Our Experiences with Organic Apple Orchard

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The Team

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- Grower Cooperators: A&A Orchards, Dickey Farms
Our Experiences
Program Overview

Goals of Research Program

- To develop sustainable and organic production systems for Arkansas and Southern US region producers to capture high value markets
- Small scale, or scale neutral technologies
Organic Apples

36°N

33°N
Orchard Conditions in Upper Mid South Region

Challenges

• Soils
  – Mineral, heavy, often highly eroded
  – Low nutrient content, low pH

• Pests
  – Multiple insect pests, multiple generations
  – Diseases: fireblight, apple scab, cedar apple rust, frogeye leaf spot, Brooks spot, black and white rot, bitter rot
  – Competitive Vegetation: multiple plants, 4 season succession

• Weather: Fluctuating weather; hot, humid, dry summers

Organic Apples
Questions from Growers

How can we sustainably and organically manage:

- Crop thinning
- Competitive vegetation management
- Nutrient management
- Insect and Disease management

And, is it economical
The “Big” Questions

• Can we grow apples in an organic system in our region?

• How can we control competitive vegetation?
  – And how does that impact the orchard ecosystem

• How to provide sufficient and timely nutrition from organic sources?
  – And the interaction with competitive vegetation management
Additional Questions

• How does management affect soil quality and health?
• Does an organically managed orchard sequester carbon?
• Can we control insect and disease pests with organic means?
• How sustainable are organic management techniques?
Organic Orchard Research

**Project Goal:**
- Develop best management practices for establishment of sustainable organic apple orchard for the south

**Project Objectives:**
- Evaluate tree, soil, system responses to:
  - Organic Ground Cover Management System
  - Organic Nutrient Sources
Experimental Treatments

Ground Cover Treatment (GT)
- 1. Municipal green compost (GC)
- 2. Woodchip (WC)
- 3. Shredded White Paper (SP)
- 4. Mow-n-blow (MB)
  - Tree plot size was 2m x 2m (2m wide vegetation mgmt strip)

Nutrient Sources (NS)
- 1. Untreated control (nutrients derived from GT) (NF)
- 2. Composted manure (poultry litter) (PL)
- 3. Commercial Organic Fertilizer (poultry or alfalfa based) (CF)
  - Applied at recommended N rates
Experimental Design

- Random Complete Block Design (4x3 factorial)
  - 4 Groundcover Management Systems (GMS): main plot effect
  - 3 Nutrient Sources (NS): subplot effect
- 6 blocks; 72 total treatment plot combinations
- Treatment trees completely guarded on all sides
- Annual springtime application of GMS and NS
  - GMS: 2m by 10-12 cm deep band
  - NS: adjusted to 50 g N/tree/year
Experimental Design

- Two wire vertical axis training system
- Spacing: 2 m between trees; 4 m between rows (0.4 ha)
- Density: 1485 trees/ha (610 tr/ac)
Plant Material and Management

- **Management Standards**: US NOP Certified Organic
  - Treatments employed at planting reapplied annually in March

- **Preplant**: Leveled, pasture-fed animal manure added as amendment at 3 mt/ha, soil limed, cultivated, summer cover, cultivated, cover crop planted.

- **Permanent Cover Crop**: fescue (*Festuca spp cv. K-31*) + white clover; nurse crop of winter wheat
## Nutrient Sources

<table>
<thead>
<tr>
<th>Certified Commercial Organic Fertilizer</th>
<th>Locally Available Poultry Litter. Contents: bedding, poultry manure</th>
</tr>
</thead>
</table>

![Fertilizer](image1.jpg)  
![Poultry Litter](image2.jpg)
Organic Apples
Groundcover Management Treatments

- Shredded paper
- Mow-blow
- Wood chips
- Green compost
## Treatment Nutrient Contents

