High Density Apple Production

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Outline

• Principles of High Density Apple Production
• Site selection/preparation
• Rootstocks
• Training Systems
• Tree Establishment and Nutrient Management
• Tree Management
  – Leader management
  – Lateral management
PRINCIPLES OF HIGH DENSITY APPLE PRODUCTION
Principles of High Density Apple Production

• High early yields = high tree density

• Balance vegetative and fruiting

• Grow fruit, not trees!
Balance Growth and Fruiting

Excessive fruit load
- Large yields
- Small apples
- Weak trees

Excessive vigor
- Small yield
- Larger fruit
- Poor fruit color development
Vertical Growth

- Vigorous vegetative growth
- Not fruitful
- Weak crotch angles
Horizontal Growth

- Less vigorous
- Very fruitful
- Greatest flower production near base
- Strong crotch angle
SITE SELECTION/PREPARATION
CHOOSING YOUR NURSERY STOCK
Selecting Rootstocks for High Density Systems

• Must be dwarfing rootstocks
• With vigorous scion cultivars
  – dwarfing clone of M.9 or B.9 rootstock and/or greater planting distances.
• With weak scion cultivars
  – vigorous clone of M.9 rootstock should be used and/or closer planting distances.
Whip vs. Feathered

• Tall spindle system
  – Requires use of highly feathered trees (8-15 laterals)
  – Economic benefits are based on fruiting in year 2 and 3
    • If fruiting does not start until year 4 or 5 cost of maintenance overwhelms the benefit
TREE ESTABLISHMENT AND NUTRIENT MANAGEMENT
Irrigation

• Highly feather trees produce a lot more leaves in the first few years
  – Low root:shoot ratio

• Root systems are insufficient to meet tree demand

• Water stress can greatly reduce tree yield potential and jeopardize critical early yields
Irrigation

• Dry years can have dramatic impact on yield and disrupt the vegetative and fruiting balance

• Irrigation system should be installed within 4 weeks of planting
Leader Management

• Managing leader is necessary to maintain shape of tree and lateral branching

• Pruning invigorates tree growth and delays fruiting - not desirable in HD system
  – May be required if whips are used or if poor lateral development
  – Consider cost of delayed production with initial cost of highly feathered trees

• Other leader management techniques:
  – Weak leader renewal
  – Snaking
  – Bagging
Nutrient Management

• N is the most critical nutrient for vegetative growth

• Ca spray becomes critical
  – Greater demand, less supply
Fertilization Years 1-3

• Highly feather trees require supplemental fertilizer (N) to support early growth
  – Nurseries should apply urea foliar spray before leaf drop to provide reserve in the trees
  – Spoon feed through the irrigation system 2x/wk for 12 wks

• Forms of N readily available:
  – Calcium nitrate
  – Ammonium phosphate (?)
N Fertilization Year 3 +

• Low fertilizer requirements required to keep trees ‘calm’
  – Minimal vegetative growth

• Consider soil fertility
  – The soil can contribute significant amounts of nutrients

• Utilize soil and tissue analysis
Crop Load Management

• Do not over crop the trees during the establishment period
  – Poor vegetative growth
  – Increased stress
  – Biennial bearing
  – Trees do not fall into natural balance

• Tendency to over crop is high with:
  – Precocious root stocks
  – Highly feathered trees (no pruning)
Crop Load Recommendation During Establishment

- Annual cropping varieties (i.e. Gala)
  - 5 fruits/cm² TCA

- Biennial cropping/slow growing varieties (i.e. Honeycrisp)
  - 3-4 fruits/cm² TCA

(Robinson 2008)

<table>
<thead>
<tr>
<th>Year</th>
<th># Fruit /tree (annual bearer)</th>
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<tbody>
<tr>
<td>2</td>
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<tr>
<td>3</td>
<td>50-60</td>
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TRAINING SYSTEMS
Central Leader

• 200-300 trees/acre

• Usually used with semi-dwarfing rootstock

• Leave only one trunk for the central leader.

