Early detection of litchi graft incompatibility

Karin Hannweg, Moses Molope, Elli Hajari & Dzuni Nonyane
ARC-Tropical and Subtropical Crops
Why?

• imported cultivars (China & Israel) – extend the short harvesting period in South Africa

• grafting success is variable due to rootstock-scion incompatibility

• compatibility is a pre-requisite for successful grafting & ultimately tree performance:
  • a proper continuum between rootstock and scion - water & nutrient uptake
  • distribution of photosynthetic assimilates
  • tree performance and yield

• compatibility is dependent on anatomical, biochemical, physiological & genetic variables
Why?

Aims:

- determine which selected scion-rootstock combinations are incompatible
  - identify incompatibility observations (anatomical, biochemical and/or physiological) as soon as possible after grafting

- determine genetic relatedness of the cultivars and rootstocks

- combine and compare the observations with the genetics & ultimately develop a model for predicting compatible scion-rootstock combinations
Compatibility & Genetic Relatedness

- compatibility is difficult to predict, but there is general consensus that a degree of taxonomic (i.e. genetic) relatedness should exist in order for a particular rootstock/scion combination to be compatible

- the greater the taxonomic distance between stock and scion the smaller the chances of forming a successful graft union
Compatibility & Genetic Relatedness

Group 1: ‘Mauritius’

Group 2: ‘McLean’s Red’

Group 3: ‘Brewster’

Group 4: ‘Wai Chee’
What have we done so far?

- Identification of cultivars for the study
- Preliminary graft incompatibility observations
- Optimisation of dye uptake
- Grafting onto clonal rootstocks
- Physiological studies: Survey of chlorophyll content index
Identification of cultivars for the study
### Identification of cultivars for the study

- **18 cultivars were selected:**

  **Rootstocks & controls**
  - Mauritius
  - McLean’s Red
  - Wai Chee
  - Brewster

  **Israeli cvs**
  - Chakparat
  - Hung Long
  - Kim Cheng Mesa
  - Kwai May Red
  - Late Seedless
  - Nuomici
  - Sah Keng
  - Souey Tung
  - Yellow Red

  **Under contract**
  - Sivan
  - Tamuze
  - Yuli

  **Other**
  - Kaimana
  - Garnet
  - Fay Zee Siu

Photo: R. Cronje
Observations of ‘degrees of incompatibility’
Observations of ‘degrees of incompatibility’

Young nursery trees
Observations of ‘degrees of incompatibility’

3 - 5 year old trees
Observations of ‘degrees of incompatibility’

3 - 5 year old trees
Optimising & visualising dye uptake & incompatibility?
Optimising & visualising dye uptake & incompatibility?

(Dwarfing/incompatible rootstock) (Compatible rootstock)

(Scion) (Graft union) (Rootstock)

(Olmstead et al., 2006)
Optimising & visualising dye uptake & incompatibility?

Performance of the litchi compatible graft J/J and incompatible graft J/Z

(Chen et al., 2017)
Optimising & visualising dye uptake & incompatibility?

Anatomical analysis of the litchi compatible graft (top) and incompatible graft (bottom) - standard tissue staining for microscopy

(Chen et al., 2017)
Optimising & visualising uptake & incompatibility?

Anatomical analysis of the litchi compatible graft (top) and incompatible graft (bottom) - standard tissue staining for microscopy

(Chen et al., 2017)
Optimising & visualising dye uptake & incompatibility?

(Chen et al., 2015)
Optimising & visualising dye uptake & incompatibility?

(Chen et al., 2015)
Optimising & visualising dye uptake & incompatibility?

• time required?

• cut grafts 2-3cm below the graft union between 7:30 – 9:00am

• retain leaves (dye moves through stems by transpirational pull)

• immediately place into water/dye (depending on the circumstances) – 3 to 6 hours
Optimising & visualising dye uptake & incompatibility?
Optimising & visualising dye uptake & incompatibility?

