Organic Growing

Michael Bomford
Kentucky State University
US Organic Farms, 2006
<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Quantity</th>
<th>Organic</th>
<th>Conventional</th>
<th>Organic Premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus</td>
<td>11#</td>
<td>$60.00</td>
<td>$22.00</td>
<td>173%</td>
</tr>
<tr>
<td>Avocado: Hass</td>
<td>48 Ct</td>
<td>$48.50</td>
<td>$32.00</td>
<td>52%</td>
</tr>
<tr>
<td>Broccoli</td>
<td>14 Ct</td>
<td>$32.00</td>
<td>$12.00</td>
<td>167%</td>
</tr>
<tr>
<td>Carrots</td>
<td>24x2#</td>
<td>$44.00</td>
<td>$14.00</td>
<td>214%</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>12 Ct</td>
<td>$32.00</td>
<td>$12.00</td>
<td>167%</td>
</tr>
<tr>
<td>Celery</td>
<td>24 Ct</td>
<td>$47.50</td>
<td>$26.00</td>
<td>83%</td>
</tr>
<tr>
<td>Lettuce: Greenleaf</td>
<td>24 Ct</td>
<td>$31.20</td>
<td>$15.00</td>
<td>108%</td>
</tr>
<tr>
<td>Lettuce: Red Leaf</td>
<td>24 Ct</td>
<td>$37.00</td>
<td>$15.00</td>
<td>147%</td>
</tr>
<tr>
<td>Lettuce: Romaine</td>
<td>24 Ct</td>
<td>$36.75</td>
<td>$18.00</td>
<td>104%</td>
</tr>
<tr>
<td>Mushroom: Portabella</td>
<td>5#</td>
<td>$19.00</td>
<td>$8.50</td>
<td>124%</td>
</tr>
<tr>
<td>Mushroom: Shiitake</td>
<td>3#</td>
<td>$21.50</td>
<td>$14.50</td>
<td>48%</td>
</tr>
<tr>
<td>Onions, Yellow Med</td>
<td>40#</td>
<td>$35.00</td>
<td>$12.00</td>
<td>192%</td>
</tr>
<tr>
<td>Peas: Snow</td>
<td>10#</td>
<td>$32.00</td>
<td>$11.00</td>
<td>191%</td>
</tr>
<tr>
<td>Potato: Red A</td>
<td>50#</td>
<td>$64.50</td>
<td>$17.00</td>
<td>279%</td>
</tr>
<tr>
<td>Potato: Yukon Gold</td>
<td>50#</td>
<td>$36.00</td>
<td>$26.00</td>
<td>38%</td>
</tr>
<tr>
<td>Potato: Russet</td>
<td>70 Ct</td>
<td>$44.50</td>
<td>$19.00</td>
<td>134%</td>
</tr>
<tr>
<td>Radish</td>
<td>24 Ct</td>
<td>$43.75</td>
<td>$13.00</td>
<td>237%</td>
</tr>
<tr>
<td>Spinach</td>
<td>24 Ct</td>
<td>$56.00</td>
<td>$24.00</td>
<td>133%</td>
</tr>
<tr>
<td>Squash, Winter: Acorn</td>
<td>30#</td>
<td>$41.25</td>
<td>$18.50</td>
<td>123%</td>
</tr>
<tr>
<td>Zucchini</td>
<td>20#</td>
<td>$49.50</td>
<td>$16.00</td>
<td>209%</td>
</tr>
</tbody>
</table>

Average Organic Premium 146%*
Exponential growth

- U.S. organic food sales have grown between 17 and 21% annually for two decades (total U.S. food sales over this time have grown 2-4% annually)

- Organic food sales represent approximately 3% of U.S. food sales.
  - (Organic Trade Association 2008)
Albert Howard (1873-1947)

- British agricultural scientist.
- 25 years in India.
- Critical of reductionist agricultural science and specialization
- Blamed fall of past civilizations on unsustainable agriculture
- Wrote *An Agricultural Testament* (1940)
Howard on Eastern agriculture

“The small-holdings of China, for example, are still maintaining a steady output and there is no loss of fertility after forty centuries of management.”