• Remove branches with crotch angles less than 60 degrees.

• Remove all branches directly across from one another on the leader.

• Space lateral branches uniformly around the leader to prevent crowding as the limbs grow in diameter.
Slender Pyramid

- Hybrid of central leader and vertical axis (limb renewal)
- 300-500 trees/acre
- Tree height 14-16’
- Rootstocks: M.7, M.26, G.30, G.935, G.6210
- Trees are not headed at planting
- Bottom scaffolds are encouraged to fill in during first 2 year - other lateral removed
- Establish hierarchy of loose whorls around leader
- Renewal pruning of higher tier laterals
Vertical Axis

- 500-900 trees/acre
- Dwarfing rootstocks
- Narrow pyramid shape with dominant central leader
- Max height of about 12-14’
Tall Spindle

- 1000-1500 trees/acre
- Dwarfing root stock
- Highly feathered trees (10-15 feathers)
- Early fruiting - 2\(^{nd}\) and 3\(^{rd}\) leaf
- No permanent wood! All scaffolds are renewed by complete removal when they become too big
- Upper branches bent below horizontal to devigorate
### Yield Of 4 Different Training Systems (NY)

<table>
<thead>
<tr>
<th>Variety</th>
<th>System</th>
<th>Tree</th>
<th>Den.</th>
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<th>3rd</th>
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<td>Central Leader</td>
<td>218</td>
<td>0</td>
<td>1</td>
<td>24</td>
<td>25</td>
<td></td>
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<td>37</td>
<td>113</td>
<td>150</td>
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<tr>
<td></td>
<td>Vertical Axis</td>
<td>726</td>
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<td>239</td>
<td>327</td>
<td>566</td>
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<td></td>
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<td>1307</td>
<td>13</td>
<td>351</td>
<td>771</td>
<td>1135</td>
<td></td>
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<tr>
<td>Honeymcrisp</td>
<td>Central Leader</td>
<td>218</td>
<td>0</td>
<td>1</td>
<td>27</td>
<td>28</td>
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<tr>
<td></td>
<td>Slender Pyramid</td>
<td>444</td>
<td>0</td>
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<td>3</td>
<td>132</td>
<td>578</td>
<td>713</td>
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(Data: T. Robinson, Cornell)
Yield of Training Systems (NY)

McIntosh apple trees planted in 2002 and trained to various systems in northern New York State.

YIELD/ACRE (in bushels)

- Tall spindle
- Solaxe
- Vertical axis
- Slender pyramid
- Central leader

SOURCE: Cornell University
Optimal Tree Density

Economic studies show a ‘sweet spot’ for tree density ~ 1000 trees / acre

- Feathered trees + steel tube tree stake
- Feathered trees + 4 wire trellis
- Inexpensive feathered trees + 4 wire trellis
Tree Density

- Optimal tree spacing depends on:
  - Rootstock vigor
  - Scion vigor
  - Soil fertility

John Clements (UMASS) has developed spacing calculator to assist

- [http://www.umass.edu/fruitadvisor/m/index.html](http://www.umass.edu/fruitadvisor/m/index.html)
SLENDER SPINDLE
Slender Pyramid

- **Density:** medium (340 trees/A)
  - in-row spacing: 8’
  - Between row: 16’

- **Tree Height:** 14-16’

- **Rootstock:** semi-dwarf
  - M.7, M.26, M.30, G.30, G.935, G.6210
VERTICAL AXIS
Vertical Axis

- 500-1000 trees/acre
- Dwarfing rootstocks
- Narrow pyramid shape with dominant central leader
- Max height of about 10’
- Few cuts made during the first few years
Tree Spacing and root stock

- Between row: 12-14’
- In row: 5-7’
- Tree height: 12-14’

- Rootstocks:
  - M.9, G.41, G.11, G.16
  - M.26- can be used but only with weaker scions
Vertical Axis: Planting Year