<table>
<thead>
<tr>
<th>Treatment</th>
<th>%</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
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<tr>
<td><strong>Poultry Litter (PL)</strong></td>
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<tr>
<td><strong>Commercial Fertilizer (CF)</strong></td>
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<td><strong>Control (NF)</strong></td>
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<td><strong>GC</strong></td>
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</tr>
<tr>
<td><strong>WC</strong></td>
<td>.9</td>
</tr>
<tr>
<td><strong>SP</strong></td>
<td>.22</td>
</tr>
<tr>
<td><strong>MB</strong></td>
<td>1.1</td>
</tr>
</tbody>
</table>
Report

• Competitive Vegetation Management
• Disease Control
• Insect Control
• Soils and Nutrient Management
• Tree Growth and Performance
Competitive Vegetation Management
Survival

Compost
WoodChip
ShredPaper
Mow/Blow
Vegetation/Weed Density

- Compost
- Wood Chips
- Mow-Blow
- Shredded Paper

Year of Study

Vegetation Cover (%)
Vole Damage

Vole Damage Rating (0-5) for different ground cover systems and nutrient source treatments.
Competitive Vegetation Mgmt

Greatest need was during establishment
  – Became less challenging as trees matured and canopy closed.
Ground Covers

**Mow and Blow**

- *Too much competitive vegetation; too competitive*

- Did not improve soil quality and health
- Lowest amount of water infiltration and percolation;
  - highest soil density
- Greatest vole damage
- Highest tree loss
- Reduced tree growth and performance
  - Lowest yields and performing
- Highest insect populations, esp. Japanese Beetles and PC

- Did not produce enough mulch early enough in the season
  - May work with more intentional vegetation; need to have a mulch by April and through July.
Ground Covers

**Shredded paper**
- Best spring weed control
- Problem on young trees due to excess Na release
- Caused pH shift to >8.0 (from 6.0)
- Tied up N
- Broke down by August; autumn vegetation
- More mature trees responded well
  - Increasing yields; reflected light
- At some points became anaerobic under the mulch
Ground Covers

**Compost**
- Over applied N when applied for vegetation control and in combination with nutrient sources
- Caused pH shift to >7.0
- Stimulated weeds under the trees
- Strong habitat for voles
- Trees were too vigorous;
  - Stimulated lots of surface roots into the compost
  - Trees became scion rooted
  - Became nonproductive
- Did result in significantly increased soil OM as deep at 6-10” into the rootzone
- Did increase soil fauna
Ground Covers

**Woodchips**
- Breaks down slowly
- Some tie-up of N
  - Took approximately 3-5 years to stabilize
- Increased soil OM, maintained pH
- Increased soil fauna, fungi
- Suppressed many weeds but Bermudagrass grew over the top
  - Controlling vegetation in woodchips was difficult
- Did not need to be applied annually
- Good alternative, especially combined with cultivation
Competitive Vegetation Management Alternatives

Some vegetation is probably ok

– However, we do not know how much
– Less competition for young trees, more for mature trees
– Perennial vegetation is largest problem
– Spring, early summer vegetation is most competitive with tree growth and nutrition
  • March - June
Best Practices for Competitive Vegetation Management

1. Start with a clean planting row
   – Consider solarization or plastic cover during planting and establishment

2. Use a managed ground cover
   – There is limited knowledge of adaptable ground covers
   – Potential for use of endophyte infected fescues

3. Minimize spreading, creeping grasses such as Bermudagrass and Johnson grass

4. Consider combination of under-tree, shallow tillage followed by mulch systems
   – Wood chip mulches provide benefits to soil
   – Paper mulch is excellent for water retention and vegetation control
Cultivation “Sandwich” System

After cultivation:
- Apply Nutrient Source
- Top with compost
- Top and seal with woodchips
Learning from Mistakes

