Comparing carbohydrate reserves and tree productivity in two mango cultivars under high and low planting density

Gerhard Rossouw

Queensland Government

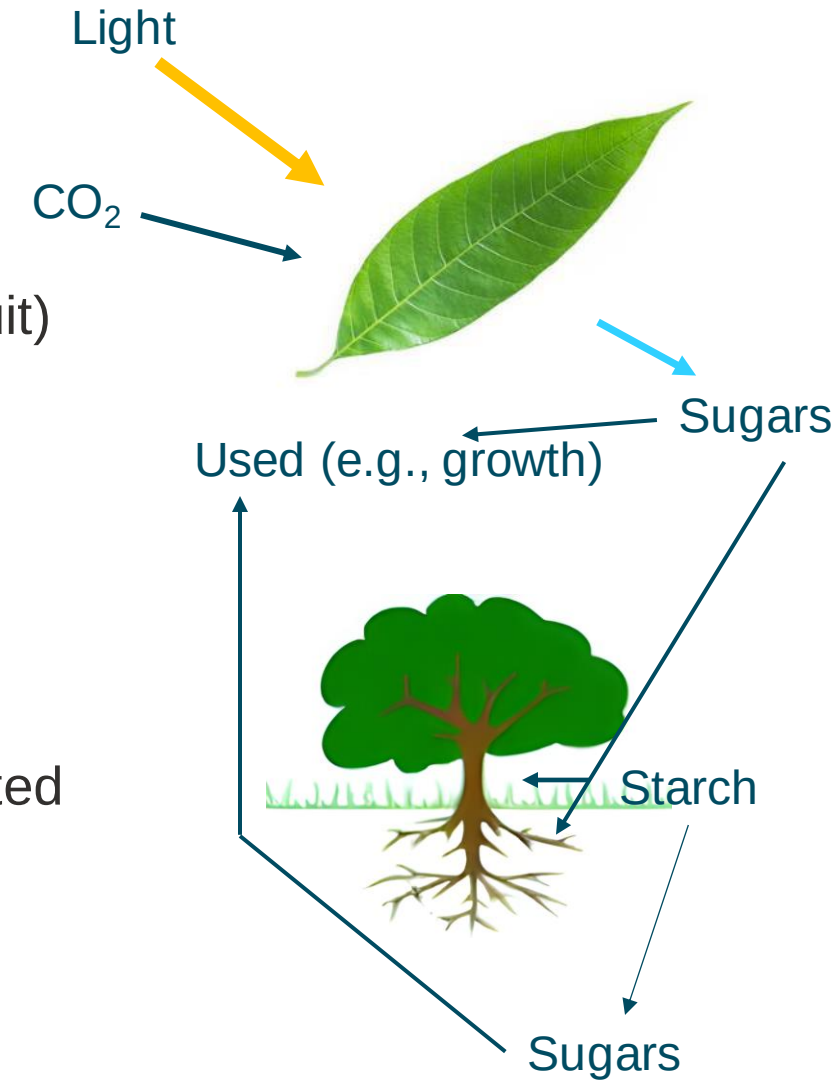
Roles of carbohydrates in fruiting

- Carbohydrate (CHO) availability: limiting factor for reproductive development
  - Flower initiation, flowering, fruit set, growth, retention, maturation
- Increased cropping: greater competition for carbohydrates
  - Fruiting may also compete with vegetative growth

Insufficient carbohydrates
Greater proportion of non-fruiting terminals
Poor flowering and irregular bearing
Poor fruit set
Smaller, fewer fruit
Increased fruit drop
Slow/incomplete maturation
Poor flavour development
Low yields

