Sustainable Horticulture in Fruit Production

David Granatstein and Eugene Kupferman

Washington State University Tree Fruit Research & Extension Center
Wenatchee, WA USA
Outline

• What is sustainable agriculture? (definition, strategies)
• Sustainability issues in fruit production
• Has fruit production become more sustainable? (IFP, organic, comparisons)
• Future sustainability
Sustainable Agriculture
“A long-term goal”

Economically Viable

Environmentally Sound

Socially Acceptable

Meet the needs of today without compromising the ability of future generations to meet their needs

A 3-legged stool

Not a set of farming practices

Meet the needs of today without compromising the ability of future generations to meet their needs
Three Major Strategies for Sustainability

- **Efficiency**
  (water, spray, nutrients)

- **Substitution**
  (IGRs, microbials for organophosphates)

- **Redesign**
  (perennial polyculture)

(McRae et al., 1990)
Redesigning Farming

Albert Smith farm, southeast Minnesota
Redesigning Agroecosystems

‘Pedestrian’ orchard benefits:
- economic (faster returns, higher quality fruit, lower labor costs for maintenance)
- environmental (better IPM)
- social (less ladders, less worker injury)

Trade-off: more sunburn?
Rose gardens planted in 2000; parasitism increases thru the summer and has increased from 2001-2005

Rosa woodsii

Redesign with Rose Gardens

Courtesy: T. Unruh
How do we measure sustainability in agriculture?

System comparison studies
- long term studies
- do they use the latest technology?

Established standards
- soil erosion (tolerable soil loss)
- water quality (10 mg/L nitrate)
- pesticide residues, worker exposure

Indices – soil quality, Env. Impact Quotient

Economics – profitability, new farmers

Social – family farms, community impacts, food quality and human health

No single unifying measure
Global Sustainable Ag Trends

**Production**
- IPM / Biocontrol of pests
- Organic farming
- Water quality protection (pesticides, nutrients, pathogens)
- Biodiversity enhancement on farms

**Marketing**
- More product identity – ecolabels, wine grape sustainability code, fair trade, country of origin
- Social accountability in business - SASA; sustainable business practices
**Sustainability Issues in Fruit Production**

**- Economic -**

**WSU study – high density Fuji apple, 40 ha farm**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable costs</td>
<td>$7350 / ha</td>
</tr>
<tr>
<td>Fixed costs</td>
<td>$6867 / ha</td>
</tr>
<tr>
<td>Labor</td>
<td>$ 3.12 / box</td>
</tr>
<tr>
<td>Total growing + harvest</td>
<td>$10.28 / box</td>
</tr>
<tr>
<td>Warehouse costs</td>
<td>$ 7.50/ box</td>
</tr>
<tr>
<td>Breakeven</td>
<td>$17.78 / box</td>
</tr>
<tr>
<td>Ave. price 2000</td>
<td>$12.75 / box</td>
</tr>
<tr>
<td>Loss</td>
<td>$6916 / ha</td>
</tr>
</tbody>
</table>

1995-2002 – price > breakeven in 4 of 8 years

(Schotzko, 2004)
Sustainability Issues

Marketing, Input, and Farm Shares of Food System Dollars

- Market share
- Farm share
- Input share

Year: 1910 to 1990

Percent: 0 to 100

(S. Smith)
Sustainability Issues in Fruit Production

- Environmental -

Pesticides
Water quality, quantity
Energy
Atmosphere (e.g. methyl bromide)
Biodiversity, habitat
Loss of farmland, urbanization
Sustainability Issues - Environmental

INSECTICIDE RESISTANCE

NUMBER OF RESISTANT SPECIES


TOTAL (504)
CYCLODIENE (291)
DDT (263)
ORGANOPHOSPHATE (260)
CARBAMATE (85)
PYRETHROID (48)

(Source: US EPA)
Social Sustainability

- Family farms
- Rural communities
- Food security
- Next generation of farmers
- Farm workers
- Human health
- Fair trade
Has fruit production become more sustainable?

Pest management successes – IPM, biocontrol, reduced risk products

**Apple - *Cydia pomonella* control – change over time**

- Lead arsenate
- DDT
- Azinphos-methyl
- Pheromone mating disruption
- Codling moth granulosis virus
- ??

Conventional then

Conventional now
Has fruit production become more sustainable?

