Weed and Nutrient Management in Organic Orchards

David Granatstein

WSU CSANR
Wenatchee, WA

UC Organic Tree Fruit Meeting, Feb. 23, 2011
Outline

• Organic tree fruit trends and economics
• Weed control studies
• Growing N
• Discussion
World organic temperate tree fruit area, 2008

Total area 116,000 ha

- Apples: 35,268
- Apricots: 10,683
- Plums: 8,045
- Cherries: 7,256
- Pears: 6,776
- Peaches & nectarines: 6,402
- Stone fruit, no details: 3,418
- Pome fruit, no details: 1,191
- Temperate fruit, no details: 36,809

Source: FiBL/IFOAM survey, CDFA 2008; WSDA 2008

http://csanr.wsu.edu/Organic/OrganicStats.html
# Economic Estimates

## Organic / conventional* apple production

<table>
<thead>
<tr>
<th></th>
<th>USA (WA)</th>
<th>Canada (BC)</th>
<th>USA (NY)</th>
<th>Switz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>71</td>
<td>+58</td>
<td>309</td>
<td>+312</td>
</tr>
<tr>
<td>Weed control</td>
<td>493</td>
<td>+43</td>
<td>129</td>
<td>+115</td>
</tr>
<tr>
<td>Pest mgt.</td>
<td>644</td>
<td>+17</td>
<td>367</td>
<td>+60</td>
</tr>
<tr>
<td><strong>Total direct cost</strong></td>
<td>3,685</td>
<td>-4</td>
<td>3,190</td>
<td>+92</td>
</tr>
<tr>
<td>Gross return</td>
<td>7,209</td>
<td>+40</td>
<td>6,979</td>
<td>+66</td>
</tr>
<tr>
<td>Net return</td>
<td>183&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td>3,002</td>
<td>+17</td>
</tr>
<tr>
<td>Price (US$/lb)</td>
<td>0.14</td>
<td>+58</td>
<td>0.18</td>
<td>+74</td>
</tr>
<tr>
<td>Yield (ton/ac)</td>
<td>26.0</td>
<td>n.d.</td>
<td>16.0</td>
<td>-5</td>
</tr>
</tbody>
</table>

% Diff. is % difference between conventional and organic. n.d. is no difference. * For NY and Switzerland, ‘conventional’ system was Integrated Fruit Production
WA: ‘Golden Delicious’/M26; Yakima Valley; adapted from Glover et al., 2002. <sup>a</sup> Conv. apple lost US$4587/ha
BC: variety not specified, Okanagan Valley, BC; MAFF, 2002.<sup>b</sup>
NY: IFP vs. organic; ‘Liberty’/M9; G. Peck, unpublished; <sup>b</sup> no pruning, training, taxes, interest, etc.; cullage IFP 3-17%, organic 3-75%; <sup>c</sup> gross margin only
Switzerland: IFP ‘Golden Delicious’ vs. organic scab resistant variety; E. Bravin, ARBOKOST, ACW. No land charge or establishment cost included.
## WA Apple Costs at Full Production

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit thinning</td>
<td>630</td>
<td>653</td>
<td></td>
</tr>
<tr>
<td>Chemicals, fertilizer</td>
<td>1,518</td>
<td>900</td>
<td>+68%</td>
</tr>
<tr>
<td>Total variable costs</td>
<td>6,558</td>
<td>5,651</td>
<td>+16%</td>
</tr>
<tr>
<td>Total fixed costs</td>
<td>4,848</td>
<td>5,105</td>
<td>-5%</td>
</tr>
<tr>
<td>Total costs</td>
<td>11,407</td>
<td>10,757</td>
<td>+6%</td>
</tr>
<tr>
<td>Production bin/ac</td>
<td>50 x $300/bin</td>
<td>50 x $250/bin</td>
<td></td>
</tr>
<tr>
<td>Gross income</td>
<td>15,000</td>
<td>12,500</td>
<td>+20%</td>
</tr>
<tr>
<td>Net return</td>
<td>3,593</td>
<td>1,743</td>
<td>+106%</td>
</tr>
</tbody>
</table>

‘Gala’/M.9 4’x10’ trellised
Price Trends
Washington Apples

Gala

$/Box FOB

20
10
0
1995 96 97 98 99 2000 01 02 03 04 05 06 07 08 2009 to 11/15/10

Fuji

$/Box FOB

20
10
0
1995 96 97 98 99 2000 01 02 03 04 05 06 07 08 2009 to 11/15/10

WAGCHA data; FOB average, all storage, grades, sizes
Price Trends
Washington Pears