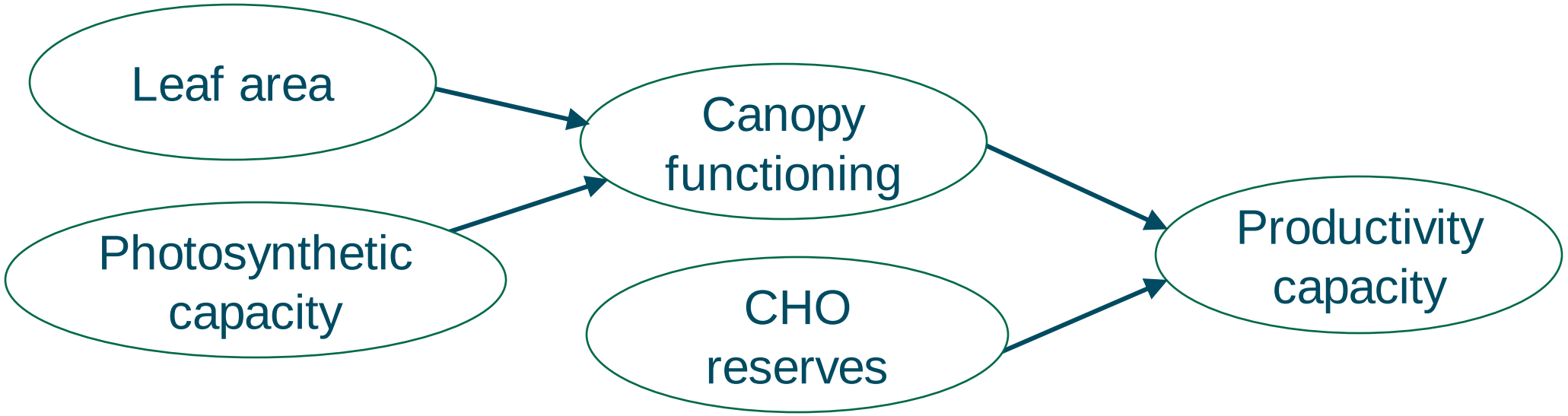
Carbohydrate sources

1. Leaves
   - Primary source, photosynthesis generates sugars
   - Sugars transported to growing tissues (e.g., buds, flowers, fruit)
   - Excess sugars converted to starch, stored as reserves
2. Reserves
   - Starch stored in roots, wood (trunk, branches, shoots)
   - If demand exceeds sugar production: starch reserves converted back to sugars
   - Act as buffer: greater reliance under higher crop load



Objectives

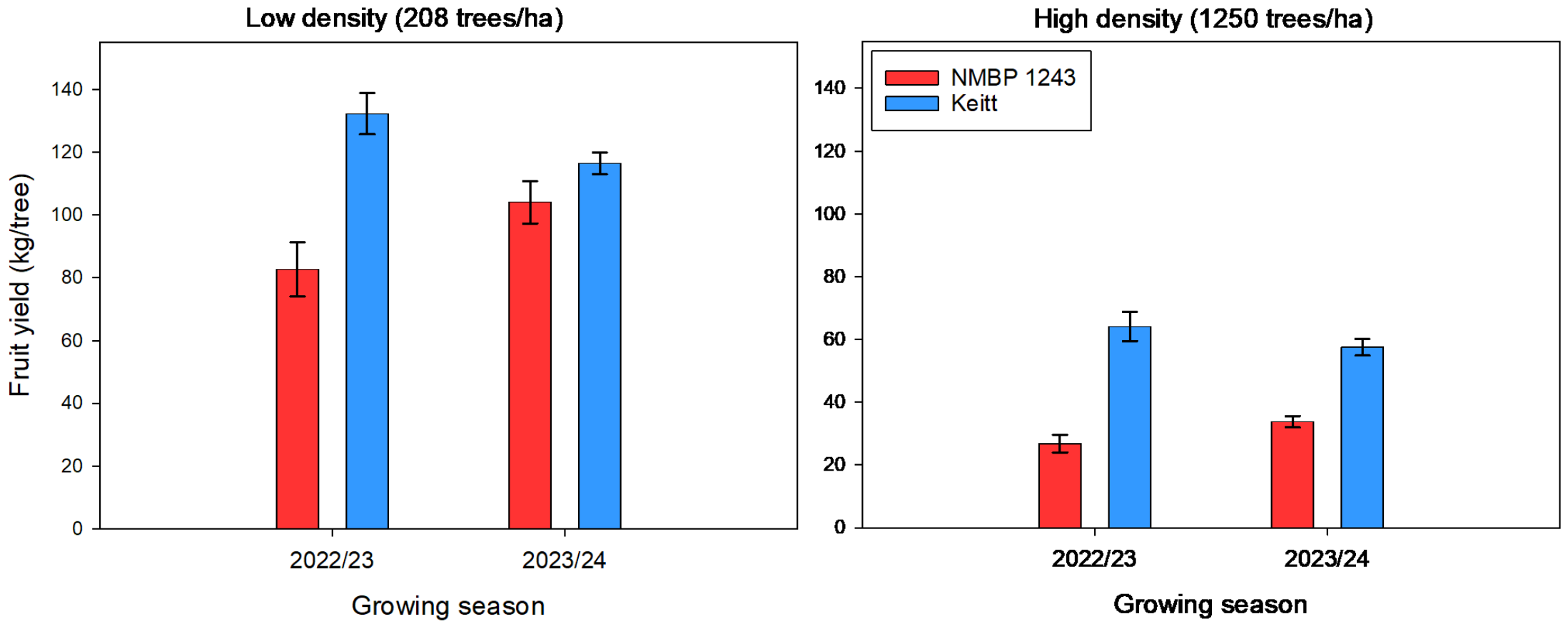
- Increasing planting density: to boost productivity on land area basis
- Understanding carbohydrate reserve contributions to fruiting
  - Low (8 x 6 m) vs high (4 x 2 m) planting density
  - Cultivars with varied characteristics [NMBP 1243 (Yess!) and Keitt]
- Long-term effects of *tree size* on reserves and tree-level productivity?
  - Do mango cultivars regulate their reserves differently?