- Tiny farms
- Labor intensive
- Integration of crops and livestock
- Lots of legumes
- Little cultivation
Howard on Western agriculture

- Large, growing farms
- Monocultures
- Mechanization
  - Machines consume resources but do not contribute urine/dung
- Synthetic fertilizer dominates
- Food prices too low... farmers forced off land
Lady Eve Balfour (1899-1990)

- Among first women to graduate from University of Reading (agriculture)
- 1939 – began long term experiment comparing conventional and organic production
- 1943 – wrote *The Living Soil*
- 1946 – founded the Soil Association

“Healthy soil, healthy plants, healthy people.”
J.I. Rodale

• Bought farm in PA to test Howard’s ideas
• Popularized term ‘organic,’ through his *Organic Gardening and Farming* magazine
• Relationship with science
  – Presented reader testimonials as research ("science for the people by the people")
  – Solid long-term research trials continue
Lady Eve Balfour (1899-1990)

Jerome Irving Rodale (1898-1971)
Certification:
Who can use the word “organic”?

- >$5,000 annually?
  - *Must* certify.
- <$5,000 annually?
  - *May* certify
  - must follow standards
  - subject to audits (NOP pays)
- Misuse of “organic”
  - $10,000 fine

As of 10/21/02

USDA ORGANIC
GOLD New Potatoes $1.50 per pound Scott County from our farm

Fayette Co. $1.50
Heirloom Tomatoes
100% Chemical Free
Organic Certification Requirements

1. Management plan, approved by certifier
   - Required:
     • Boundaries, buffer zones separate organic from conventional
     • Organic seed, transplants
     • Maintain/improve soil fertility, organic matter
     • Rotation
   - Prohibited:
     • Synthetic fertilizers and pesticides
     • Genetically modified organisms
     • Sewage sludge
     • Burning (some exceptions)

2. Record keeping
Organic Production Standards

Organic agriculture is “a production system that is managed in accordance with the Act and regulations in this part to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity.”
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Site specific conditions

- not a cookbook
- plans reflect unique characteristics of each operation
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Cultural practices (how you grow)

- crop timing
- crop selection
- resistance
- interplanting
- spacing
- orientation
- etc...

USDA ORGANIC
Organic Production Standards

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**Biological practices**

( use your friends)

- release biocontrols
- develop beneficial habitat
- livestock grazing
- rhizobial inoculation
- etc...

USDA ORGANIC

KENTUCKY STATE UNIVERSITY
Organic Production Standards

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Mechanical practices (use tools)
- till
- weed
- mow
- flame
- fence
- etc…
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Ecological Balance

- achievement of steady state by ecosystem
- dynamic equilibrium between organisms and environment
- reduced outbreaks / extinctions (symptoms of imbalance)
Organic Production Standards

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Organic Production Standards

- Land is certified by gov’t-approved agencies
- Farmer develops and follows organic farm plan
- Synthetic substances prohibited
  - Includes synthetic organics
- Natural substance allowed
  - Includes natural inorganics
- Maintain or increase soil organic matter content
- Separation from conventional products
  - In time – 3 year transition period
  - In space – buffer zones, barriers, separate containers, equipment cleaning etc.
- $10,000 fine for misuse of word

Some exceptions
Clear Boundaries & Buffers

Organic

Conventional

Buffer

Organic

Conventional
Organic Seed and Transplants

• Expect 20% price premium
• Organic transplants difficult to find…
  – Potential market!
• No wetting agents or synthetic fertilizer in potting mix
• Organic fertilizers available
  – Bone meal, blood meal, soy meal, fish meal, compost etc.
Soil Fertility: Cover Cropping

- Rye/vetch mix adds ~135 lb N/acre
- Slow release
- Organic matter
- Erosion control

WVU organic research project

Soil organic matter (%)

- Winter rye & vetch cover crop
- Cover crop + compost @10t/acre

Y-axis: Soil organic matter (%)
X-axis: Year (1998-2006)
Soil Fertility: Animal Waste
Soil Fertility: Animal Waste

- Raw manure pre-harvest interval:
  - > 90 days if edible portion does not contact soil
  - > 120 days if edible portion contacts soil
Soil Fertility: Compost

- No pre-harvest interval
- Strict requirements for manure-based compost
  - 131-170°F for 15 days in windrows
  - C/N = 25-40
Why Mulch?

