.15 a</td>
<td>1.20 b</td>
<td>3.61 a</td>
</tr>
<tr>
<td>B (mg/L)</td>
<td>0.06</td>
<td>0.07</td>
<td>0.07 a</td>
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<tr>
<td>NO\textsubscript{3}-N (ppm)</td>
<td>20.11</td>
<td>12.27</td>
<td>26.53 a</td>
</tr>
<tr>
<td>NH\textsubscript{4}-N (ppm)</td>
<td>0.37</td>
<td>0.33</td>
<td>1.59 a</td>
</tr>
<tr>
<td>K (mg/L)</td>
<td>94.50</td>
<td>84.88</td>
<td>28.50 a</td>
</tr>
<tr>
<td>pH</td>
<td>7.39 a</td>
<td>7.53 b</td>
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<tr>
<td>EC (dS/m)</td>
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<td>0.68 b</td>
<td>1.54 a</td>
</tr>
<tr>
<td>CEC (meq/100g)</td>
<td>9.54</td>
<td>10.16</td>
<td>7.78</td>
</tr>
<tr>
<td>OM %</td>
<td>1.55 a</td>
<td>1.06 b</td>
<td>1.21 a</td>
</tr>
<tr>
<td>C (total) %</td>
<td>0.87 a</td>
<td>0.51 b</td>
<td>0.71 a</td>
</tr>
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<tr>
<td>Cu (ppm)</td>
<td>8.26 a</td>
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<td>8.03</td>
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**Blue Pair** = grinding significantly less than burning

**Yellow pair** = grinding significantly greater than burning
WOR increased soil C content by 68% (0-30 cm) compared to the Burn treatment.

WOR lead to +8 tons per ha of C sequestered compared to the burn treatment, 9 years after recycling.
Soil Organic Matter and Available Water Capacity
by
Berman D. Hudson
J. Soil and Water Cons. 49(2):189-194.

We estimate that Whole Orchard recycling has increased the water holding capacity of our soil by 15% based on this curve and that SOM has increased from 1.07 (burn) to 1.52 (grind) (2017 results).

Figure 1. Water content at FC and PWP versus OM content of sand surface horizons.
Impacts on soil hydraulic properties?

- Improved soil aggregation (significant higher Mean Weight Diameter in the Grind treatment (610 vs 534)
- Compaction was reduced in the Grind plots (-27%)
- Higher infiltration rate in the Grind treatment (0.003 vs 0.001 cm/s)
- Increased water retention (+13% at FC) in the Grind plots
Carmel trees were rated for bud failure symptoms

Trees growing in the grind plots had less bud failure
Whole Orchard Recycling has:

- Increased soil organic matter
- Increased soil organic carbon
- Increased soil nutrients
- Increase soil microbial diversity
- Increased orchard productivity
Growers started using manure spreaders to spread wood chips back on the soil surface.
Orchard removal typically involves five machines and costs between $600-700 acre. Horizontal grinders can chip up 15-20 acres per day. Two inch screen sizes are recommended rather than four inch screens to reduce chip size.
The Morbark horizontal chipper can chip up 15-20 acres per day.

Screens can be used to limit chip size to 2 inches or less.
Kuhn & Knight manure spreaders were modified to spread wood chips.

Keeping the chips and having them spread back onto your orchard floor will cost an additional $400 per acre.

Wood chips are spread uniformly over the entire field surface.
When 64 tons of wood chips are returned to the soil per acre:

- N = 0.31 %, 396 lbs/ac
- K = 0.20 %, 256 lbs/ac
- Ca = 0.60 %, 768 lbs/ac
- C = 50 %, 64,000 lbs/ac

The nutrients will be released gradually and naturally.
After spreading the woodchips growers can proceed with typical land preparation practices for the next orchard: ripping, disking, fumigation....
64 tons per acre caused initial tree stunting and total weed suppression. The C:N ratio was out of balance.