Experimental overview

- Survey of CHO reserves in key storage tissues and tree-level productivity, over 2 growing seasons
  - **2023/24** and 2024/25
  - DAF Walkamin research station (Planting Systems Trial)
  - NMBP 1243 (Yess!) and Keitt
  - Low (208 trees/ha) vs high (1250 trees/ha) planting density
  - Starch, soluble sugars in roots and scion trunk wood
  - Fruit yield/tree, size, dry matter
  - Leaf photosynthetic capacity assessment

Results - productivity



- **Keitt: smaller trees but highly productive**
- Can carbohydrate dynamics (reserve regulation) help explain these productivity differences?

Canopy functioning

A) Leaf area (canopy volume) × B) photosynthetic capacity

Density	Cultivar	Canopy volume (m^3) 2022/23	Canopy volume (m^3) 2023/24	Yield efficiency (kg/m^3) 2022/23	Yield efficiency (kg/m^3) 2023/24
Low	NMBP 1243	32	25	3	4
Low	Keitt	18	13	8	9
High	NMBP 1243	5	3	6	11
High	Keitt	4	3	18	20

1.8X

1.9X

2.7X

2.3X

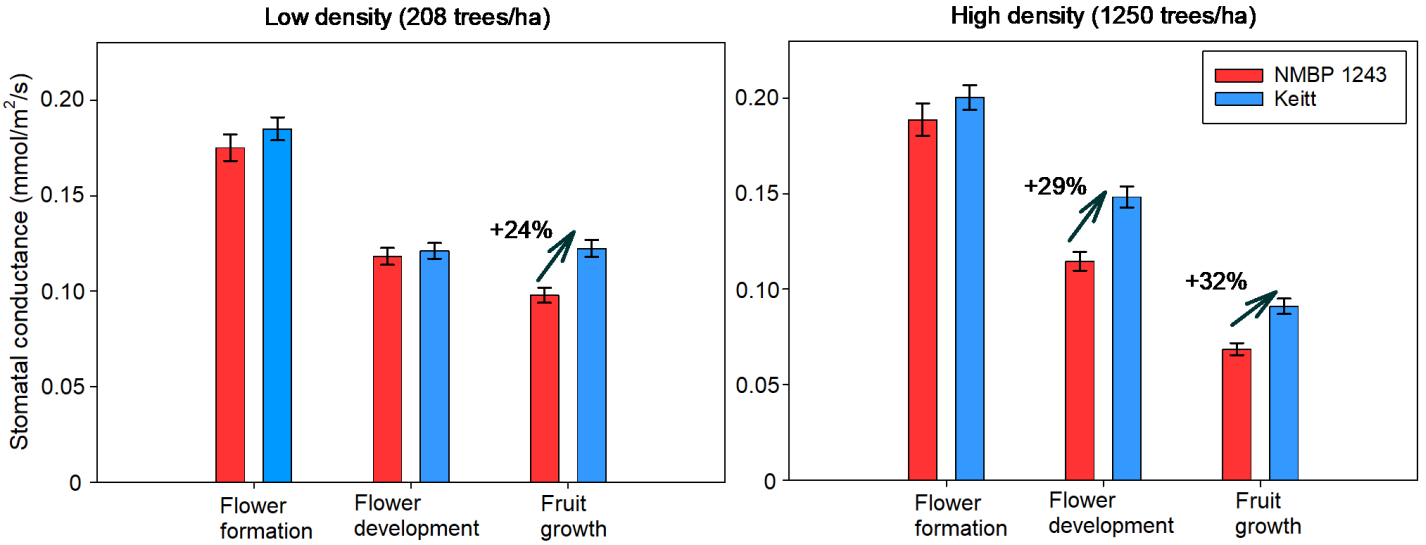
3X

1.8X

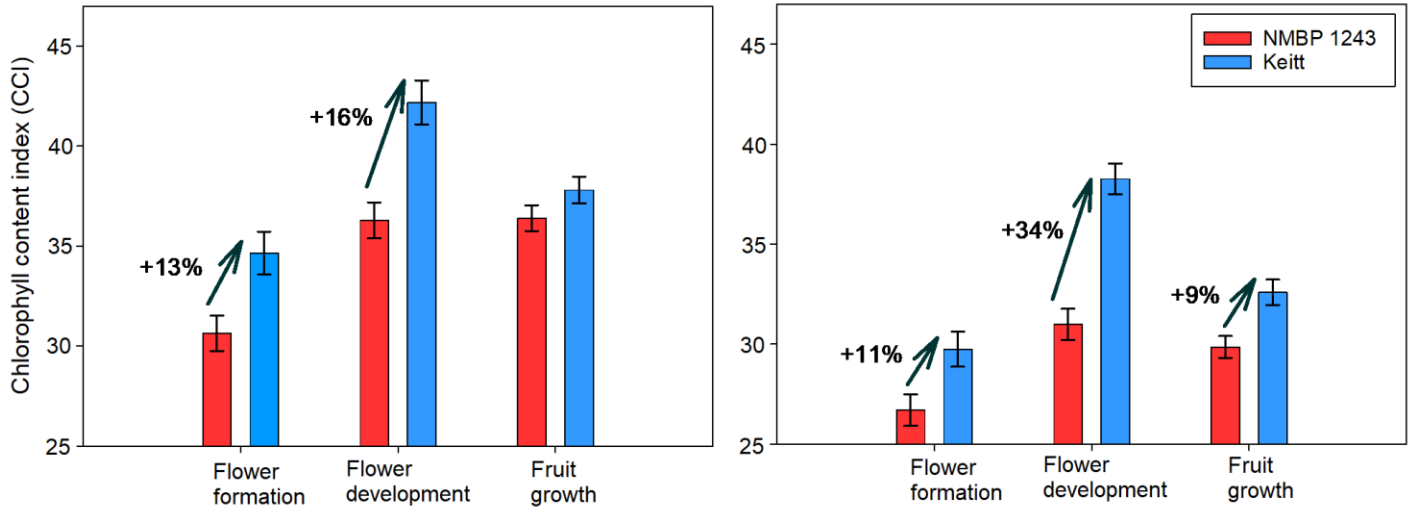
- NMBP 1243: up to double the canopy size vs Keitt, for low density
- Since high density trees are maintained small, similar volume for both cultivars
- Keitt exhibits much greater yield efficiency
- Yield efficiency upregulated in high density

