Modular Ecological Design:
A Fruit and Vegetable
Polyculture System for Urban Areas

Joe Kovach IPM Program
OSU/OARDC Wooster, OH
http://ipm.osu.edu
latest updates

The Ohio State Integrated Pest Management (IPM) program is a comprehensive program that is designed to encourage collaboration and innovation among Ohio Agricultural Research and Development Center (OARDC) scientists and Ohio State Extension personnel to better address the pest management needs of the citizens of Ohio. Our goal is to reduce the environmental, economic and social risk associated with managing pests (insect, disease or weed). To accomplish this goal we work with OSU collaborators in 5 areas of emphasis to evaluate and disseminate new IPM information. These areas are Agronomic IPM, High Value Crop IPM, Conservation Partnerships, Pest Diagnostics, and School IPM. In addition this year we will enhance our collaboration with the Cleveland Botanical Garden Green Corp. Urban Youth Program.

For more information contact:

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Annual Reports
Cornell Organic Guides
Crop Profiles
Elements of IPM
Fruit
IPM Internal Grant Program
Lady Beetle Information
Links
Modular Ecological Design
Newsletter
People
Why Urban Ag Project?

• Industrial Food (many books)
• Eat Corn
• Eat Oil (pesticides, fert. transport)
• For local food to succeed need $16/gal
  – $20/gal gasoline
• Peak Oil – 2008? Price inc. no Production inc.
• 2015 a big spike in prices and no going back
  ($150 barrel oil)
Goals

- Integrated Pest Management
- Ecological Principles
- Polyculture Experiment
- Cuba
What is IPM?

• Integrated Pest Management is an ecosystem-based strategy that focuses on long-term prevention of pests through a combinations of techniques.

• Combines the best control tactics to reduce reliance on pesticides, minimize environmental effects, and keep pests at an acceptable level.
Integrated Pest Management

• Does not rely on any one tactic more than others

• Exhaust other options before pesticides are used

• Pesticides are used only after monitoring indicates they are needed.

• Pest control products are selected and applied in a manner that minimizes risks to humans, nontarget organisms and the environment.
Integrated Pest Management

- Pest is weed, disease, insect, mite, vertebrate

- Not a chemical free system – good design helps but usually is not enough
  - Pesticides can be used at appropriate times
  - OMRI or organic approved or conventional

- Nature bats last!!!
IPM Methods

• Monitoring - scouting, thresholds
• Forecasting – models to predict pest develop.
• Cultural Control - resistant varieties, hoeing
• Biological Control - predators, antagonist
• Chemical Control - pesticides, pheromone
NY Strawberry Pesticide Use
(Herb., Fung., Insect.)

* NYIPM, NASS
Ecologically Based IPM

• General Principles
  – Select and grow a diversity of crops that have natural defenses against pests
  – Choose varieties with resistance or tolerance
  – Build the soil with organic matter
Integrated Pest Management
Builds on strengths of natural systems
(Ecomimicry)

• Three concepts
  – Ecosystem Stability
  – Biodiversity
  – Biological Control
Ecosystem Stability

• Ecosystems with more diversity
  – Are more stable
  – Greater resistance
    • Ability to avoid or withstand disturbances
  – Greater resilience
    • Ability to recover from stress
Ecosystem Stability

- Reduce tillage/cultivation - fewer weeds
- Reduce mowing - less disruption, increase beneficials
- Maintain “permanent” ground covers
- Add organic matter - substrate for good MO’s
- Use cover crops - inc. moisture retention
- Use crop rotation - breaks pest cycle
- Increase crop diversity - more difficult to find
- Create corridors - highways of habitat
Integrated Pest Management

• Tries to apply stress to the pests
  – Interrupt their life cycle
  – Remove alternative food sources

• Enhance beneficial population
  – Avoid agrochemicals where possible
  – At least better timing
Integrated Pest Management

- Is a preventative approach
  - Uses little “hammers”
  - Instead of one big “hammer”

- Relies on Biological Control (as much as possible)
  - Beneficial predators and parasites
  - Disease-causing organisms
  - Beneficial fungi and bacteria that inhabit roots
What is Biological Control?