IPM and Biocontrol in Washington Apples

Total kg a.i./yr

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>1989</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guthion</td>
<td>193,270</td>
<td>117,680</td>
</tr>
<tr>
<td>Dimethoate</td>
<td>5,410</td>
<td>60</td>
</tr>
<tr>
<td>Malathion</td>
<td>28,820</td>
<td>1,730</td>
</tr>
<tr>
<td>B.t.</td>
<td>370</td>
<td>11,090</td>
</tr>
<tr>
<td>Spinosad</td>
<td>n.a.</td>
<td>3,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practice</th>
<th>% growers using</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field monitor</td>
<td>91</td>
</tr>
<tr>
<td>Econ. threshold</td>
<td>37</td>
</tr>
<tr>
<td>Use biocontrols</td>
<td>34</td>
</tr>
</tbody>
</table>

Source: WSU IPM survey
Mating Disruption in Apples

Pheromone Communication

Pheromone Confusion

Pheromone dispensers
Codling moth pheromone products uses in Washington apple and pear orchards

Total ha treated with pheromone products


Source: J. Brunner
Has fruit production become more sustainable?

Water conservation – micro sprinklers, drip irrigation, soil moisture monitoring, deficit irrigation

Evaporative cooling?

Effect of Orchard Mulching on Soil Moisture Depletion

![Photo: L. Schrader](source-image-url)
Has fruit production become more sustainable?

US per capita fresh fruit consumption 1970-2004:
Apple – no change
Orange -33%
Total +24%
Banana +48%
Grape +177%

Greater emphasis on fruit and vegetable consumption
– ‘Five A Day’ campaign

Growth in pre-sliced fruit – meets the convenience factor, healthy snack food

New fruit varieties, more focus on flavor

Decline in ‘Red Delicious’ production – Washington State
Has fruit production become more sustainable?

Two established approaches:

Integrated Fruit Production (IFP)

Organic farming

Similarities:
• Emphasize bio-intensive management, whole system
• Use guidelines, standards, certification, label identity
• Restrict materials

Differences:
• IFP focus on IPM, organic focus on soil
• Synthetics generally not allowed in organic, fewer tools
• Organic standards more rigid, less adaptable to locale
• Organic more widely known by consumers, higher price
• No GMOs in organic
Integrated Fruit Production (IFP)

Framework, guidelines and principles developed by IOBC (1993)

- Crops
- Nutrient management
- Soils
- Biological diversity and landscape
- Pest control
- Product quality

Strong emphasis on Integrated Pest Management (IPM) and biocontrol

Many regional, national programs for pome fruit, stone fruit, grapes
Integrated Fruit Production (IFP) Experience

- Driven by Europe (40% of apple and pear acreage in IFP, 1994), markets demanded IFP fruit
- Exporters to Europe developed IFP programs (NZ, S. Africa, Argentina)
- Europe has good infrastructure for IFP
- IFP has helped reduce production costs
- No price premium to growers; government subsidies are key
Integrated Production in the US

- Confusion, competition with “organic”
- Provides a positive message about agriculture
- Some price premiums in other foods (beef, vegetables)
- Some success with market access for fruit (Food Alliance, Salmon Safe)
- Increased interest in wine grapes
- Infrastructure not developed
Impacts of IFP

- Pesticide reduction (50%, New Zealand)
- Resistance management, more biocontrol (apples, Italy)
- Water conservation (50%, USA)
- Improved yield (+26-45%, Canada)
- Reduced costs (bananas, Costa Rica)
Organic Agriculture

• Accounts for ~2% of food sales, <0.01% of ag land in US
• Over 10% of ag land is organic in some European countries, >5% of food sales
• Organic food sales growing at 20% per year
• Legally binding certification systems worldwide
• Strong consumer recognition, unclear understanding
• Focus on soil health, natural materials
• Fewer tools, often less durable or effective
Organic Fruit Production

Sensitive to agroclimatic conditions; often less pest and disease problems in semi-arid regions

Higher cost: fertility, pest control, labor

Yields, quality – similar to conventional in Washington; up to 50% reductions in more humid regions

IPM, biocontrol progress benefits organic

Need price premium; but often more profitable

Requires higher level of management
Apple Price Trends – Washington State, USA

Fuji

Golden Delicious

WA Growers Clearinghouse data
Organic and Sustainability

- Organic farms vary in their sustainability, as do conventional.
- Organic farm A might be more or less than conventional farm B.
- Organic farms are more likely to be more sustainable than conventional.