Canopy functioning

Stomatal conductance



Chlorophyll

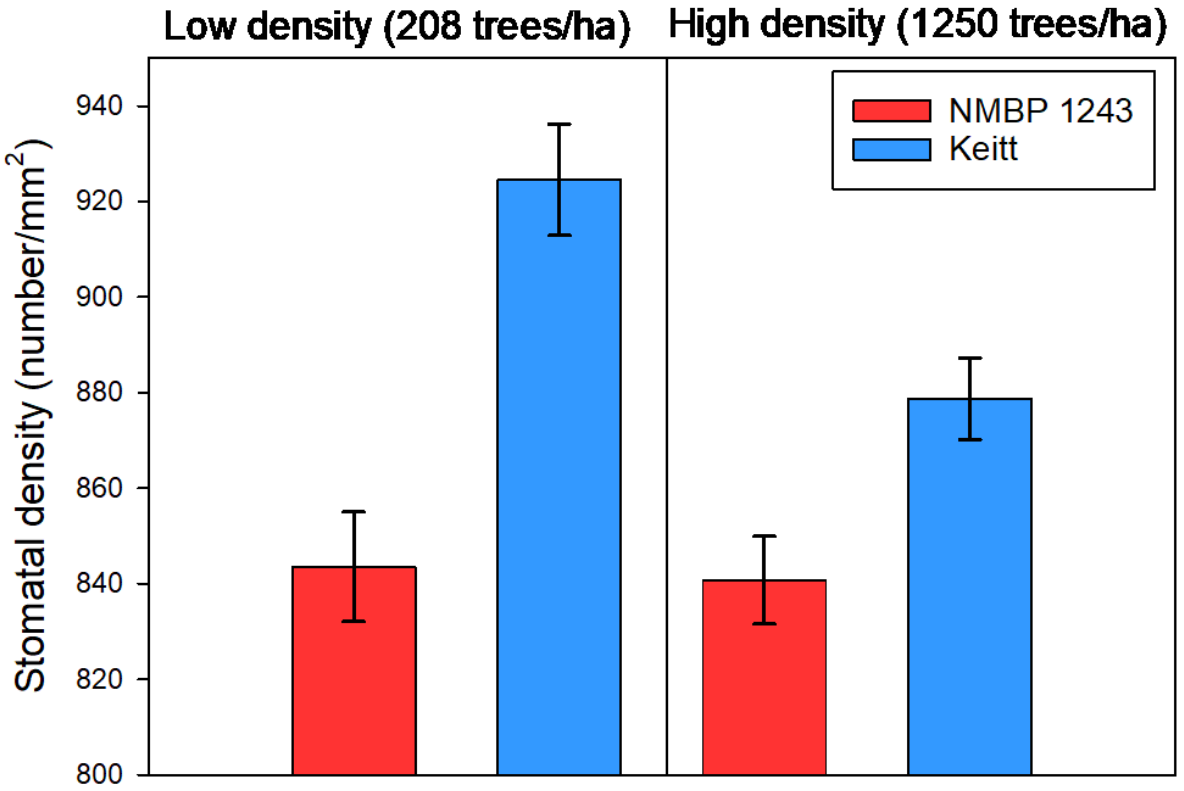


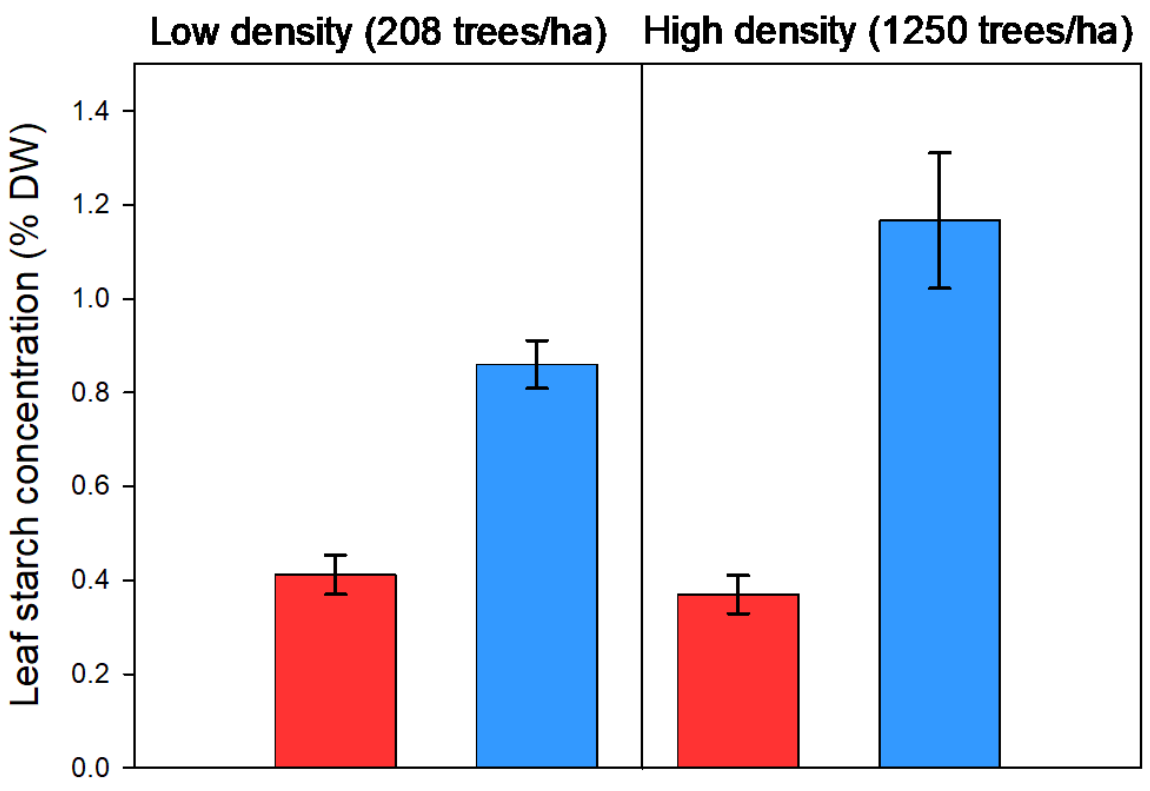
A) Leaf area (canopy volume)
× B) photosynthetic capacity