We doubled our nitrogen applications through fertigation in order to get the desired growth.
Northwest Tiller: can till, level, and roll in one pass

After WOR, you have 3 years to incorporate the wood chips and prepare the orchard floor for harvest.
Panaeolus sp. observation counts

Control
Wood Chips

1/4/18
1/30/18
0.8 oz of N applied in March

Control
Control

70 tons per acre rate
Both treatments received 45 lbs N/acre
Figure 8.1. Nitrogen cycle in soil. (From Stevenson, 1982.)
The San Joaquin Valley Air Pollution Control District (SJVAD) has recently approved a program that will reward growers with funding from $300-600 per acre up to $60,000 per year to implement whole orchard recycling.

For more information on these incentive programs, contact Jacob Whitson with SJVAD at 559-230-5800 or at Jacob.Whitson@ValleyAir.org.

CDFA's Healthy Soils Program may start providing growers with incentives to practice Whole Orchard Recycling

www.cdfa.ca.gov
Thank You!
Could Cover Crops or Whole Orchard Recycling Help with Orchard Management?
Upcoming Sessions at 3:30 p.m.

- Incentive Assistance: Help Applying for Grants That Fund On-Farm Practices (Room 1)
- South Korea and Japan: Almonds Make Life Beautiful (Room 2)
- Pest Management Considerations in an Ever-Changing Regulatory Environment (Room 3)
Visit the Exhibit Halls and Participate in the Passport Game

- 3P Partners #2206  
- ABC Booth #526  
- AC Horn #421  
- Ag Spray Equipment #2203  
- Bayer CropScience #127  
- Best Drayage #2112  
- Bird Gard, LLC #1812  
- Borrell USA #327  
- Cablevey Conveyors #217  
- Central Life Sciences #917  
- JAX, Inc. #413  
- JKB Energy #635  
- K-Coe Isom #707  
- Lincoln Agribusiness Services #733  
- Napasol #2205  
- NETZSCH Premier Technologies #218  
- Satake #521  
- Suterra, LLC #1638  
- TOMRA Sorting Solutions #335  
- Trécé, Inc #516  
- Valent U.S.A. #621  
- Westbridge Agricultural Products #1534  
- Wilkey Industries #320  
- Yara North America #627

The first 500 attendees to turn in a completed passport card to the ABC booth (#526) will receive a hat and will be entered to win one of seven amazing prizes!
Research Poster Session
Wednesday, 4:30 p.m. – 6:00 p.m.
Pavilion & Building D

Featured Topics:
• Soil Quality (e.g., Cover Crops, Composts, Whole Orchard Recycling)
• Pest Management
• Irrigation Management
• Biomass/Co-Products
• Almond Leadership Special Projects (Building D)
Shuttle Schedule

Shuttle service will be provided by The Almond Conference from the downtown hotels to Cal Expo daily.

- Downtown Pickup Location: Hyatt Sacramento Front Drive
- Cal Expo Pickup and Drop-Off Location: Blue Gate

Shuttle Schedule:

- Tuesday, Dec. 10
  - 6:45 a.m. – 6:30 p.m.
- Wednesday, Dec. 11
  - 6:45 a.m. – 6:30 p.m.
- Thursday, Dec. 12
  - 6:45 a.m. – 1:30 p.m.
2019 Research Update

Pick up a copy at the ABC booth #526
Join the Conversation!

Use #AlmondConf to share highlights from The Almond Conference
Dedicated Trade Show Time
4:30 p.m. – 6:00 p.m.

Social Reception Sponsored by:
Join Tonight’s Social Reception

Come and Sample:
ALMOND BROWN ALE

Stop by:
The Almond Board Lounge in Building D.

Sample:
Almond brown ale during the Tuesday and Wednesday receptions.

This almond beverage is the result of a special project from Dominique Camou and Lucas Schmidt in collaboration with Temblor Brewing Company.

Industry members and attendees are welcome to stop by and have a taste.

When:
Tuesday and Wednesday evening reception from 4:30-6:00 p.m.

4:30 p.m. – 6:00 p.m. - Pavilion + Building D
Thank you!