PLANT IMPROVEMENT STRATEGIES FOR LITCHIS IN SOUTH AFRICA

I.J. Froneman, J.H. Husselman, R.B. Cronje, A. Severn-Ellis & A.D. Sippel

ARC-Institute for Tropical and Subtropical Crops, Private Bag X11208, Nelspruit 1200
Introduction
SA Commercial Cultivar Distribution

% Cultivars planted

- Third Month Red: Oct
- R1G22: Oct-Nov
- Mauritius: Nov-Jan
- Fay Zee Siu: Nov-Jan
- Mc Lean’s Red: Jan-Feb
- Wai Chee: Feb-Mar
Main aims of Litchi Improvement in SA

- Early harvest (October/November)
- Late harvest (February/March)
- High, regular yields
- Improved fruit quality
Plant Improvement

Current Strategy at ARC-ITSC

A. Breeding

B. Importation
A. Breeding

Phases:
- Pollination / Irradiation
- Seedling growth management (nursery phase)
- Seedling growth management (orchard phase)
- Evaluation and selection
- Propagation
- Time frame: approximately 10-20 years
B. Cultivar Importation

Phases:

- Import documentation
- Quarantine inspection
- Quarantine propagation
- Orchard establishment
- Evaluation
- Propagation
- Time frame: 5-10 years
A. Breeding
• Gene pool of 46 genotypes available for breeding purposes
• Currently 9 hectares of seedlings available
• Plant density 1000 -1250 seedlings/ hectare

B. Cultivar evaluation
• Imported cultivars & ARC breeding material
• Evaluations in ARC & Industry orchards
• Done in 4 different regions to determine climatic adaptability
Methods
Hybridization Strategies

- Open pollination - only female parent known
- Controlled pollination - both parents known

Caging

Hand pollination
Irradiation Strategy

- Gamma and X-rays
- Seed and vegetative material
- Create chromosome breaks for mutation formation
Irradiation of litchi bud wood

- Irradiate
  - Irradiated Budwood for propagation

Vegetative propagation
- Auxiliary bud out of mutated area
- Auxiliary bud partly in mutated area
- Partially mutated L-1 part
- Fully mutated L-1 part

Non-mutated mV1 plant
(Mutation of part)

Mericlinal Chimera in budwood
(Mutated partly in L-1)

Mericlinal mV1 Chimera
(Enlarged mutated L-1 part)

Periclinal mV2 Chimera
(Fully mutated L-1 part)
Propagation Strategies for Cultivars/Selections

- Grafting
- Top working
- Micro air-layering
Other Propagation Methods

Budding  Cuttings
Growth Enhancement Strategies

Nursery phase
- Controlled atmosphere
- Optimum nutrition
Growth Enhancement Strategies

Orchard phase
- Orchard floor management
- Autumn flush control
- Girdling
Results
Evaluation Criteria (tree characteristics)

Harvesting season

Production
Evaluation Criteria (fruit characteristics)

**Fruit size**

![Graph showing fruit size with dimensions and percentage](image)

**Fruit mass**

![Graph showing fruit mass with dimensions and percentage](image)

**Fruit composition**

![Graph showing fruit composition with dimensions and percentage](image)
Promising Seedling Selections Phase I

- Fay Zee Siu seedling
  - Early season, small seed, good taste, better colour
  - Mass: 28g
  - Length: 39 mm
  - Width: 37 mm
  - Flesh: 74%
  - Seed: 6%
  - Skin: 20%

- Brewster seedling
  - Mid season, small seed, good taste
  - Mass: 17g
  - Length: 30 mm
  - Width: 32 mm
  - Flesh: 83%
  - Seed: 1%
  - Skin: 16%

- WC x MR seedling
  - Late season, small seed, good taste
  - Mass: 20g
  - Length: 32 mm
  - Width: 33 mm
  - Flesh: 74%
  - Seed: 3%
  - Skin: 23%
- San Ye Hong seedling
  - Early, good colour, taste
  - Mass: 20 g
  - Length: 34 mm
  - Width: 36 mm
  - Flesh: 71%
  - Seed: 9%
  - Skin: 20%