- B) Photosynthetic capacity
  - Largely influenced by:
    1. Stomatal conductance
    2. Chlorophyll content
- During reproductive cycle:
  - Keitt: higher stomatal conductance + more chlorophyll
  - Suggests greater photosynthetic capacity
- Low planting density: more chlorophyll

Canopy functioning

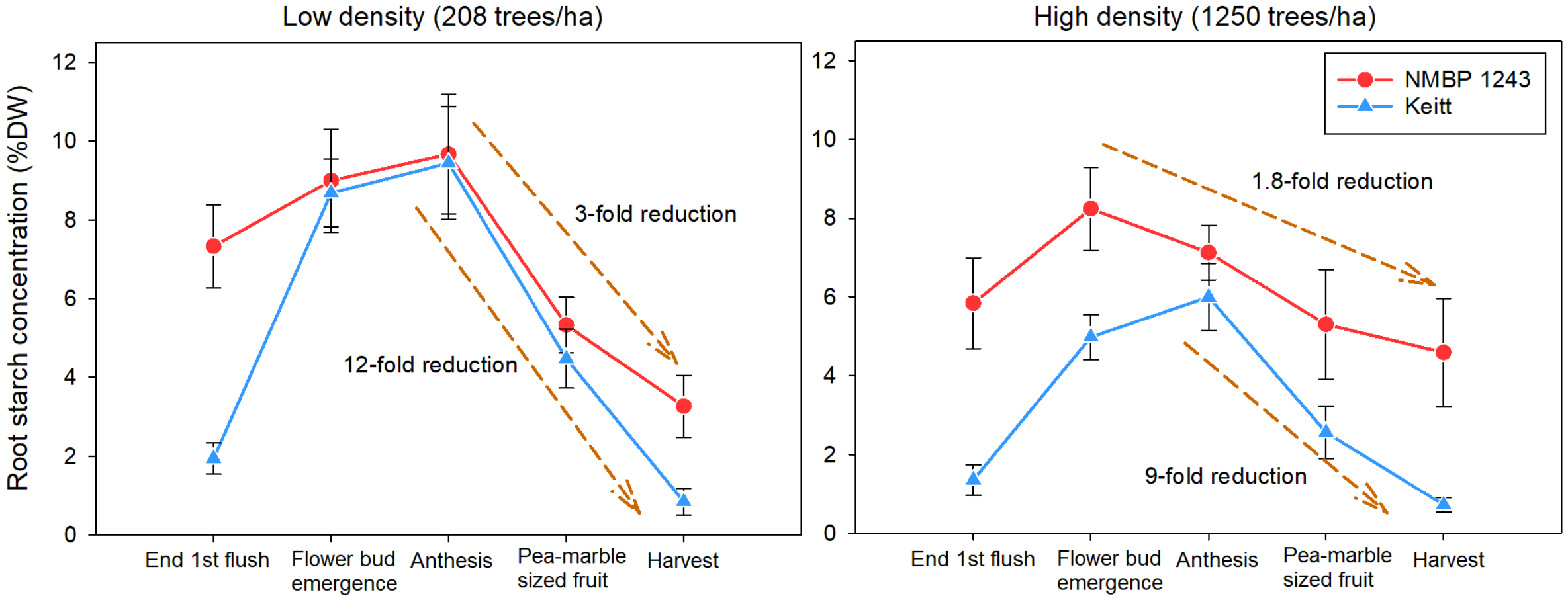
A) Leaf area × B) photosynthetic capacity