• Weed management
• Moisture retention
• Add O.M.

What Mulch?

• Organic
  – wood chips, shredded bark, chopped leaves, straw, grass clippings, compost, sawdust, pine needles, paper

• Inorganic
  – gravel, stone, black plastic, landscape fabric
Organic Mulch

- 4”-6” to completely discourage weeds
- Mulch next to stems invites slugs, rodents
- Slows warming in spring
- Adds O.M.

Plastic Mulch

- Warms soil, radiates heat at night
- Protects fruit from rotting
- Conserves moisture
- Non-renewable, non-biodegradable
- Organic standards require complete removal each year
The organic farmer feeds the soil and the soil feeds the plant.

-Jerome Belanger
Good earth

- Soft, crumbly
- Warms quickly
- Drains well
- Holds moisture
- Little clodding / hardpan / crusting / erosion
- Little fertilizer need
- Rich, earthy smell
- High quality crops
Living Soil?

- Minerals: 45%
- Water: 25%
- Air: 25%

- Fungi: 42%
- Bacteria: 26%
- Earthworms: 15%
- Protozoa: 2%

Organic matter: 1-5%

- Stabilized organic matter (humus): 33% - 50%
- Decomposing organic matter (active fraction): 33% - 50%
- Fresh residue: <10%
- Living organisms: <5%
Soil Minerals

- Insoluble components:
  - Aluminum, Silicon, Iron oxide

- Most minerals needed by plants are “locked” in molecules

- Small proportion available to plants through:
  - weathering
  - acids produced by roots and microbes
  - chelating substances

Form multiple bonds to a single metal ion (eg. heme):
## Plant Nutrients

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<tr>
<th>Non-mineral</th>
<th>Macronutrients</th>
<th>Micronutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon (C from CO₂)</td>
<td>Nitrogen (N from N₂ via N fixation)</td>
<td>Boron (B)</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Copper (Cu)</td>
<td></td>
</tr>
<tr>
<td>Hydrogen (H from H₂O)</td>
<td>Potassium (K)</td>
<td>Iron (Fe)</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>Manganese (Mn)</td>
<td></td>
</tr>
<tr>
<td>Oxygen (O from CO₂ &amp; H₂O)</td>
<td>Magnesium (Mg)</td>
<td>Molybdenum (Mo)</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>Zinc (Zn)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chlorine (Cl)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cobalt (Co)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nickel (Ni)</td>
<td></td>
</tr>
</tbody>
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Absorbed by roots with soil solution
CB HOPKNS CaFe
“Mighty good, Nice Coffee”
Closed Mon -- Cu Zn!

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<td></td>
<td>Nickel (Ni)</td>
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</tbody>
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Earthworms

- Create tunnels for water infiltration / root penetration
- Process soil and organic matter through gut, making nutrients available to plants
- Mix soil
- Like surface residue
- Killed by cultivation
  - Cut up
  - Tunnels destroyed
- Killed by some pesticides
Arthropods
(Insects, mites, spiders, centipedes etc.)

- Primary decomposers
- Predators
- Scavengers
- Herbivores
- Fungivores
- Algal eaters
- Diggers
Microbes (Bacteria, fungi, actinomycetes, protozoa, nematodes)

- 70% of soil life, by mass
- Release nutrients from soil
- Change nutrients to plant-available forms
- Increase nutrient uptake of roots (mycorrhizae)
- Decompose organic matter
- Sweet, earthy small (actinomycetes)
- Fix nitrogen from air (bacteria, algae)
- Plant diseases
- Biological controls

4,500 lbs/ac
Organic matter = Food for soil life
Conditions that favor soil life

- Nutrient source = organic matter
- pH > 5.5
- Aeration
  - Need $O_2$ for respiration
  - Some micronutrients become too available (toxic) without $O_2$
  - Allows soil to warm quickly
- Not too wet, not too dry
  - Water carries nutrients (soil solution)
  - Wilting point $\approx 50\%$ of soil water used
Soil pH

Availability

4  5  6  pH  7  8  9

- Fungi
- Bacteria/Actinomycetes
- Nitrogen
- Calcium/Magnesium
- Phosphorus
- Potassium
- Sulfur
- Iron/Manganese/Zinc/Copper
- Molybdenum
- Boron
Nutrients in Soil
(Approximate proportions for P, K & Mg)

- Total Reserves: 100%
- Exchangeable Nutrients: 5%
- Available Nutrients: 0.1%
- Weathering & microbial breakdown
- Soil Test
- Crop Needs: 1%

Nutrients in Soil (Approximate proportions for P, K & Mg)
Weathering & microbial breakdown

Living Soil Goal: Keep pipeline open by feeding microbes

Conventional Goal: Replenish supply of available nutrients (hydroponics)
Aggregation

- Promoted by soil life; promotes soil life
- Improves structure of clayey and sandy soils
  - Reduced crusting
  - Increased air and water infiltration
  - Reduced compaction

**MICROBIAL AND FUNGAL BYPRODUCTS GLUE THE PARTICLES TOGETHER**

DISPERSED STATE  AGGREGATED STATE
# Aggregation

<table>
<thead>
<tr>
<th>Enhances aggregation</th>
<th>Reduces aggregation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulches, cover crops</td>
<td>Bare soil</td>
</tr>
<tr>
<td>Grasses, perennials</td>
<td>Annuals</td>
</tr>
<tr>
<td>No-till, low-till, and conservation till systems</td>
<td>Cultivation (especially when too wet or too dry)</td>
</tr>
<tr>
<td>OM addition</td>
<td>Excess fertilization (salt build-up; OM breakdown)</td>
</tr>
</tbody>
</table>
White mold (Sclerotinia sclerotiorum)
Pest Management: Solarization and Biofumigation
Soil-borne disease management options

- **Biofumigation**
  - General: Use of volatile chemicals produced by plants to control or suppress soil-borne pests and diseases
  - Specific: Soil incorporation of brassicas, which contain glucosinolates that break down into volatile isothiocyanates

- **Solarization**
  - Using clear plastic over the soil surface to capture solar energy, heat soil, and kill weed seeds and soil-borne pests and diseases
Pest management: Resistant varieties
Pest Management: Farmscaping
Pest management: Inorganics

- Copper
  - toxicity problems with heavy, prolonged use
- Sulfur
  - 59% of agricultural fungicide use, by weight
  - high ecological impact (Cornell)
- Lime
- Bordeaux mixture (copper sulfate + lime)
Pest Management: Botanicals

• Chemicals derived from plants
  – Rotenone
    • rat poison, very toxic to fish, linked to Parkinson’s
    • allowed under NOP; temporary ban in Europe
  – Pyrethrum
    • neurotoxin, quick knock-down
    • chemistry inspired synthetic pyrethroids
  – Neem
    • inhibits moulting
NEEM: God's Gift to Mankind

Azadirachtin (Azadirachtin A)

C_{36}H_{44}O_{18}

Exact Mass: 720.26
Mol. Wt.: 720.71
Pest Management: Microbials

• Bacteria
  – e.g. *Bacillus thuringiensis*

• Fungi
  – e.g. *Coniothyrium minitans*

• Nematodes
  – e.g. *Steinernema*
Pest Management: Oils & Soaps

- Oils
  - Petroleum / vegetable based
  - kill through suffocation
  - most widely used insecticide, by weight

- Soaps
  - kill through desiccation (penetrate protective waxy covering)
  - mainly kill soft-bodied insect

- No resistance observed to these modes of action
Easy to grow organically in KY

Difficult to grow organically in KY
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http://organic.kysu.edu
502-597-5752