- Tai So seedling
  - Mid, small seed, good taste
  - Mass: 34 g
  - Length: 35 mm
  - Width: 34 mm
  - Flesh: 81%
  - Seed: 2%
  - Skin: 17%

- Tai So seedling
  - Late, good colour, firm flesh, low acid
  - Mass: 23 g
  - Length: 36 mm
  - Width: 35 mm
  - Flesh: 66%
  - Seed: 12%
  - Skin: 22%
Tai So x San Ye Hong seedling (R1G22)
- Early, good colour, size
- Mass: 26 g
- Length: 38 mm
- Width: 36 mm
- Flesh: 77%
- Seed: 6%
- Skin: 17%

Tai So mutation (Tai So Supreme)
- Mid, good size, taste
- Mass: 30 g
- Length: 41 mm
- Width: 37 mm
- Flesh: 77%
- Seed: 10%
- Skin: 13%
Promising imported cultivars

Kaimana

Garnet
Challenges

Horticultural
• Incompatibility of scion/rootstock
• Influence of rootstock
• Timing of grafting/ top-working
• Litchi graft success rate

Breeding
• Lack of variation
• Capacity and cost
Technology transfer

- Study groups
- Cultivar days
- Bud wood distribution
- Training on multiplication
Litchi improvement was based on open pollination and specific crosses

What has been achieved?
- 2 Cultivars registered, 20 pending

Why is change needed?
- Outcome of open-pollination is unsure
- Long generation time intervals
- Increase in costs
- Complex logistics
Future Breeding Direction
New Direction

Aim

• Maximizing the use of desired genetic variation
• Moving towards genomics assisted breeding
Targeted Breeding & Selection

- Requirements on plants in future will be enormous & difficult to achieve based on conventional breeding strategies only
- Biotechnology in combination with breeding methods can promote directed selection and cross-breeding

**Benefits of new approach:**
- Reduced development time
- Reduced space in field trials
- Save in cost
• Plant traits can be linked to genes & networks of genes

• Molecular markers linked to these genes are used to identify plant characteristics at seedling stage

• Biotechnology methods can accelerate breeding considerably
Development of Genomic Tools

• Advances in DNA sequencing has lead to the ability to sequence the whole genome of an organism

Significance
• Genotyping using markers is ultimately reactive, rather than proactive
  – you can only look for known variants!
• As a result, variants that are rare, remain unidentified and a lot of data is missed
Genomics in the ARC

- ARC established a Biotech Platform in 2010
- The Biotechnology Platform is the most advanced genetic sequencing and genotyping facility in Africa - consists of six teams of researchers and postgraduates
- ARC-ITSC in collaboration with the Biotech Platform is currently sequencing the genomes of guava and the guava wilt pathogen
The litchi genome is currently being sequenced and might be available shortly according to BGI (Beijing Genome Initiative)

Significance:

- The Litchi Reference Genome will provide the opportunity to identify millions of markers across the litchi genome
- Association of these markers with traits leads to the linking of genotype to phenotype
- Leading to the detection of variation and improvement of breeding efficiency
Mini Core Collection for ARC

Current efforts focus on:

• The establishment of a small but diverse core collection of litchi cultivars

Purpose of the mini core:

• Increase available genetic diversity
• Assessment of genetic diversity
• Development of markers & gene mining
• Association mapping
Conclusion

• Plant Improvement is a long-term investment
• Development time can be reduced with genomics
• Molecular tools need to be developed to assist in cultivar selection
• Limited base of cultivars in SA needs to be expanded
• Introduce the best characteristics of pristine cultivars for hybridization

Collaboration with leading litchi countries essential in taking Litchi Plant Improvement forward!
Acknowledgements

South African Litchi Growers’ Association (SALGA)

Agricultural Research Council (ARC)

Technology and Human Resources for Industry Programme (THRIP)
Thank you for your attention!
Cultivar background

- First litchis 1876

- Initially only Mauritius (Tai So) McLean’s Red (Bengal)

- Industry problems:
  - Short harvesting period,
  - competition on markets

- Added: Fay Zee Siu
  Wai Chee

First litchi tree in SA
Background

South African litchi industry
## World Litchi Supply

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### Harvesting Period and market presence

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