- Using uncomposted horse manure in field preparation, although improving soil OM and nutrition, introduced weeds
- Use of green compost, stimulated weed growth and introduced weeds
- Use of wood chips, loved by Bermudagrass
- Mow and Blow; too much competition for the tree; excessive mouse problems
- No supplemental nutrition; trees grew but less and did not crop
Alternatives for Competitive Vegetation Management

• Organic Herbicides
• Flaming
• Cultivation
• Combinations
• Plastic Mulches
• Living Mulches
• Doing Nothing – NOT a good alternative
Disease Management
Disease Management

• If, when possible, start with disease resistant cultivars
  – Make sure cultivars are adapted to your region

• Sanitation become a critical management tool
  – Remove all diseased wood
  – Remove all dropped fruit
Disease Management

Scab, Cedar Apple Rust, Powdery Mildew
- Control by cultivar
- Biological controls gave only marginal control in high pressure
- Lime Sulfur and sulfur sprays, copper sprays
- Sanitation is important

Fireblight
- Control by cultivar
- Have lost antibiotics for use
- Sanitation is important
- Fall copper, pre-bloom copper
- Some efficacy of biologicals; marginal control in high pressure years
Disease Management

Fruit Rots: Bitter, Black, White

• No Good Controls
  – Tried to minimize impact with combination of biological fungicides and multiple sulfur applicatoins

• Became a limiting factor
• Must minimize any insect damage
• Related to fireblight infections
  – Sanitation is important
Disease Management

Best management practices

• Select Rs cultivars
• Sanitation
• Pruning
• Strong preventative program
• Strong prophylactic program
Observations on Pest Management

Disease Management

• Quince rust
  – Unique Occurrence in 2012

• Summer rots
  – A problem; will emphasize more summer pruning, orchard sanitation, fall S application, and summer S application, and battery of other suppressants (carbonates, etc.)
Insect Pest Management
Primary, Key Pests

- Oriental fruit moth
  - 3-5 generations, starting at bloom
- Codling moth
  - 4-6 generations, starting at bloom
- Rosy apple aphid
  - Bloom and post bloom
- San Jose scale
  - Post bloom, early summer
- Plum curculio
  - Bloom, early summer; 2-3 generations
Insect Pest Management

Oriental and Codling moths

- Entrust/Bt/Cyd-X applied during first hatch
- Mating disruption was effective in early and mid season
  - Followed by Entrust/Bt/Cyd-X

- Control was good:
  - Damage was 0-7% during orchard trial
Insect Pest Management

San Jose Scale

- Dormant oils to minimize overwintering
- Light oils during flight/crawler stage in May/June (JMS Stylet Oil)
Insect Pest Management

Plum Curculio

• Most difficult to control
  – Suffered 4-100% crop loss; limiting pest
• Reduced first generation feeding and egg laying with Surround® from bloom through post bloom period
• Some efficacy of perimeter *attract-and-kill*
• Some efficacy of bagging fruit after bloom
• Very little control of 2nd and 3rd generation
  – Difficult to scout, monitor, model
• Minimal PC damage strongly linked to rots
• Damage increased with tree age
Observations on Other Insects

- **Mites**
  - No outbreak in organic orchard
- **Control of rosy apple aphids**
  - Patience + treatments
  - Seeding with predators
- **Japanese Beetle; no significant problem**
  - Although in 1 season higher damage rating in MB
Insect Pest Management

Best Practices

• Sanitation and orchard maintenance
• Strong scouting and preventative program
  – Do not let problems build up
Observations on Pest Management

• Cornerstone method:
  – *Strong, high level IPM*
    • Scouting, modeling
  – Deterrence with Surround® (kaolin clay) film
  – Attract/bait, kill
Pest Management

Total number of sprays
- Copper; 2x (fall and spring)
- Surround® averaged 5 applications/yr
  - 3 trips/application
- Oil sprays
  - 3-4 applications/year
- Supplemental insect control (oil, Bt, etc.)
  - 3-8 sprays/year
- Lime-Sulfur and Sulfur Sprays
  - 2 times for thinning
  - 5-7 times for disease control
- Other bio-fungicides, bio-bactericides
  - 5-7 times

