Using Ecological Principles to Design Organic Small Fruit Systems

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http://ipm.osu.edu
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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Goals

• Integrated Pest Management
• Ecological Principles (Biological Realities)
• Japanese Beetles
• Examples/Opinions
What is IPM?

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

• No matter what the design, soil health, cultivars, location, polyculture system

• 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
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)
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) - Don’t buy biocontrols for small plots
• 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
Problems with Organic Fruit Production

1) Perennials - hard to rotate
2) Long time from planting to 1st harvest
   usually 1 - 4 years
3) Long growing season. Some fruit bloom early
   (May) and are not harvested until Sept.
   Increase chance of problems
4) Purpose of fruit
Problems with Organic Fruit Production

- Purpose of fruit is to be eaten (seed dispersal)
- So by it’s nature it will be susceptible to many pests
- Toxic leaves okay, but it’s tough to have toxic fruit
- The more native the fruit the less pest pressure
Organic Fruit Production Continuum
(from an IPM standpoint)

Small fruit:
- Blueberries
- Brambles
- Strawberries
- Grapes
- Plum
- Cherry
- Pear
- Peach
- Apple

Tree fruit:

Easier

Harder
Polyculture Examples
Slavic Village – Cleveland Bot. Garden
4 Treatments Replicated 4 Times, SR, MR, CB, RB
Groundhog, Rabbit, Deer Fence

I garden, therefore I fence

June 2005
## 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>
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<tbody>
<tr>
<td>Families</td>
<td>139</td>
<td>53</td>
<td>37</td>
<td>51</td>
</tr>
<tr>
<td>Indiv '05</td>
<td>25,258</td>
<td>16%</td>
<td>54%</td>
<td>30%</td>
</tr>
<tr>
<td>'06</td>
<td>16,202</td>
<td>21%</td>
<td>50%</td>
<td>29%</td>
</tr>
<tr>
<td>'07</td>
<td>24,118</td>
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<td>51%</td>
<td>28%</td>
</tr>
<tr>
<td>'08</td>
<td>23,493</td>
<td>20%</td>
<td>45%</td>
<td>32%</td>
</tr>
<tr>
<td>Year</td>
<td>No. JB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>15,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>60,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>283,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>441,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>162,000</td>
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<td></td>
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<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>
## 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>Non</td>
<td>172 a</td>
<td>232 a</td>
<td>118 a</td>
<td>142 a</td>
<td>271 a</td>
<td>74 a</td>
<td>41 a</td>
<td>19% a</td>
<td></td>
</tr>
<tr>
<td>HT</td>
<td>196 b</td>
<td>243 a</td>
<td>123 a</td>
<td>185 b</td>
<td>333 b</td>
<td>86 b</td>
<td>44 b</td>
<td>38% b</td>
<td></td>
</tr>
<tr>
<td>Inc.</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Inc. 14%  30%  23%  16%  7%
# 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>
</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>
</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>
</tr>
</tbody>
</table>

| %   | -19%  | 96%   | 79%   | 23%  | 16%  | -    | -   |

Tunnels have a shading impact and reduce wind

Strawberries are primarily wind and gravity pollinated
## Japanese Beetle
(July-Aug) 2006, 2007

<table>
<thead>
<tr>
<th>Crop</th>
<th>No. JB</th>
<th>%</th>
<th>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><strong>29.8 c</strong></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><strong>3.1 a</strong></td>
<td><strong>15.5 a</strong></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><strong>57.7 c</strong></td>
</tr>
</tbody>
</table>

Royalty

Prelude
# Japanese Beetle

## Blueberry (JB/5ft/date)

<table>
<thead>
<tr>
<th>Trt</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR</td>
<td>10.0 a</td>
</tr>
<tr>
<td>CB</td>
<td>9.9 a</td>
</tr>
<tr>
<td>RB</td>
<td>11.1 a</td>
</tr>
<tr>
<td>SR</td>
<td>13.6 a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duke</td>
<td>14.7 a</td>
</tr>
<tr>
<td>Bluecrop</td>
<td>13.9 a</td>
</tr>
<tr>
<td>Elliot</td>
<td>4.9 b</td>
</tr>
</tbody>
</table>
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. popilliae* 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 malath/carb.)</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)
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?
Organic Strawberries in OH
(2000-2004)

Field - OSU/OARDC, Wooster - 0.5 A,
“Ohio” Strawberry

No pesticides since 1996

2000 - April - cover crop (oats & peas)
    July - plowed under
    August - planted rye (bet. rows)
    oat (rows)
Weed Biomass By Treatment

Weed labor hours:

2002 = 1955/A
2003 = 1029/A
2004 =  527/A
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
Annual Strawberry Production In Landscape Cloth
# Harvest Evaluations 2002-2004

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total wt/A</th>
<th>% Clean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>10.3</td>
<td>62</td>
</tr>
<tr>
<td>Dairy Barn</td>
<td>9.9</td>
<td>54</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>10.4</td>
<td>51</td>
</tr>
<tr>
<td>Vermicomp</td>
<td>9.5</td>
<td>51</td>
</tr>
<tr>
<td>Yard Waste</td>
<td>9.4</td>
<td>54</td>
</tr>
</tbody>
</table>
Tarnished Plant Bug
Preventative Tactics

Weed management - reduce flowering weeds
  • cover crops - rye or sudan grass

Maintain or Promote Ecosystem Stability
  • untouched ditches and roadside, okay
  • mowing (OK except at strawberry bloom)
  • disking, drought, renovation
    (promotes instability)

Cultivar selection
## TPB Resistance (untreated damage)

<table>
<thead>
<tr>
<th>Strong ( &lt; 30%)</th>
<th>Slight (30 - 40%)</th>
<th>Little (&gt; 40%)</th>
<th>None (&gt; 50%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chambly</td>
<td>Veestar</td>
<td>Settler</td>
<td>Scott</td>
</tr>
<tr>
<td>Oka</td>
<td>Canoga</td>
<td>Blomidon</td>
<td>Surecrop</td>
</tr>
<tr>
<td>Cavendish</td>
<td>Annapolis</td>
<td>Guardian</td>
<td>Kent</td>
</tr>
<tr>
<td>Honeoye</td>
<td>Redcoat</td>
<td>Gov. Simcoe</td>
<td>Redchief</td>
</tr>
<tr>
<td>Jewel</td>
<td>Glooscap</td>
<td>Allstar</td>
<td>Conrwallis</td>
</tr>
<tr>
<td>Sparkle</td>
<td>Catskill</td>
<td>Midway</td>
<td></td>
</tr>
<tr>
<td>Seneca</td>
<td></td>
<td>Raritan</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earliglow</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lateglow</td>
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</table>
## TPB Resistance

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honeoye</td>
<td>Holiday</td>
</tr>
<tr>
<td>Jewel</td>
<td>Holiday</td>
</tr>
<tr>
<td>Seneca</td>
<td>Holiday</td>
</tr>
<tr>
<td>Chambly</td>
<td>Honeoye</td>
</tr>
<tr>
<td>Oka</td>
<td>Honeoye</td>
</tr>
<tr>
<td>Cavendish</td>
<td></td>
</tr>
<tr>
<td>Sparkle</td>
<td></td>
</tr>
<tr>
<td>Northeaster (?)</td>
<td>Holiday</td>
</tr>
</tbody>
</table>
### Economics

**Breakeven Price:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Con.</th>
<th>Org</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>$0.81/qt</td>
<td>$1.77/qt</td>
</tr>
<tr>
<td>2003</td>
<td>$0.66/qt</td>
<td>$1.30/qt</td>
</tr>
</tbody>
</table>

**Profit/A:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Con.</th>
<th>Org</th>
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</thead>
<tbody>
<tr>
<td>2002</td>
<td>$15,650@$1.80</td>
<td>$8,294@$2.25</td>
</tr>
<tr>
<td>2003</td>
<td>$19,493@$1.80</td>
<td>$14,774@$2.00</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. price received per qt</td>
<td>$1.80</td>
<td>$1.80</td>
</tr>
<tr>
<td>Discount Rate You Would Like to Use</td>
<td>24%</td>
<td>24%</td>
</tr>
</tbody>
</table>

**Summary for Organic Strawberries**

*By Albert DelMarre and Regina Neuhauwer - Cornell Cooperative Extension*

Avg. price received per qt: $1.80
Discount Rate You Would Like to Use: 24%

**Summary for Conventional Strawberries**

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Avg. price received per qt: $1.80
Discount Rate You Would Like to Use: 24%
Strawberries

Cultural controls

1. Avoid wet spots
2. Select resistant varieties - TPB, Diseases
3. Do not plant after sod, tomatoes, potatoes
4. Avoid woods and fence rows
5. Maintain narrow rows
6. Remove fruit when ripe
7. Good sanitation, rogue diseased plants
8. Sodded middles?
9. Landscape cloth/black plastic?

Potential pest problems
Slugs, gray mold, weeds
Brambles

Cultural controls

1. Avoid low spots (raised beds)
2. Select resistant varieties
3. Do not plant near wild brambles
4. Do not plant within 250 yards of conifers (psyllid)
5. Prune damage branches
6. Remove fruit when ripe
7. Good sanitation, rogue plants

Potential pest problems
Japanese beetles, Yellow jackets
Blueberry

Cultural controls

1. Adjust soil pH
2. Select resistant cultivars
3. Do not plant near woods (wild blueberry & other fruit)
4. Prune damage branches
5. Remove fruit when ripe
6. Practice good sanitation
7. Mulch with sawdust for moisture and weed control

Potential pest problems
Birds, Japanese beetles
2008
Questions?
Organically Approved Herbicides

25% Acetic Acid

57% Pelagonic acid
Potential Organic Herbicides

Live Above Ground Biomass (48 hr)

- Untreated
- BurnOut
- Scythe

$4,642/A
$1,444/A