Rootstock patterns of dye uptake were visualised using the dye-uptake method:

- ‘Mauritius’
- ‘McLean’s Red’
- ‘Wai Chee’
- ‘Brewster’

Are there differences between rootstock cultivars?
ROOTSTOCKS

'‘Mauritius’'

'‘McLean’s Red’'

'‘Wai Chee’'

'‘Brewster’'

old wood  new wood
Optimising & visualising uptake & incompatibility?

Scion patterns of dye uptake were visualised using the dye-uptake method (*detached branches*):

- ‘Chakrapat’
- ‘Hung Long’
- ‘Kim Cheng Mesa’
- ‘Souey Tung’
- ‘Kwai May Red’
- ‘Late Seedless’
- ‘Tamuze’
- ‘Mauritius’

- ‘Fay Zee Siu’
- ‘Kaimana’
- ‘Sivan’
- ‘Yellow Red’
- ‘Nuomici’
- ‘Sah Keng’
- ‘Garnet’
- ‘McLean’s Red’

Are there differences between scion cultivars?
SCIONS

‘Fay Zee Siu’

‘Garnet’

‘Kaimana’

‘Kwai May Red’

old wood — new wood
SCIONS

‘Late Seedless’

‘Nuomici’

‘Sah Keng’

‘Sivan’

old wood  new wood
SCIONS

‘Yellow Red’

‘Chakrapat’

‘Hung Long’

‘Kim Cheng Mesa’

old wood  new wood
Optimising & visualising dye uptake & incompatibility?

What does a compatible rootstock: scion combination look like?
Optimising & visualising dye uptake & incompatibility?

What does a compatible rootstock: scion combination look like?

Uptake time: 6 hours
Optimising & visualising dye uptake & incompatibility?
What does an incompatible rootstock: scion combination look like?
Optimising & visualising dye uptake & incompatibility?

What does an incompatible rootstock: scion combination look like?

2-3 year old grafts
Optimising & visualising dye uptake & incompatibility?

What does an incompatible rootstock: scion combination look like?

uptake time: 6 hours
Grafting onto rootstocks
Grafting onto rootstocks

- litchi is highly heterozygous
- unknown impact of seedling parents on rootstock performance?
Grafting onto clonal rootstocks

3x ‘Wai Chee’ seedlings
Grafting onto clonal rootstocks

3x ‘Wai Chee’ seedlings
Grafting onto clonal rootstocks

3x ‘Wai Chee’ seedlings
Grafting onto clonal rootstocks

3x ‘Wai Chee’ seedlings

- Impact on yield?, field performance?, tolerance to pests & diseases/, abiotic factors?
Grafting onto clonal rootstocks
Grafting onto clonal rootstocks

uniformity
Grafting onto clonal rootstocks

uniformity
Grafting onto clonal rootstocks

uniformity
Grafting onto clonal rootstocks

- 18 selected cultivars were grafted onto clonal ‘Wai Chee’ rootstocks at Schagen nursery
- ten budwood sticks/cultivar – unless suitable material was limited e.g. ‘Yuli’
## Grafting onto clonal rootstocks

### Cultivars grafted onto ‘Wai Chee’ clonal rootstocks

<table>
<thead>
<tr>
<th>CULTIVAR</th>
<th>QUANTITY GRAFTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewster</td>
<td>10</td>
</tr>
<tr>
<td>Chakrapat</td>
<td>10</td>
</tr>
<tr>
<td>Fay Zee Siu</td>
<td>10</td>
</tr>
<tr>
<td>Garnet</td>
<td>10</td>
</tr>
<tr>
<td>Mauritius</td>
<td>10</td>
</tr>
<tr>
<td>Hunglong</td>
<td>10</td>
</tr>
<tr>
<td>Kaimana</td>
<td>10</td>
</tr>
<tr>
<td>Kim Cheng Mesa</td>
<td>10</td>
</tr>
<tr>
<td>Kwai May Red</td>
<td>10</td>
</tr>
<tr>
<td>Late Seedless</td>
<td>10</td>
</tr>
<tr>
<td>McLean's Red</td>
<td>10</td>
</tr>
<tr>
<td>Noumici</td>
<td>10</td>
</tr>
<tr>
<td>Sah Keng</td>
<td>10</td>
</tr>
<tr>
<td>Sivan</td>
<td>10</td>
</tr>
<tr>
<td>Suey Tung</td>
<td>10</td>
</tr>
<tr>
<td>Tamuze</td>
<td>0</td>
</tr>
<tr>
<td>Wai Chee</td>
<td>10</td>
</tr>
<tr>
<td>Yellow Red</td>
<td>10</td>
</tr>
<tr>
<td>Yuli</td>
<td>4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>174</strong></td>
</tr>
</tbody>
</table>
Grafting onto clonal rootstocks

