Whole Orchard Recycling Effects on Long Term Carbon Sequestration and Soil Health in California Almond Orchards

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Background
• Unproductive orchards are historically burned before replanting but aggressive climate change mitigation and adaption policies are calling for a change.

Whole orchard recycling (WOR), where whole trees (~60T C/ha) are ground and returned to the soil, may serve as a feasible alternative to capture carbon back into the soil while improving resilience of Almond orchards.

• California soils are historically low in organic matter and recycling biomass could provide a mean to: 1) significantly build up soil health and water conservation while 2) decreasing the cumulative GHG impacts associated with Almond production.

Soil C pools and fractions
• As expected, grind plots had more total C and N, organic C, labile C, and organic matter content compared to the burn treatment (Table 1).

Table 1. Soil chemical properties (0-15 cm).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Grind</th>
<th>Burn</th>
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</thead>
<tbody>
<tr>
<td>Total C</td>
<td>45.2</td>
<td>39.8</td>
</tr>
<tr>
<td>Organ C</td>
<td>31.1</td>
<td>27.7</td>
</tr>
<tr>
<td>OM</td>
<td>25.2</td>
<td>19.1</td>
</tr>
</tbody>
</table>

Figure 1. Plot layout and treatments.

• 14.6 T/ha C stored in the grind plots across the soil profile compared to the burn: +58% TC (0-30 cm) in the grind, 9 years after incorporation (Fig. 2).

Figure 2. Total carbon stored in the grind and burn soil at different soil depths. Different letters indicate significant difference between the treatments (P<0.05). *NS, no significant difference.

Soil aggregation and hydraulic properties
• WOR improved wet aggregate stability (+19%) compared to the burn treatment (Fig. 3).

Figure 3. Total carbon and nitrogen content in different soil aggregate sizes (a and b, respectively). *Significant difference at P<0.05.

• WOR increased soil microbial biomass, +46% and +14% (MBC and MBN, respectively) (Fig. 4).

Figure 4. Microbial biomass carbon (a) and nitrogen (b) in the grind and burn treatments. *Significant difference at P<0.05.

Methods
• The trial was established in 2008 at the University of California Kearney Agricultural Research and Extension Center (Parker, CA) on a sandy loam.

• Half of a 20-year-old stone fruit orchard was recycled using land clearing equipment (grind treatment) and the other half was burned (burn treatment). Orchard was replanted with 3 almond varieties (Nonpareil, Butte, and Carmel) in a complete randomized block design.

• In 2017, a deficit irrigation trial was implemented for 28 days from 6/5 to hull split (T3) on the Nonpareil variety (Fig. 1).

• Dark irrigation (80% ET) and regular irrigation (100% ET) treatments were split (7/3) on the Nonpareil variety (Fig. 1).

WOR improves tree water status
• Higher stomatal conductance (+9.7%) in the grind treatment under both irrigation scenarios (Fig. 5).

Figure 5. Soil enzyme activity in the grind and burn plots.

Conclusions and next steps...
• Soil carbon content and labile pools remained significantly higher 9 years after biomass incorporation compared to open field burning.
• WOR provides an opportunity to improve soil health and its potentials to both conserve water and increase yields.
• Overall, Cumulative GHG impact is reduced by 46%.
• Studying long term and short term effects of whole orchard recycling on soil nitrogen retention is ongoing.
• In a soil column experiment using 15N labeled fertilizer, we will measure shifts in processes involved in soil N availability and retention such as gross N mineralization, immobilization, and leaching.

Acknowledgements
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