- Ideal tree has 4 branches evenly spaced and central leader
- Remove any branches within 18” of soil surface
- Remove branches that are at a narrow angle or unevenly spaced around the leader
- Poorly branched tree (B) head leader and remove branches
Vertical Axis: Summer Pruning

• July- Any branches less than $60^\circ$ angle should be spread or tied down
  – Avoid excessive weights which will increase angle beyond $60^\circ$

• Sept- tree weights can be removed
Vertical Axis: 2\textsuperscript{nd} Year

- Spring- Remove vigorous shoots that compete with the central leader
- July- Weight limbs that are less than 60° angle
Vertical Axis: 3\textsuperscript{rd} Year

- Spring- removed vigorous branches that compete with the central leader or shoots not trained to proper angle

- Prune lower branches that have grown into adjacent tree
  - Cut back to 2-year old wood or older to a less vigorous lateral branch
Vertical Axis: Mature Tree

- Manage height:
  - Bend over top
  - Head central leader back to less vigorous lateral branch on 2 year old wood or older

- Maintain pyramid shape
  - Bottom- cut back into 2 year old wood or older
  - Top- cuts should be made near the central axis
    - Buds at base of stub cuts will produce new branch
Vertical Axis: Mature Trees

• Remove:
  – dead/diseased branches
  – upright suckers
  – branches growing in toward tree
  – Branches will narrow angles
  – Branches directly above another branch to prevent shading

• Redeveloping Pyramid Shape
  – Cut back limbs to less vigorous laterals to the desired form
TALL SPINDLE
Tall Spindle

- 1000-1500 trees/acre
- Dwarfing root stock
- Early fruiting - 2\textsuperscript{nd} and 3\textsuperscript{rd} leaf
- No permanent wood! All scaffolds are renewed by complete removal when they become too big
- Upper branches bent below horizontal to devigorate
Tall Spindle: Planting

• Planting stock must be high caliper and highly feathered (8-15 Feathers)

• Very little growth is needed to fill the small space, so minimal pruning is needed

• Remove only larger branches that are out of balance with rest of tree
  – Greater than 2/3 the diameter of the leader
  – Stub cut that leaves adventitious bud for renewal branch
Tall Spindle: Planting

• Large Caliper
  – Do not head the leader
  – Remove all feathers below 24”
  – Remove feathers larger than 2/3 dia. of leader
  – Do not tip the feathers

• Med Caliper poorly feathered trees or whips
  – Head leader at 60”
  – Remove feathers larger than 2/3 dia. of leader
  – Score above every other bud along leader from 24”-42” high
Tall Spindle: First Summer

• Pinch side shoots in upper ¼ of leader when shoots are 4-5” long
  – Re-pinich when regrowth is 4-5” long

• Tie leader to support system

• Train lower branches to below horizontal
  – Encourage flower production
Tall Spindle: 2nd Year

• Do not head leader
• Do not head feathers
• Remove:
  – Branches competing with leader
  – Narrow angled branches
  – Large scaffolds (2/3 dia. Of leader)
    • Large branches = large trees
  – Side branches longer than 2”
Early Cropping Is Essential

- Tall spindle requires reduced vegetative growth
- Recuperate establishment costs
- Cropping must begin in second year
- Cropping targets:

<table>
<thead>
<tr>
<th>Year</th>
<th># of fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-5</td>
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<tr>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
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<tr>
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<td>70</td>
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<tr>
<td>5</td>
<td>90</td>
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</tbody>
</table>
Tall Spindle: Year 3-5

• Bend top
• Limit height by cutting back to weak fruitful side branch
• Remove:
  – Branches larger than ¾” diameter
• Shorten older, pendant branches to a weak side branch or spur
Tall Spindle: Mature Trees

• Limit height by cutting to a weak fruitful side branch
• Annually remove 2 branches (limb renewal pruning)
  – Focus on middle tiers of branches first, then upper
• Remove low hanging branches
• Shorten pendant branches to point of bend
• Do not over prune!