Bartlett

D’Anjou

WAGCHA data; FOB avg, all storage, grades, sizes
Cherry Price Trends
Washington State

WAGCHA data. Conventional prices are from season FOB histories; may include organic 2008-2010. Organic prices are from season FOB histories or from sales data search. All grades and sizes. Photo: ARS Image Gallery
<table>
<thead>
<tr>
<th>Was organic fruit production profitable?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008 crop</td>
<td>43%</td>
<td>57%</td>
</tr>
<tr>
<td>2009 crop</td>
<td>65%</td>
<td>35%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wash. organic orchardists</th>
</tr>
</thead>
</table>

| Compare cost of organic fruit production to similar conventional. (% of responses) |
|--------------------------------|-----|-----|-----|
|                                | 2008| 2009| 2010|
| 20% or more lower             | 4   | 5   | 3   |
| 10% lower                     | 8   | 15  | 1   |
| Similar                       | 13  | 7   | 7   |
| 10% higher                    | 34  | 18  | 28  |
| 20% or more higher            | 41  | 55  | 61  |
How do you see your organic fruit production changing over the next five years?

1. Expand acres under organic management
2. Decrease acres of organic management
3. Stay about the same
4. Exit organic production
5. Exit all fruit production
6. Don’t know

Wash. organic orchardists, Jan. 2011
Weed Control

Why control weeds?

• Limit competition with young trees – nutrients, water
• Minimize rodent habitat
• Weeds as hosts for pests, disease inoculum
• Maintain good sprinkler pattern
## Organic Orchard Weed Control Options

<table>
<thead>
<tr>
<th>Method</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillage</td>
<td>Effective; rodents; low cost</td>
<td>Reduced tree growth, fruit size; soil quality; damage trees</td>
</tr>
<tr>
<td>Flaming</td>
<td>Control weeds around trunk; rodents; low cost</td>
<td>Tree injury, perennial weeds, fossil fuel</td>
</tr>
<tr>
<td>Inert mulches</td>
<td>Effective; soil quality; moisture</td>
<td>Costly; N tie up; soil quality</td>
</tr>
<tr>
<td>Living mulches</td>
<td>Add biodiversity; soil quality; fix N</td>
<td>Competition; rodents; persistence</td>
</tr>
<tr>
<td>Organic herbicides</td>
<td>Control weeds around trunk; rodents; no tree, root damage</td>
<td>Effectiveness; high cost; multiple applications</td>
</tr>
</tbody>
</table>

*(Granatstein & Mullinix, 2008)*
## Alternative Weed Control Costs

<table>
<thead>
<tr>
<th>Method</th>
<th>Rate</th>
<th>Freq.</th>
<th>Cost/ac/yr ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(ac)</td>
<td>Material</td>
<td>Appl.</td>
</tr>
<tr>
<td>Glyphos.</td>
<td>0.5 l</td>
<td>4/yr</td>
<td>24</td>
</tr>
<tr>
<td>Weed fabric</td>
<td>5’ x 3750’</td>
<td>1/6 yr</td>
<td>286</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>8.5 ton</td>
<td>1/2 yr</td>
<td>319</td>
</tr>
<tr>
<td>Wood chip</td>
<td>100 yd³</td>
<td>1/3 yr</td>
<td>200</td>
</tr>
<tr>
<td>Spray on</td>
<td>3.4 ton</td>
<td>1/1.5 yr</td>
<td>234</td>
</tr>
<tr>
<td>Flaming</td>
<td>48 lb</td>
<td>3/yr</td>
<td>36</td>
</tr>
</tbody>
</table>

(Hogue et al., 2002)
Brewster orchardist:
- Burn 4-5 ac/hr
- 10 gal propane/hr
- 4x per season
- Cost $70-80/ac

Flame Weeding
Wenatchee orchard:
Fabric $330-800/acre; lasts ~ 10 yr
Labor to apply $100-200/acre
Labor to open and close each year $200/acre
Weed Fabric in Sweet Cherry

OSU, Hood River, OR – 2001-2007

- Fabric groundcover vs. bare ground in tree row
- 2001-2004 – fabric $2125/acre increased costs
- 2004 – fabric trt gross returns $3240/acre more than bare ground (1st yr of production)
- 2005 - $1633/acre more with fabric
- Fabric – trees produced more fruit at an earlier age, maintained higher yields

(Tomasini et al., 2007)
WVC Mulch Trial

Weed Control by Mulches – 6/1/00

8-yr ‘Red Delicious’/M.26
Wenatchee, WA

Shredded paper mulch
Effect of Orchard Mulching on Soil Moisture Depletion
Spray-on Paper Mulch

Applied August 2001

Cost and longevity are key issues.