Budstick growth 4 weeks after grafting

<table>
<thead>
<tr>
<th>CULTIVAR</th>
<th>QUANTITY GRAFTED</th>
<th>NUMBER BUDSTICKS GROWING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewster</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Chakrapat</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Fay Zee Siu</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Garnet</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Mauritius</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Hunglong</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Kaimana</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Kim Cheng Mesa</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Kwai May Red</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Late Seedless</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>McLean's Red</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Noumici</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Sah Keng</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Sivan</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Souey Tung</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Tamuze</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Wai Chee</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Yellow Red</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Yuli</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

*NB: we did not note any dead budsticks 4 weeks after grafting and will continue to monitor*
## Grafting onto clonal rootstocks

<table>
<thead>
<tr>
<th>CULTIVAR</th>
<th>QUANTITY GRAFTED</th>
<th>NUMBER BUDSTICKS GROWING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewster</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Chakrapat</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Fay Zee Siu</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Garnet</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Mauritius</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Hunglong</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Kaimana</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Kim Cheng Mesa</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Kwai May Red</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Late Seedless</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>McLean's Red</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Noumici</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Sah Keng</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Sivan</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Souey Tung</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Tamuze</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Wai Chee</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Yellow Red</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Yuli</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>
Grafting onto clonal rootstocks

<table>
<thead>
<tr>
<th>CULTIVAR</th>
<th>QUANTITY GRAFTED</th>
<th>NUMBER BUDSTICKS GROWING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewster</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Chakrapat</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Fay Zee Siu</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Garnet</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Mauritius</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Hunglong</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Kaimana</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Kim Cheng Mesa</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Kwai May Red</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Late Seedless</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>McLean's Red</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Noumici</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Sah Keng</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Sivan</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Souey Tung</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Tamuze</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Wai Chee</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Yellow Red</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Yuli</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>
Grafting onto clonal rootstocks

‘Brewster’  ‘Chakrapat’  ‘FZS’  ‘Garnet’

‘Mauritius’  ‘Hung Long’  ‘Kaimana’  ‘Kim Cheng Mesa’
Grafting onto clonal rootstocks

‘Kwai May Red’  ‘Late Seedless’  ‘Mclean’s Red’  ‘Nuomici’

‘Sah Keng’  ‘Sivan’  ‘Souey Tung’  ‘Yellow Red’
Survey of chlorophyll content index (CCI)
Survey of chlorophyll content index (CCI)

• CCI **may** form part of the study along with visualisation (and quantification) and the genetic studies (CCI is a value proportional to the amount of chlorophyll in a leaf)

• are there differences between cultivars?

• surveyed all the cultivars used in the study (G4 and I4, ARC-TSC, Nelspruit)

• 10 measurements per tree, 5 trees per cultivar

• *(critical to use the same leaf age/maturity)*
Survey of chlorophyll content index (CCI)

- differences between incompatible and compatible scion: rootstock combinations?
- will variability impede discerning differences between compatible and incompatible combinations? Use actual chlorophyll content?
What’s next?

- regular recording of graft success of cultivars grafted onto clonal ‘Wai Chee’ rootstocks
- visualisation of dye uptake across the graft union at 2 - 6 months after grafting (3 months - Kaimana:Mauritius)
- quantification of dye uptake across the graft union (microscope software, LAM)
- clonal propagation of the other rootstocks in the study (Schagen nursery: Sakkie Froneman)
Acknowledgements

• SALGA for funding

• The Fruit Farm Group (Schagen nursery), in particular Sakkie Froneman, for providing the clonal rootstocks & his enthusiasm for the project