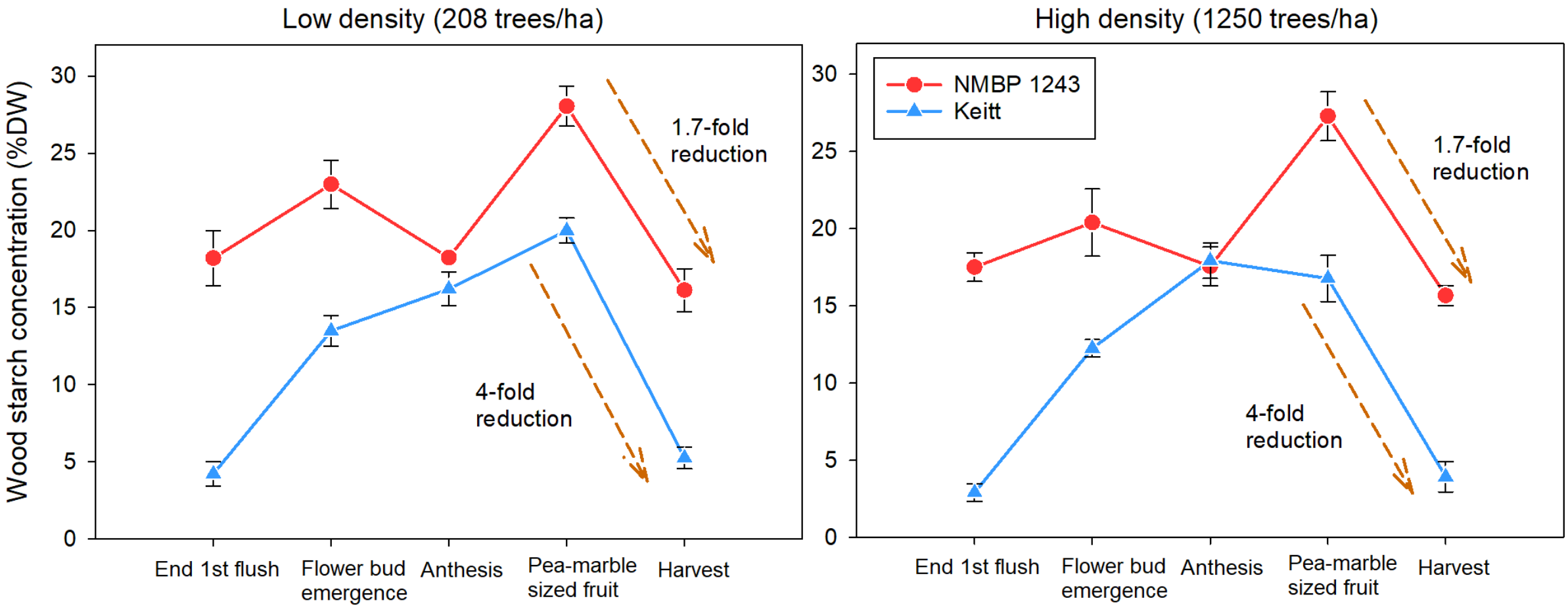
- Increased stomatal density for Keitt: higher photosynthetic capacity
- Increased leaf starch synthesis also suggests greater capacity for Keitt
- **Overall, NMBP 1243 trees exhibit greater leaf area whereas Keitt leaves perform much better**

Root reserves



- Keitt starts the season with lower root starch reserves than NMBP 1243
- Keitt replenishes faster and then remobilises more reserves during fruiting cycle
- Low density exhibits greater replenishment and remobilisation

Wood reserves



- Keitt starts the season with lower wood reserves than NMBP 1243, but Keitt replenishes faster
- Keitt then remobilises more reserves during fruit growth; NMBP 1243 maintains higher levels
  - Root reserves remobilised well before wood reserves

Conclusions

- Keitt outperforms NMBP 1243 in productivity
  - *Keitt uses what's available; NMBP 1243 tends to keep some in reserve*
    - NMBP 1243 trees predisposed to larger vegetative canopies
    - Keitt predisposed to higher productivity
    - Keitt uses more reserves (including from wood): contributes to greater productivity capacity
- Root reserves: used earlier than wood reserves
  - Important to be optimised by start of a fruiting cycle
- Starch reserve regulation seems driven more by cultivar than planting density

Conclusions

- Information for breeders/future cultivar selection
  - Improved understanding: physiological traits of highly productive cultivars
- Orchard intensification
  - Keitt appears very suitable for higher planting density
    - Very productive on a canopy volume basis
- Productivity optimisation
  - 1) