High density planting

The Small Trees High Productivity Initiative

What are we doing?
What have we learnt?
Any application to citrus?

Helen Hofman, Snr Horticulturist, DAF Queensland
The Small Trees High Productivity Initiative

Transforming the productivity of subtropical and tropical tree crops
2014-2018

- avocado
- macadamia
- mango
Why?

Avocado 7-11 tonnes/ha

Apple 60-100 tonnes/ha
Four foci

1. Managing vigour

Anahita Mizani, PhD candidate
The Small Trees High Productivity Initiative

1. Managing vigour

2. Optimising light

Janine Conway,
Horticulturist and Hanna Toegel, Technical officer
The Small Trees High Productivity Initiative

1. Managing vigour
2. Optimising light
3. Manipulating architecture

Hanna Toegel and Carola Parfitt, Technical Officers
The Small Trees High Productivity Initiative

1. Managing vigour
2. Optimising light
3. Manipulating architecture
4. Maximising crop load

Dr Paula Ibell, Horticulturist

Department of Agriculture and Fisheries
Main activities

1. Planting systems trials – integrate all four foci
2. Various trials to understand/improve crop loads
3. Light interception measurement in variety of orchards
4. Selection/trials of vigour-controlling rootstocks
5. Plant modelling
   – to be used in virtual experimentation to test hypotheses
   – carbon allocation
   – light distribution models
6. Molecular/genetic studies on how floral initiation, architecture and juvenility are regulated
   – Map over time of gene expression in plant tissues
   – Experiments to understand regulation by hormone or sugar signalling
## Planting Systems Trials

<table>
<thead>
<tr>
<th></th>
<th>Avocado Hass on 2 rootstocks</th>
<th>Macadamia 2 varieties</th>
<th>Mango 3 varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low density</td>
<td>9 x 5m 222 trees/ha</td>
<td>8 x 4m 312 trees/ha</td>
<td>8 x 6m 208 trees/ha</td>
</tr>
<tr>
<td><strong>Medium density</strong></td>
<td>6 x 3m 555 trees/ha</td>
<td>6 x 3m 555 trees/ha</td>
<td>6 x 4m 450 trees/ha</td>
</tr>
<tr>
<td><strong>High density</strong></td>
<td>4.5 x 2m 1111 trees/ha</td>
<td>5 x 2m 1000 trees/ha</td>
<td>4 x 2m 1250 trees/ha</td>
</tr>
</tbody>
</table>
… and comparing tree training systems

- Conventional v. central leader with evenly spaced lateral branches; limb bending; trellising
Avos and mangos: trellising for support and training
What have we learnt so far?

Some examples
1. Managing vigour

Macadamia high-density pruning trial
Dr John Wilkie
<table>
<thead>
<tr>
<th>Treatment</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedged</td>
<td>2.3 a</td>
<td>4.8</td>
<td>4.3 a</td>
<td>3.7 a</td>
</tr>
<tr>
<td>Hedged + UCZ</td>
<td>3.0 ab</td>
<td>5.0</td>
<td>6.2 c</td>
<td>4.6 b</td>
</tr>
<tr>
<td>Selective pruning</td>
<td>4.4 c</td>
<td>5.9</td>
<td>5.8 bc</td>
<td>5.4 c</td>
</tr>
<tr>
<td>Selective + UCZ</td>
<td>3.9 b</td>
<td>4.8</td>
<td>4.6 ab</td>
<td>4.4 b</td>
</tr>
</tbody>
</table>

Means in the same column that have the same letter or no letter are not significantly different at the 95% confidence level.

UCZ= uniconazole as ‘Sunny’

In a high density system, selective pruning gave better yields than hedging.
2. Optimising light

Avocado total light interception study
Dr John Wilkie

Only small increases in light interception as trees begin to crowd

Commercial orchard, Childers, 12 blocks, 2 years, 2015 data shown
2. Optimising light

Light interception at Avocado Planting Systems Trial 18 mths after planting

![Graph showing light interception and canopy volume relationship]

- Commercial orchard, Childers, 12 blocks, 2 years, 2015 data shown
- Conventional planting 9%
- 6 x 3 planting 18%
- 4.5 x 2 planting, trellis 41%

$r^2 = 0.979$
Don’t go above 80% light interception (avocado)
3. Manipulating architecture

Avocado studies
Helen Hofman

Most fruit on short branches

Understand which architecture is optimal
3. Manipulating architecture

Macadamia limb bending
Ben Toft, PhD candidate

Limb bending effective in increasing flowering but only when done during floral initiation

Racemes found on an entire branch unit (black) and on the first order axis of a branch unit (grey) after limb bending at different times. A = control (not bent); B = bent to horizontal before vegetative flush C = bent to horizontal during floral initiation (May 2015), bars show standard error of the mean.

Understand optimum timing of interventions
4. Maximising crop load

Mango crop load experiment
Dr Paula Ibell

Removing flowers did not affect yield (kgs) until 95% of flowers were removed.
4. Maximising crop load

Avocado tipping and Cytolin® trial

Helen Hofman

Reducing vegetative competition in spring improved fruit set but crop loads ‘balanced’ out by season-end.

Error bars show standard error of the means.
**Integrating light, vigour, architecture, crop load**

**Avocado Planting Systems Trial (May 2016, first crop)**
Dr John Wilkie, Helen Hofman

<table>
<thead>
<tr>
<th></th>
<th>Canopy volume per tree (m³)</th>
<th>Yield per tree (kg)</th>
<th>Yield per ha (tonne)</th>
<th>Yield per m³ canopy volume (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low density</td>
<td>15.5</td>
<td>7.4</td>
<td>1.7 a</td>
<td>0.47</td>
</tr>
<tr>
<td>Medium density (CL)</td>
<td>11.6</td>
<td>3.2</td>
<td>1.8 a</td>
<td>0.27</td>
</tr>
<tr>
<td>High density (CL, limb bending, trellised)</td>
<td>13.9</td>
<td>6.5</td>
<td>7.3 b</td>
<td>0.49</td>
</tr>
</tbody>
</table>

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CL = central leader.

MD: Heavy pruning reduced flowering intensity and fruit set.

Shape trees when young.

Early high yields per ha.
Citrus and high density planting

- High density planting not new
  - inc. in Aust 1980s Hutton, Broadbent, Bevington viroid dwarfing

- Results vary but often:
  - higher yields from higher densities in early years
  - plateauing out to same/ha as low density at 7-10 years

- Past trials:
  - minimal management (mostly hedging)
  - standard rootstocks
What’s different? Is the time ripe?

- Robotics proceeding apace
  - easier with a ‘fruit wall’
- Higher land and water costs
- Labour costs increasing
- Pickers not getting any taller
- Paradigm shift to shorter life (trees/varieties/HLB)

What hasn’t changed?

- Proven low-vigour rootstocks
  - ‘Flying Dragon’, hybrids of ‘Flying Dragon’, ‘C-35’
- Low value products/premium for market segments (?)
- Cost of trees
Rootstocks and varieties

• dwarfing rootstock essential?

• is it an option to focus instead on scions? Plant cultivars
  – that are precocious and regular bearing
  – have a natural central leader shape
  – use mounds, PGRs, pruning to manage vigour
  – accept shorter life?
Macadamia ‘741’
Recalcitrant
Upright
Nuts on older wood

‘A203’
Precocious
Spreading
Nuts on recent growth
Thinking about high density planting?  
From the grower’s perspective

• Our approach is not (yet?) proven: assess costs/risks  
  – is product value high enough?

• Intensive planting = intensive management  
  – must optimise light interception and distribution: regular pruning and early tree shaping essential  
  – use full range of other vigour-management strategies: rootstocks, mounds, PGRs

• If vigour can’t be controlled, perhaps still economic for shorter tree-life  
  – plant precocious varieties  
  – have a Plan B for thinning out trees
Thinking about high density planting?
From the industry perspective

- Invest in development/trialling of vigour-controlling rootstocks/precocious varieties
- Trial potential tree structure(s) and densities in tandem with developing robotic technology
- Assess effects on fruit quality/quantity
Acknowledgements

The Small Tree - High Productivity Initiative is an initiative of the Queensland Government. Major partners include:

- the Department of Agriculture and Fisheries (DAF),
- DAF’s research alliance with The University of Queensland (Queensland Alliance for Agriculture and Food Innovation) (QAAFI), and
- the NSW Department of Primary Industries.

Key parts of the initiative have been co-funded by Horticulture Innovation Australia Limited using the across horticulture levy and voluntary contributions from DAF and matching funds from the Australian Government.

Particular thanks to:

- industry members of the various advisory committees and
- growers who have supported our on farm trials.