- The regulation of pest population densities below and economic injury level via a biological antagonist
Biological Control Potential?

• Many pest pop. are regulated below plant damaging levels by naturally occurring enemies (500 pests of apples in OH)
• There is extensive evidence for successful biocontrol
• Biocontrol is not a panacea; it will not work in some situations
Biological Control

• Classical - importation & establishment of natural enemies, w/o further assistance
• Augmentative releases - periodic (pesticide model)
• Environmental manipulation - attractants, alternative preys
• Preservation of natural enemy flora & fauna
Biological Control Impediments

• High cost of beneficials - raise plant/prey/predator
• Availability & quality of biologicals
• Lack of research documenting success
  – Success rate (15-20%)
  – Usually best in Greenhouses, Islands, California
• Don’t buy bio control insects for small outdoor plots
Enhancing Beneficials/Biocontrol

- Characteristics typical of fields with plenty of indigenous beneficials
  - Fields are small - a lot of edges, natural vegetation
  - Cropping systems are diverse
    - Include perennials and flowering plants
  - Crops are managed with minimal agrichemical inputs
  - Soils high in organic matter, biological activity during off season
    - Covered with mulch or vegetation
Biodiversity
(sp. richness and eveness)

• Spatial diversity - across a landscape, within fields

• Genetic diversity - different varieties, different crops

• Temporal diversity - different crops at different stages of growth
Fertility

• Slow release of nutrients the best,
  – any compost is good compost (yard waste, dairy barn, vermicompost)

• Pests seem to follow the Nitrogen (plant suckers i.e. mites & aphids)

• Too much synthetic fertilizer cause nutritional imbalances
Given that we will eventually run out of oil, can we design a food production system that is:

- Close to consumers
- Simulates natural systems
  Ecomimicry
- Uses Ecologically Based Pest Management
- Economically viable $\approx 90,000/\text{A}$
  $= 10$ per ft of row
Modular Ecological Design

Goal - to determine optimal layout of an intensive fruit & vegetable polyculture system that mimics natural systems & can be used by the small periurban or urban farmer.

Modular
Economics
Pest density
Efficiency
Some Principles of Good Farming/Gardening

• Plan your farm/garden and set goals
• Look at the whole picture (water, soil, crops, goals)
• Fertility and slope of land
• Learn and grow through reading and meetings
• A farm must be profitable ($, joy)
Economic IPM and Marketing

Product = Bundle of Benefits
Marketing Strategies

How to differentiate your product?

1) Price - more efficient, less cost

2) Quality - characteristic that customers want

Use different strokes for different folks
Selling Strategies

• Not all customers are alike
  – The old days of Henry Ford when “You can have any color you want, as long as it’s black” are long gone.

• Use different strokes for different folks

• The Law of the Slight Edge
  Once established, difference between a champion and an also-ran, more often than not, is a very slim margin
Models for Differentiating Consumers

- Environmental Consumer
- Lifestyle - Health Consumer (LOHAS)
Types of Environmental Consumers

- **True Natural**
  - Deep Env concern
  - Will pay
  - Female
  - Low & upper income

- **New Green Mainstream**
  - Heartbeat of Am.
  - Interested in Env.
  - Need a “reason”
  - Only when convenient

- **Affluent Healers**
  - Well Ed.
  - Upscale
  - Personal well being focused
  - Family & goal orient

- **Young Recyclers**
  - Young
  - Never married
  - Reject paying a premium
  - Solid waste

- **Overwhelmed Unconcerned**
  - Not optimistic
  - Economically “just getting by”
  - Apathetic
  - Reject that chemicals harms the environment

Hartman Group
Lifestyle and Economic Potential

• Cities are where the money is
• City dwellers are clamoring for good local food
• To get top dollar target LOHAS