- Total: Averaged 20-26 applications with as many as 35 tractor trips/year
Tree Nutrition
Tree Nutrient Management

• Trees require nutrition
  – The no fertilizer treatment trees grew adequately, but did not crop well
    • Showed early season nutrient deficiency symptoms
• No differences between application of poultry litter and certified formulated fertilizer
  – Poultry litter more rapidly released N
• Foliar nutrient analysis a valuable tool
  – No variation due to organic nutrients
• Early season symptoms can be deceiving
  – Trees “grow into” their nutrient supply
Nutrient Sources

No Fertilizer

- Trees grew adequately, but generally had lower cropping
- Trees did not look healthy; pale colors
- Lower survival compared to applying supplemental nutrition
Nutrient Sources

Poultry Litter
- Unstable, varied contents concentration of nutrients
  - Had to pay for analysis annually to calculate rate
- Response was similar to commercial fertilizer
- Quicker N response than fertilizer but faster depletion
- Required 800-1600lbs/acre to satisfy tree N requirement
  - @1%N, required 5kg/tree (10-15 lbs/tree)
- Difficult to handle, manage
- Raised soil pH significantly, >7.0
Nutrient Sources

Certified Commercial Fertilizer
- Response was similar to poultry litter
- Stable, reliable analysis
- Slower N response than poultry litter
- Expensive
- Easy to manage, apply, calibrate
Soil Nutrient Contents

Nitrogen
• Annual application of compost was about 3-5x more N than would be normally required
• NUE and N Loss
  – Using compost resulted in significant excess N with low total N recovery and use efficiency.
  – Wood chips treated trees had similar N contents and higher NUE as compost but significant less loss
  – Although paper and mow/blow had low N excess and loss and high NUE, were low in soil and tree N
Soil Nutrients

- Compost had significant late season available and total N
  – Significantly increased extractable soil NO3, followed by wood chips
  – Generally, soil NO3 has increased during the transition period
- Wood Chips had consistently higher available and total P
- Poultry litter and certified fertilizer showed increased N and P but not significant for all years
  – Poultry litter resulted in highest extractable or available soil NO3 in spring sampling (30 days after application) compared with certified fertilizer or no fertilizer
Tree Nutrition

- Early season foliar nutrition of N was significantly increased for compost and woodchips; but similar later in the season.
- After 8 growing seasons all ground cover treatments and nutrient treatments had adequate and similar foliar nutrient contents.
  - Foliar N was adequate but in the low range for many treatment combinations except GC+PL and GC+CF, which had excess N.
Best Management Practices for Organic Orchard Nutrient Management

1. Base nutrient application rates on annual foliar testing and periodic soil testing (2-5 years)
2. Nutrient source does not have a big impact
3. Apply nutrients **early** in the season, e.g. mid-March
4. Limit competitive vegetation to nutrient management zone
   - Apply nutrients to a vegetation-free strip
   - Consider applying immediately after strip cultivation
5. Cover nutrients with appropriate ground cover system (e.g. compost, wood chips, paper)
6. Be sure orchard system has adequate season-long soil water content
Tree Growth and Performance
Tree Growth and Development

- Wood chips and compost had greatest tree size; height, trunk cross-sectional area, and leaf development
  - All trees achieved target height of 3m height and 15cm² TCSA by year 4
  - All trees managed at 3.25 – 3.5m ht
  - WC and GC were large enough to crop in year 3 or 4; other treatments were delayed until 4-5
- Paper had smallest TCA; reduced chlorophyll, photosynthesis, leaf size
- No nutrient treatment resulted in reduced tree growth and a delay in production capacity
Total Vegetative Growth Estimate

Ground Cover Treatment:
- GC
- WC
- SP
- MB

Nutrient Source Treatment:
- CF
- PL
- NF

TCSA (cm²)

Years:
- 2013
- 2012
- 2011
- 2010
- 2009
- 2008
- 2007
- 2006
- Plntg

Organic Apples
Tree Height

Ground Cover Treatment

Nutrient Source Treatment

Organic Apples
Early Yields

Fruit production was significantly reduced by weather in 4 of first 6 cropping years; trees did not make target yields

- All trees bloomed in 3rd leaf although SP and MB were not large enough to sustain a crop
- Crop had reduced crop in 4th leaf with frosts.
- Crop was lost in 5th and 9th leaf due to fruit set (rain) and sunburn, heat drop, rots.
- Poor flower formation and set in years 6 and 7 due to excessive summer heat the year before.
  - Yield in year 6 reduced by sunburn and heat drop
  - Yield in year 7 reduced by May frost and snow
Early Yields

- Wood chips and compost treated trees had significantly greater cumulative fruit yields compared to shredded paper and mow/blow (lowest)
- Certified fertilizer and poultry litter treated trees had significantly greater cumulative yields compared with no fertilizer
- No treatments affected average fruit weight or size
- Compost plus additional nutrients resulted in excessive nitrogen application and has shown a correlation to reduced seasonal yields
Cumulative yield (6 seasons)

<table>
<thead>
<tr>
<th>Ground Cover Treatment</th>
<th>Cumulative Yield (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost</td>
<td>70</td>
</tr>
<tr>
<td>WoodChip</td>
<td>70</td>
</tr>
<tr>
<td>ShredPaper</td>
<td>50</td>
</tr>
<tr>
<td>Mow/Blow</td>
<td>-26%</td>
</tr>
</tbody>
</table>
Cumulative yield (6 seasons)

Cumulative Yield (kg/tree)

Nutrient Source Treatment

None  CommFert  Poultry Lit

-12%
Nitrogen Application and Cropping

Excessive N reduces yield potential

\[ R^2 = 0.5557 \]
General Observations

Soil Conditions

- Ground Cover systems affected soil temperatures and seasonal soil moisture content
  - Shredded paper resulted in reduced soil temps and highest average soil water moisture content
  - Mow/blow resulted in highest soil temps and lowest average soil water moisture content
- Soil Density
  - Density in all decreased since preplant
  - Density in wood chips and compost lightest; paper heaviest
- Water Infiltration
  - Greatest under paper and wood chips
  - Least under mowed, mow/blow
Summary and Conclusions

• SP and WC provided some competitive vegetation management, but additional inputs were needed
• GC provided excess N nutrition at rate it was applied
• GC resulted in significant improvements in soil biology, soil quality and health
• WC resulted in best combination of soil health, tree growth, and cropping
• Either nutrient source provided sufficient nutrition and similar results
• MB resulted in greatest tree loss
• No nutrition resulted in adequate tree growth, but lowest soil biology measurements, and lowest cumulative yields
Summary and Conclusions

- Trees lost cropping due to environmental conditions
  - Seemed very sensitive to environment
    - Cultivar reasons; treatment (N) reasons
  - Lost crop to frosts, freezes, hail and excessive heat
  - Cultivar was not well adapted; importance of CV selection.
- Organic management showed significant improvement in soil quality and health
  - Compared to conventional orchard
    - Decreased soil density
    - Significantly increased water infiltration
    - Significantly increased soil organic matter
    - Significantly increased C and N sequestration
    - Significantly increased soil microorganisms and biological activity
Thanks for your Attention

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Organic Herbicides

• Several available
  – Acids: Acetic Acid, Pelargonic Acid
  – Oils: terpenoids – Clove Oil, Mint Oil, etc.
  – Allelopathics
  – Soaps, Salts, etc

• Generally have to be applied at high concentration, frequently
  – Best if applied 2-5 times at 5-7 day intervals
Organic Herbicides