Hypothetical distribution of farms on a sustainability index.
### The European Experience

<table>
<thead>
<tr>
<th>Indicators</th>
<th>++</th>
<th>+</th>
<th>0</th>
<th>-</th>
<th>--</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil (erosion, OM)</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground and Surface Water (leaching)</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate and Air</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm Input and Output (nutrient, water, energy use)</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal Welfare and Health</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of Produced Food</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:** ORG compared to CONV: ++ much better, + better, 0 same, - worse, -- much worse

*Stolze et al, 2000: The Environmental Impacts of Farming in Europe*
Nitrate Leaching Rates - Europe

Reduction in nitrate leaching from organic farms compared to conventional Authors

>50% Smilde (1989)
>50% Vereijken (1990)
57% Paffrath (1993)
40% (sand) Blume et al. (1993)
0% (loam)
50% Reitmayr (1995)
40% Berg et al. (1997)
64% Haas (1997)

(Scialabba and Hattam, 2002)
Sustainable Ag Trial – California

Conv. 2 yr, Conv. 4 yr, low input, organic – 12 year study

Yield difference never more than 10%

Cover crop – increased summer infiltration 2x, decreased winter runoff >10x

Conv. Lost 10x more applied N than low input, 5x more than organic

<table>
<thead>
<tr>
<th></th>
<th>N input (kg/ha)</th>
<th>Loss of applied N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Org</td>
<td>1924</td>
<td>4.6</td>
</tr>
<tr>
<td>Low</td>
<td>1550</td>
<td>2.4</td>
</tr>
<tr>
<td>Conv 4</td>
<td>1827</td>
<td>22.3</td>
</tr>
<tr>
<td>Conv 2</td>
<td>1584</td>
<td>28.5</td>
</tr>
</tbody>
</table>

(Huyck et al., 2003)
Effect of apple orchard management system on sustainability indicators

WSU Orchard Systems Trial - Washington, USA

<table>
<thead>
<tr>
<th>Metric</th>
<th>Conv.</th>
<th>Integrated</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy input (MJ/ha)</td>
<td>516,489</td>
<td>488,661</td>
<td>445,328</td>
</tr>
<tr>
<td>Environmental impact rating</td>
<td>2,893</td>
<td>2,211</td>
<td>466</td>
</tr>
<tr>
<td>Soil quality rating</td>
<td>0.70</td>
<td>0.81</td>
<td>0.83</td>
</tr>
<tr>
<td>TCSA 6th leaf (cm²)</td>
<td>28.0</td>
<td>28.2</td>
<td>28.5</td>
</tr>
<tr>
<td>Fruit yield 1996-99 (MT/ha)</td>
<td>210</td>
<td>205</td>
<td>198</td>
</tr>
<tr>
<td>Variable costs ($/ha/yr)</td>
<td>10,145</td>
<td>9,666</td>
<td>9,124</td>
</tr>
</tbody>
</table>

(Reganold et al., 2001)
Organic Orchards in the Northeast USA  
*Pest Management Costs IFP vs. Organic Apples - 2004*  

<table>
<thead>
<tr>
<th>Cost category</th>
<th>IFP (US$/ha)</th>
<th>Organic (US$/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray products</td>
<td>$961</td>
<td>$2,198</td>
</tr>
<tr>
<td>Spray labor</td>
<td>$768</td>
<td>$889</td>
</tr>
<tr>
<td>Hand thinning</td>
<td>$684</td>
<td>$929</td>
</tr>
<tr>
<td>Cultivating</td>
<td></td>
<td>$57</td>
</tr>
<tr>
<td>Fruit washing</td>
<td></td>
<td>$1,754</td>
</tr>
<tr>
<td><strong>Totals for year:</strong></td>
<td><strong>$2,413</strong></td>
<td><strong>$5,827</strong></td>
</tr>
</tbody>
</table>

(See Merwin et al., 2005)

**Environmental Impact Quotient**  
-- Red Delicious apple, New York State, USA  
<table>
<thead>
<tr>
<th>Conventional</th>
<th>IPM</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>938</td>
<td>167</td>
<td>1799</td>
</tr>
</tbody>
</table>

(See Kovach et al., 1992)
Sustainable Ag Trial – California

(Huyck et al., 2003)
Ecolabels for Sustainable Production

Marketing sustainability:
• Know your consumer
• Clear, credible message
• Distinguish self-interest, altruism
• Benefits to growers in addition to price premium
## Importance of environmental sector to consumers
(% responses very high and high)

<table>
<thead>
<tr>
<th>Environmental Sector</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>57</td>
</tr>
<tr>
<td>Air</td>
<td>22</td>
</tr>
<tr>
<td>Habitat</td>
<td>11</td>
</tr>
<tr>
<td>Soil</td>
<td>6</td>
</tr>
<tr>
<td>Energy</td>
<td>5</td>
</tr>
</tbody>
</table>

(Hartman, 1997)
Future Sustainability

Mega-trends:
• Peak oil
• Climate change

Source: IPCC
Campbell, C. 2004
Future Sustainability

Likely trends:

• Mechanization to reduce labor
• Nutritional / nutraceutical content
• Greater importance of ‘local’
• Blurring of lines – conventional vs. organic – more integration of good ideas
• Is IFP or Organic more sustainable?

Ultimate impact = sustainability gain x area (e.g. 100% IFP in New Zealand apple, 50% pesticide reduction; 5% organic apple in WA)