LOHAS- Lifestyles of Health and Sustainability
  – 1/3 US pop. - 63 million adults
  – Goods & Services
    • Health and Fitness
    • Environment
    • Social Justice
    • Personal development
    • Sustainable living
Slavic Village – Cleveland Bot. Garden
Commodities and Treatments

Solid Row

Mixed Row

Checker board

4 trees/shrubs
I. Apples (SwC)
II. Peaches
III. Blueberries
IV. Raspberries

4 herbaceous
Strawberries
Edamame soybeans
Tomatoes
Green beans

Early, Mid, Late cultivars

The fourth treatment (not shown) is a mixed row configuration on raised beds.
Layout of plots

RB = Raised Bed
SR = Solid Row
MR = Mixed Row
CB = Checker Board

Each plot - 44' x 60'
Total Acres - 1.4 A
4 Treatments Replicated 4 Times, SR, MR, CB, RB
Groundhog, Rabbit, Deer Fence

I garden, therefore I fence
June 2006 - Weeding Cost

2005 Weeding Costs - $1.35/ft
Labor hrs (760 hr) = $6,080

2006 Cost - $0.37/ft
Landscape Cloth = $1,250
Labor (214 hr) = $1,612
Total = $2,862
2007

HT = $9.50/ft
## High Tunnel Growth Differences (cm)

<table>
<thead>
<tr>
<th>Trt</th>
<th>All</th>
<th>Ap</th>
<th>Blue</th>
<th>Rasp</th>
<th>Peach</th>
<th>Soy</th>
<th>Stra</th>
<th>Apples</th>
<th>Aph/M</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>172</td>
<td>232</td>
<td>118</td>
<td>142</td>
<td>271</td>
<td>74</td>
<td>41</td>
<td>19%</td>
<td>a</td>
</tr>
<tr>
<td>HT</td>
<td>196</td>
<td>243</td>
<td>123</td>
<td>185</td>
<td>333</td>
<td>86</td>
<td>44</td>
<td>38%</td>
<td>b</td>
</tr>
<tr>
<td>Inc</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16%</td>
<td>7%</td>
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</table>
## High Tunnel Yield Differences (g/m)

<table>
<thead>
<tr>
<th>Trt</th>
<th>Straw</th>
<th>S Rasp</th>
<th>F Rasp</th>
<th>Tom</th>
<th>Soy</th>
<th>Blue</th>
<th>SnP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>4673a</td>
<td>2276a</td>
<td>2086a</td>
<td>6806a</td>
<td>1147a</td>
<td>706a</td>
<td>269a</td>
<td></td>
</tr>
<tr>
<td>HT</td>
<td>3779b</td>
<td>1162b</td>
<td>3736b</td>
<td>8764b</td>
<td>1348b</td>
<td>951a</td>
<td>387a</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>-19%</td>
<td>96%</td>
<td>79%</td>
<td>23%</td>
<td>16%</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Tunnels have a shading impact and reduce wind

Strawberries are primarily wind and gravity pollinated
## Japanese Beetle
(July-Aug)

<table>
<thead>
<tr>
<th>Year</th>
<th>No. JB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>15,000</td>
</tr>
<tr>
<td>2006</td>
<td>60,000</td>
</tr>
<tr>
<td>2007</td>
<td>283,000</td>
</tr>
<tr>
<td>2008</td>
<td>441,000</td>
</tr>
<tr>
<td>2009</td>
<td>162,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trt</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High Tunnel</td>
<td>11,300 (4%)</td>
</tr>
<tr>
<td>No HT</td>
<td>271,700 (96%)</td>
</tr>
</tbody>
</table>
# Japanese Beetle
(July-Aug) 2006, 2007

<table>
<thead>
<tr>
<th>Crop</th>
<th>No. JB</th>
<th>%</th>
<th>No. JB</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rasp</td>
<td>30,146</td>
<td>52</td>
<td>109,292</td>
<td>39</td>
</tr>
<tr>
<td>Peach</td>
<td>22,789</td>
<td>38</td>
<td>11,047</td>
<td>4</td>
</tr>
<tr>
<td>Soy</td>
<td>1,851</td>
<td>3</td>
<td>108,239</td>
<td>38</td>
</tr>
<tr>
<td>Straw</td>
<td>1,652</td>
<td>3</td>
<td>20,232</td>
<td>7</td>
</tr>
<tr>
<td>Blue</td>
<td>1,486</td>
<td>3</td>
<td>32,115</td>
<td>11</td>
</tr>
<tr>
<td>Apple</td>
<td>488</td>
<td>1</td>
<td>2,801</td>
<td>1</td>
</tr>
<tr>
<td>Tomato</td>
<td>0</td>
<td>0</td>
<td>110</td>
<td>0</td>
</tr>
</tbody>
</table>
## Japanese Beetle Raspberry (JB/5ft/date)

<table>
<thead>
<tr>
<th>Trt</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR</td>
<td>10.4 a</td>
<td>35.0 b</td>
</tr>
<tr>
<td>CB</td>
<td>11.7 ab</td>
<td>29.8 c</td>
</tr>
<tr>
<td>RB</td>
<td>13.3 bc</td>
<td>43.6 a</td>
</tr>
<tr>
<td>SR</td>
<td>15.3 c</td>
<td>37.8 b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Royalty</td>
<td>3.1 a</td>
<td>15.5 a</td>
</tr>
<tr>
<td>Carol</td>
<td>12.0 b</td>
<td>36.4 b</td>
</tr>
<tr>
<td>Prelude</td>
<td>22.9 c</td>
<td>57.7 c</td>
</tr>
</tbody>
</table>
### Japanese Beetle Blueberry (JB/5ft/date)

<table>
<thead>
<tr>
<th>Trt</th>
<th>2007</th>
<th>Cultivar</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR</td>
<td>10.0 a</td>
<td>Duke</td>
<td>14.7 a</td>
</tr>
<tr>
<td>CB</td>
<td>9.9 a</td>
<td>Bluecrop</td>
<td>13.9 b</td>
</tr>
<tr>
<td>RB</td>
<td>11.1 a</td>
<td>Elliot</td>
<td>4.9 b</td>
</tr>
<tr>
<td>SR</td>
<td>13.6 a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Trt**: Treatment
- **2007**: Year
- **Cultivar**: Blueberry cultivar
- **2007**: Year for cultivar growth
Japanese Beetle Traps

- 2 bait types
  - Mimics scent of virgin female
  - Sweet smelling food type of lures

- U of Kentucky research
  - Traps attract more beetles than catch (40-50%)

- Traps are not recommend for control
JB Cultural Control

• Habitat modification
  – Grubs and eggs are extremely sensitive to dry conditions.
  – Try not to irrigate during egg laying, drip irrigate and do not water sodded middles

• Cultivar selection?

• Do not plant trees that are highly susceptible
  – Jap and Norway maple
  – Birch, pin oak, apples, Prunus sp.
  – Lindens, Virginia creeper
JB Biological Control

- Insect Parasites - imported wasps
  - Tiphia popilliavora
  - Tiphia vernlis - controls JB in Japan
    - 1920’s released in E. US, established
    - Better in southern US

- Imported parasitic fly
  - Hyperecteina aldrichi
JB Biological Control

- Bacterial Milky Disease
  - *Bacillus popilliae*
  - *Bacillus lentimorbus*
- Some effectiveness in E. US, but variable
- Better in southern US, warmer soil
- The spore count needs to build up for 2-3 years to be effective
- In OH and KY test trials have not produced satisfactory results
- Already have some *B. popillae* in our soils
JB Biological Control

• Beneficial Nematodes - apply at 2nd instar (Sept)
  – *Steinernema* - 24 species (Steinernematidae: Rhabditida)
    Symbiotic bacterium *Xenorhabdus*
  – *Heterorhabditis* - 8 species
    (Heterorhabdititidae: Rhabditida)
    Symbiotic bacterium: *Photorhabdus*

http://www.oardc.ohio-state.edu/nematodes/
JB Adult Control - Softer Chemicals

- Azadiractin - Neemix - repellant, short lived
- Kaolin clay - repellant, white residue
- Pyrethrins (Pyganic) - short lived, multiple application
- Insecticidal soap - short lived
## Japanese Beetle 2009

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Overall JB dens.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aza-Direct (Neem)</td>
<td>31.6 a</td>
</tr>
<tr>
<td>Fruit Spray (low rates of malathion/carbaryl)</td>
<td>35.3 a</td>
</tr>
<tr>
<td>Ecotec (10% rosemary, oil 2%pmint)</td>
<td>32.0 a</td>
</tr>
<tr>
<td>UTControl</td>
<td>38.0 a</td>
</tr>
</tbody>
</table>

4 – sprays (29 Jun, 6, 20, 27, Jul 2009)
### Arthropod Collections 2005-08

**Sweep net samples**

Jun, Jul, Aug, Sep, Oct

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Beneficial</th>
<th>Pest</th>
<th>Incidentals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Families</td>
<td>139</td>
<td>53</td>
<td>37</td>
<td>51</td>
</tr>
<tr>
<td>Indiv</td>
<td>’05</td>
<td>25,258</td>
<td>16%</td>
<td>54%</td>
</tr>
<tr>
<td></td>
<td>’06</td>
<td>16,202</td>
<td>21%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>’07</td>
<td>24,118</td>
<td>21%</td>
<td>51%</td>
</tr>
<tr>
<td></td>
<td>’08</td>
<td>23,493</td>
<td>20%</td>
<td>45%</td>
</tr>
</tbody>
</table>
## Insect Individuals (2006)

<table>
<thead>
<tr>
<th>Crop</th>
<th>% Pest</th>
<th>% Nat. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberry</td>
<td>50.3</td>
<td>15.6</td>
</tr>
<tr>
<td>Peach</td>
<td>35.7</td>
<td>24.7</td>
</tr>
<tr>
<td>Raspberry</td>
<td>51.2</td>
<td>12.5</td>
</tr>
<tr>
<td>Blueberry</td>
<td>44.6</td>
<td>23.2</td>
</tr>
<tr>
<td>Apple</td>
<td>61.4</td>
<td>17.4</td>
</tr>
<tr>
<td>Soybean</td>
<td>48.3</td>
<td>10.5</td>
</tr>
<tr>
<td>Potato</td>
<td>73.8</td>
<td>13.6</td>
</tr>
<tr>
<td>Tomato</td>
<td>49.5</td>
<td>11.1</td>
</tr>
</tbody>
</table>
## Shannon’s Diversity Index

<table>
<thead>
<tr>
<th>Crop</th>
<th>Biodiv 05</th>
<th>Biodiv 06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberry</td>
<td>1.69 d</td>
<td>2.22 a</td>
</tr>
<tr>
<td>Peach</td>
<td>2.24 a</td>
<td>1.91 b</td>
</tr>
<tr>
<td>Raspberry</td>
<td>1.829 c</td>
<td>1.59 c</td>
</tr>
<tr>
<td>Blueberry</td>
<td>1.64 d</td>
<td>1.46 c</td>
</tr>
<tr>
<td>Apple</td>
<td>-</td>
<td>1.17 d</td>
</tr>
<tr>
<td>Soybean</td>
<td>2.07 b</td>
<td>1.01 de</td>
</tr>
<tr>
<td>Potato</td>
<td>-</td>
<td>1.08 d</td>
</tr>
<tr>
<td>Tomato</td>
<td>1.61 d</td>
<td>0.84 e</td>
</tr>
<tr>
<td>Corn</td>
<td>2.18 ab</td>
<td>-</td>
</tr>
<tr>
<td>Green bean</td>
<td>1.89 c</td>
<td>-</td>
</tr>
</tbody>
</table>
Can Intercropping increase biodiversity?

Treatments:
1) Peaches alone
2) Peach intercropped w/ straw.
3) Strawberries alone
4) Straw. Intercropped w/ peach

Is increasing biodiversity good?
## Intercropping Biodiversity

### Beneficials/Natural Enemies

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Biodiversity ($H'$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peach</td>
<td>0.77 a</td>
</tr>
<tr>
<td>Peach inter. w/ straw</td>
<td>0.81 a</td>
</tr>
<tr>
<td>Straw</td>
<td>0.52 a</td>
</tr>
<tr>
<td>Straw inter. w/ peach</td>
<td>0.62 a</td>
</tr>
</tbody>
</table>
### Intercropping Biodiversity

#### Pest Insects

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Biodiversity (H’)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peach</td>
<td>0.79 bc</td>
</tr>
<tr>
<td>Peach inter. w/ straw</td>
<td>1.13 a</td>
</tr>
<tr>
<td>Straw</td>
<td>0.53 c</td>
</tr>
<tr>
<td>Straw inter. w/ peach</td>
<td>0.87 a</td>
</tr>
</tbody>
</table>

Is increasing biodiversity good when you increase the biodiversity of pest insects?
## Harvest Evaluations 2006

<table>
<thead>
<tr>
<th>Trt</th>
<th>Soy</th>
<th>S.Rasp</th>
<th>Straw</th>
<th>Tom</th>
<th>Pot</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>32 a</td>
<td>381 a</td>
<td>1407 a</td>
<td>2338 a</td>
<td>486 b</td>
</tr>
<tr>
<td>CB</td>
<td>59 b</td>
<td>279 a</td>
<td>1310 a</td>
<td>2083 a</td>
<td>300 a</td>
</tr>
<tr>
<td>MR</td>
<td>47 b</td>
<td>289 a</td>
<td>1314 a</td>
<td>2420 a</td>
<td>275 a</td>
</tr>
<tr>
<td>RB</td>
<td>56 b</td>
<td>505 a</td>
<td>1619 a</td>
<td>3086 b</td>
<td>475 b</td>
</tr>
<tr>
<td>%</td>
<td>67</td>
<td>81</td>
<td>24</td>
<td>48</td>
<td>73</td>
</tr>
</tbody>
</table>
## Harvest Evaluations 2007

<table>
<thead>
<tr>
<th>Trt</th>
<th>Straw</th>
<th>S.Rasp</th>
<th>F.Ras</th>
<th>Tom</th>
<th>SnP</th>
<th>Soy</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>2984</td>
<td>903</td>
<td>1512</td>
<td>3685</td>
<td>170</td>
<td>1021</td>
<td>882</td>
</tr>
<tr>
<td>CB</td>
<td>2707</td>
<td>1034</td>
<td>1429</td>
<td>5429</td>
<td>250</td>
<td>694</td>
<td>551</td>
</tr>
<tr>
<td>MR</td>
<td>2542</td>
<td>797</td>
<td>1685</td>
<td>4193</td>
<td>260</td>
<td>880</td>
<td>661</td>
</tr>
<tr>
<td>RB</td>
<td>3287</td>
<td>1403</td>
<td>1424</td>
<td>6965</td>
<td>512</td>
<td>1064</td>
<td>662</td>
</tr>
</tbody>
</table>

| %   | 20    | 54    | -     | 57  | 125 | -   | -    |
| inc |       |       |       |     |     |     |      |
Total Hours to Harvest all Crops  2005
(green beans, tomatoes, sweet corn & soybeans)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hours/Meter/Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB</td>
<td>7.31a</td>
</tr>
<tr>
<td>MR</td>
<td>6.82a</td>
</tr>
<tr>
<td>RB</td>
<td>6.44a</td>
</tr>
<tr>
<td>SR</td>
<td>5.78a</td>
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</tbody>
</table>

Means followed by the same letter are not significantly different (LSD, P>0.05)

Labor Cost = $1.00/ft for $8/hr for 6 months
# Establishment Costs

<table>
<thead>
<tr>
<th>Year</th>
<th>Establishment Costs</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Seeds</td>
</tr>
<tr>
<td>2005</td>
<td>Establishment</td>
<td>Harvest material</td>
</tr>
<tr>
<td></td>
<td>Soil prep</td>
<td>(qts, pts, container)</td>
</tr>
<tr>
<td></td>
<td>Plants</td>
<td>Weed Control</td>
</tr>
<tr>
<td></td>
<td>Fencing/Irrigation</td>
<td>Landscape cloth</td>
</tr>
<tr>
<td></td>
<td>Sub total</td>
<td>Staples</td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td>Labor - 182h</td>
</tr>
<tr>
<td></td>
<td>Weed Control</td>
<td>Sub total</td>
</tr>
<tr>
<td></td>
<td>Labor - 760h (weed, mulch)</td>
<td>6,080</td>
</tr>
<tr>
<td></td>
<td>Mulch (17 truck loads)</td>
<td>4,250</td>
</tr>
<tr>
<td></td>
<td>Sub total</td>
<td>10,330</td>
</tr>
<tr>
<td></td>
<td>Raised Beds</td>
<td>Trellis</td>
</tr>
<tr>
<td></td>
<td>Materials</td>
<td>T-post</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Lumber</td>
</tr>
<tr>
<td></td>
<td>$19,757</td>
<td>Screws, wire</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub total</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
</tr>
</tbody>
</table>

**Total investment**

- per plot: $1,530 (+ RB $1.20)
- $/ft: $3.20 (+ HT= $9.50/ft)

**Total**: $24,477
Conclusions to Date

• Jap. Beetles were a big problem in ‘07 ‘08 especially on rasp, soybeans or peaches
• High Tunnels Crops - had the fewest JBs, best growth, nicest fruit ($ 9.50/ft)
• Strawberry & Peaches had the most biodiversity
• Peaches had the lowest % pests & highest % natural enemies
• Potatoes had the highest % pests
Conclusions to Date

- Raised beds ($1.20/ft) - were easy to harvest and the best yield on some crops
  - Staff wanted solid rows on raised beds
- Paid for capital improvements (plants, fence, irrigation, etc.) after year 2
- $10/ft may be obtainable when under full production, with the correct market & certainly would be easier with a higher price than in grocery stores
Special Period (1990-present)

- Collapse of USSR
  - Trading partner
    • Sugar Cane for Oil and food
- No oil/no pesticides
- Calories
  - 2800 cal --> 1800 cal
  - Lost 20-25% of BW
  - Today = 3000 cal
  - 40% of pop. OW
Organoponicos = small urban agricultural plots
  • Cuba researchers were working on hydroponics
  • Australians come over with permaculture
  • Military connection - Raul Castro?
Organoponicos
Organoponicos
Organoponicos

Why it works:
1) Diverse cropping
2) Learned what to plant
3) Good sanitation practices
4) Use trap cropping (lettuce)
5) Plenty of “free” labor
6) **Local** farmer/IPM meetings
7) **Location, location, location**
   - Cuba’s an island - biocontrol
   - In cities - biological deserts
   - Mosquito spraying - 2x/wk
Organoponicos

Why I’m skeptical:

1) Claimed using a lot of biopesticides (Bt, Beauvaria, neem)
   • No pests/beneficials observed - too clean for biocontrol
   • CREE - no comments

2) There is no evidence that planting marigolds/sunflowers at end of row increase pest control (Caribbean magic)

3) No birds (eat them?, DDT for mosq.?)

4) Claimed they will not go back to pesticides if embargo is lifted
   • OK as long as cheap labor available