• **Advantages**
  – Easy to apply; similar to conventional
  – Quick Knock Down

• **Disadvantages**
  – Only effective on germinating, tender annuals
    • NOT effective on perennials
  – Short-term response; quick grow-back
    • Physical not Physiological effects
  – Expensive
    • Used at high concentrations
  – Can cause pest problems
Flaming

- **Advantage**
  - Quick and easy, rapid results (if any)

- **Disadvantages**
  - Only effective on germinating, tender annuals
    - NOT effective on established vegetation
    - NOT effective on perennial vegetation
  - Can have quick regrowth
    - Physical not physiological effect
  - Sustainable?? Heavy use of energy, petrol
  - Expensive; may require monthly applic.
  - Fire hazards (use with irrigation running, and well watered fields)
Cultivation

Types: shallow cultivation, rotary hoes

• **Advantages**
  – Control when needed; quick
  – Shallow Incorporation of OM
  – May reduce mice

• **Disadvantages**
  – Disturbs soil; exposes soil to air
  – May reduce surface OM
  – May prune surface tree roots
  – Requires frequent cultivation; Petroleum use
Organic Apples
Plastic Mulches

• Polyethylene Fabric Mulch
  – Advantages
    • Excellent control
    • Excellent moisture retention, best
    • Fast to apply; lasts multiple years (4-7+ yrs)
    • Possible insect barrier
Strategies and Alternatives

• Polyethylene Fabric Mulch
  – Disadvantages
    • Expensive Investment ($3000/ac)
    • Needs to be removed or “rolled back” seasonally
      – Soil may become anaerobic in wet conditions
      – Soil needs to “breathe”
      – Moved to apply nutrients
    • Difficult to apply nutrients
    • Mice
    • Soil heating
Use of Living Ground Covers

- Must not compete with tree during periods of need (especially spring and fall)
  - *Fruit trees are not very competitive!*
- Must be effective at improving soil condition (nutrition, aeration, etc.)
- Must be effective at eliminating competitive weeds
Living Ground Covers

It has been observed that living ground covers:

- Spring and summer grasses compete with fruit trees:
  - Fruit trees are very “weak” competitors for nutrients and soil oxygen
- Understory legumes may fix N, but:
  - Use K and can cause K deficiencies
  - May release N when the tree can not use
- There may not be any nutrient movement of nutrients fixed in the drive row into the orchard root system
- Living Mulches provide habitat for beneficial insects
- Living Mulches can alter orchard microclimate
General Observations

Competitive Vegetation and Tree Survival

- SP significantly reduced competitive vegetation, followed by WC
  - GC stimulated some vegetation
- No significant effect of nutrient source on competitive vegetation
  - Although least vegetation in no-nutrient control
- MB resulted in significant rodent damage and tree loss (~40%); required trapping
- SP resulted in significant tree loss; possible anerobiosis and related maladies; sensitivity to late winter injury
- Overall tree survival ranges from 60-77%
  - Additional losses to fireblight, other damage, etc.
Observations on Pest Management

**Disease Management**
- Using highly resistant CV
  - No infection of scab, cedar apple rust, mildew
- Used lime-sulfur, sulfur and some copper as preventatives
- Orchard sanitation

**Fireblight**
- Although ‘Enterprise’ has resistance, not complete.
  - Some infection in 3 high infection years
  - Had to treat; have used antibiotics
  - Missed some preventative treatments
Observations on Pest Management

- Control of codling moth and oriental fruit moth
  - Good; low pressure
  - Control methods
    - mating disruption, IPM and targeted sprays
- Plum Curculio
  - A work in progress
  - A significant problem
  - Control methods
    - Attract, bait, and kill strategies
    - Surround®; marginal effect
- Scale – Became a problem
  - Requires multiple dormant oil applications
  - Monitor for crawler stage and apply summer oil, trunk directed, and/or other sprays to control