August 2002
Winter rye
## Tillage Effects

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stem Circ. (mm)</th>
<th>Pruning Mass (g/2 trees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herb. Strip</td>
<td>100.3 a</td>
<td>604 a</td>
</tr>
<tr>
<td>Mech. Cult.</td>
<td>85.2 b</td>
<td>234 b</td>
</tr>
</tbody>
</table>

3-yr old high density apple

Significant growth reduction with tillage

*(Wooldridge and Harris, 1989)*
Tillage Effects

<table>
<thead>
<tr>
<th>Depth (in)</th>
<th>Length (in)</th>
<th>Root Conc. (in/in)</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilled (3” depth, 4x)</td>
<td>0-3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3-7</td>
<td>666</td>
<td>222</td>
</tr>
<tr>
<td></td>
<td>7-12</td>
<td>240</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>12-18</td>
<td>213</td>
<td>36</td>
</tr>
<tr>
<td>Herb. Strip</td>
<td>0-3</td>
<td>838</td>
<td>279</td>
</tr>
<tr>
<td></td>
<td>3-7</td>
<td>712</td>
<td>237</td>
</tr>
<tr>
<td></td>
<td>7-12</td>
<td>330</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>12-18</td>
<td>234</td>
<td>39</td>
</tr>
</tbody>
</table>

19-yr old pear
Trees did not compensate deeper in soil for surface roots lost from tillage

(Cockroft & Wallbrink, 1966)
Weed Control

Tillage Comparison Trial, 2004-2006

- Control (mow), wood chip mulch, Weed Badger, Wonder Weeder at tillage frequencies (2x, 3x, 4x)
- Control = mowed weeds
- Wood chip layer 6” thick

Tree row after tillage with Wonder Weeder
Wonder Weeder
465 ft/min

Weed Badger
21.2 ft/min
Wood chip mulch
Tillage Comparison Trial

‘Gala’/M.26, E. Wenatchee, WA

04/30/2004
06/29/2004
07/12/2004
07/26/2004
08/26/2004
09/16/2004
10/05/2004
03/25/2005
04/06/2005
05/16/2005
06/02/2005
07/07/2005
08/04/2005
09/06/2005

weed % cover

2004
2005

Control/Mow
Wood chip
Cult Z 4x

Tillage date
# Tillage Trial results

<table>
<thead>
<tr>
<th>TRT</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit Yield</td>
<td>Fruit Size 80-88</td>
<td>Gross Fruit Value*</td>
</tr>
<tr>
<td></td>
<td>kg/tree</td>
<td>%</td>
</tr>
<tr>
<td>Wood chip</td>
<td>22.4</td>
<td>15.5 a</td>
</tr>
<tr>
<td>Control mow</td>
<td>20.4</td>
<td>6.6 b</td>
</tr>
<tr>
<td>Cultivator Z 3x</td>
<td>17.6</td>
<td>7.0 b</td>
</tr>
<tr>
<td>p=</td>
<td>0.150</td>
<td>0.014</td>
</tr>
</tbody>
</table>
Orchard Floor Management in a New Planting

Sweet Woodruff ‘Sandwich’ system

Living mulch non-legume

‘Pinova’/EMLA.7

‘Green islands’ from fertilizer injection
Total Biomass
3-yr Pinova/EMLA.7
E. Wenatchee, WA

Yield Efficiency
(g fruit/g tree DM)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living mulch legume</td>
<td>0.78</td>
</tr>
<tr>
<td>Wood chip mulch</td>
<td>0.41</td>
</tr>
<tr>
<td>Wonder Weeder tillage</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Living Mulches

White clover
Late summer 2000

Early spring 2002

Rodents – the weak link.
Vole Trail Length
IMM Trial, Winter 05/06
(Winter 06/07, too few to analyze)

Wood chip (WC) = bare ground (CTL) = tilled (WW)

*Galium* in Sandwich system (SWNL) significantly lower voles than other in-row living mulches
Brassica Seed Meal

- BSM to control apple replant disease
- Assess weed suppression, N effect (6% N); ‘weed and feed’?

- 85% reduction of weeds with BSM; adequate for first season
- Results varied with soil type

Courtesy: L. Hoagland, M. Mazzola
3 sites
‘Gala’/M.26 – 8 yr old, sandy soil, quackgrass
‘Honeycrisp’/M.26 – 4 yr old, loam soil, quackgrass
‘Anjou’ pear – 15 yr old, loam soil, quackgrass

Comparing mulch, tillage, herbicide/burn

Shade in pears reduced weed pressure

Herbicide not effective for long, mulch helped

$230/ac for dedicated tractor and driver for cult., burn, or herb – 3-4 trips per month

‘Gala’ fruit yield: Mulch>Till>Herb, fruit size same
Effect of Weed Management on In-row Vegetation

$230/ac for dedicated tractor and driver for cult., burn, or herb – 3-4 trips per month
## Tree leaf total N, 2010

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Vantage</th>
<th>Pine Creek</th>
<th>Sundown</th>
<th>Sunrise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicide</td>
<td>2.32 b</td>
<td>1.99</td>
<td>2.66</td>
<td>2.40 a</td>
</tr>
<tr>
<td>Tillage</td>
<td>2.34 b</td>
<td>2.08</td>
<td>2.71</td>
<td>2.43 a</td>
</tr>
<tr>
<td>Wood chip</td>
<td>2.39 a</td>
<td>2.00</td>
<td>2.51</td>
<td>2.27 b</td>
</tr>
<tr>
<td>Weed fabric</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>2.37 a</td>
</tr>
<tr>
<td>( p )</td>
<td>0.012</td>
<td>0.281</td>
<td>0.562</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Foreman Land and Fruit Co.
Tree and Soil Water

Soil temperature (5 cm) Aug. 3

Till  31.3° C
Mulch  19.7° C

Optimum for dwarfing rootstock 14° C
(Skroch and Schribbs, 1986)
GreenMatch® herbicide, mid-summer
GreenMatch® herbicide, mid-summer
Going Forward

New Equipment

Weed brushes, Italy

Spin weeder

Spedovator

Microwave weeder
Nutrient Management

• Nitrogen – always needed

• Organic sources – nutrient release rate (manure vs compost), nutrient composition, origin (e.g. chicken and arsenic)

• Organic sources – higher transport cost, application cost; pre-harvest interval

• Need good water management

• Need weed control to minimize competition with trees
Peshastin Creek Growers Association
D'Anjou Pear Leaf Nitrogen, 2004

IPM Management Program
Organic Soft Conventional

Leaf Nitrogen (%)

Different horticultural practices; same insect control

Same horticultural practices; different insect control

Organic Soft Conventional

IPM Management Program

F. Peryea
Organic Nutrient Content, Release and Cost

Extensive lab and field research done on many amendments

Release rate correlated to total N

Organic fertilizer calculator developed based on this research

http://smallfarms.oregonstate.edu/calculator
White clover living mulch

- In-row
- Recycles P, K
- Root N contributions, but N fix suppressed
-Suppresses weeds
- Rodent risk

- 46% of clover N mineralized over 3 weeks
- Tree growth, fruit yield enhanced
Grow Your Own N

Nitrogen release over 3 weeks from ambient soil with and without clover, root exclusion tubes, and tube covers.

Soil Nitrate

<table>
<thead>
<tr>
<th>kg N/ha</th>
<th>7/24/2001</th>
<th>7/31/2001</th>
<th>8/7/2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>80</td>
<td>70</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>40</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

A – control plot; tube + cover; no clover

B – control plot; tube + cover; clover clippings added

C – clover plot; tube + cover, clover clippings added

D – clover plot; tube – cover, clover clippings added

E – control plot; no tube

F – clover plot, no tube

46% of clover N mineralized

Tree growth, fruit yield enhanced
Grow N Trial

• Legumes direct seeded in drive alley (4’ swath) – May 19, 2008
  ▪ Alfalfa cv. Radiant
  ▪ Jumbo Ladino white clover
  ▪ Kura clover
  ▪ Birdsfoot trefoil cv. Norcen

• SPRAY or NO SPRAY prior to seeding

• Mow and blow on to tree row
Alfalfa after seeding
Spray

Ladino clover

Year 1

No spray
## Effect of Pre-seeding Treatment on Biomass

<table>
<thead>
<tr>
<th></th>
<th>Sum of 8/08, 7/09, 8/09 cuttings</th>
<th>Legume only, 7/09</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sprayed</td>
<td>Unsprayed</td>
</tr>
<tr>
<td><strong>Dry matter (kg/ha)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>759 a</td>
<td>685 a</td>
</tr>
<tr>
<td>Ladino</td>
<td>701 a</td>
<td>719 a</td>
</tr>
<tr>
<td>Trefoil</td>
<td>783 a</td>
<td>716 a</td>
</tr>
<tr>
<td>Kura</td>
<td>476 a</td>
<td>486 a</td>
</tr>
</tbody>
</table>
Ladino Clover – May, Yr 2
Alfalfa – May, Yr 2
Mow and Blow

Legume residue in tree row after mow and blow
Year 3, 2010

Alfalfa

Trefoil

39 days after mowing
Morgan Orchard

Cumulative Cover Crop Biomass

Cover Crop Biomass, 2008-10

Biomass DM (kg/ha)

Cumulative Cover Crop Biomass

Alfalfa
Grass
Kura
Ladino
Trefoil

Spray
No spray

2008
2009
2010
% Cover of Legumes in Drive Alley

Morgan Orchard 2008-10, Kura clover

Morgan Orchard 2008-10, Alfalfa

Morgan Orchard 2008-10, Birdsfoot trefoil

Morgan Orchard 2008-10, Ladino clover
Grower Application

• Grafted ‘Fuji’ Young apple block
• Seeded mid May of 2010
• Direct seed drill directly into existing vegetation of grasses and weeds (flailed before seeding) -- double pass, high seeding rate
• Excellent establishment; ~7’ swath

Photos June 16, 2010
Direct-seeded Alfalfa

June 23, 2010
Red Clover

Tilled and seeded

June 14, 2010
## N Contribution

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>38</td>
<td>251</td>
<td>3.56</td>
<td>4.11</td>
<td>46.9</td>
</tr>
<tr>
<td>Trefoil</td>
<td>26</td>
<td>179</td>
<td>3.60</td>
<td>3.40</td>
<td>39.2</td>
</tr>
<tr>
<td>Ladino</td>
<td>25</td>
<td>173</td>
<td>2.62</td>
<td>3.92</td>
<td>32.8</td>
</tr>
<tr>
<td>Kura</td>
<td>14</td>
<td>132</td>
<td>2.72</td>
<td>3.07</td>
<td>26.7</td>
</tr>
<tr>
<td>Grass</td>
<td>15</td>
<td>103</td>
<td>3.28</td>
<td>2.30</td>
<td>24.2</td>
</tr>
</tbody>
</table>

*Ave. 2009 and 2010. Yield on a full acre basis; actual strips are 0.16 of area (2.2’ strip)*
Economics

Costs per acre of orchard, 4’ swath

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicide</td>
<td>7.15</td>
</tr>
<tr>
<td>Tractor/sprayer</td>
<td>14.85</td>
</tr>
<tr>
<td>Tractor/seeder</td>
<td>29.70</td>
</tr>
<tr>
<td>Seed</td>
<td>32.00</td>
</tr>
<tr>
<td>Total</td>
<td>83.90</td>
</tr>
</tbody>
</table>

Planting good for at least 5 yr - $21/yr cost

Alfalfa – 3.5 ton/ac/yr @ 4% N = 280 lb N

<table>
<thead>
<tr>
<th>Width</th>
<th>N content</th>
<th>Fert. Value$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5’</td>
<td>101</td>
<td>$71</td>
</tr>
<tr>
<td>4’</td>
<td>81</td>
<td>$57</td>
</tr>
<tr>
<td>3’</td>
<td>59</td>
<td>$41</td>
</tr>
</tbody>
</table>

$84 cost / 130 lb N$^b (4 yr) = $0.65/lb

$^a$Estimate N fertilizer at $0.70/lb
$^b$40% avail., accounting for Nmin (50-70%), losses
What we learned so far …

- Need multiple years to assess species
- Shade, traffic affecting growth
- Spraying out grass helped, but all legumes had reasonable stands; compensate with double pass, higher seed rate
- Need greater growing surface to boost N contribution; net ~3’ with tires
- Combinations? Alfalfa + ladino + kura?
- Effects on soil P, K levels over time?

Thanks to USDA Organic Research Special Grant for funding.
Questions ?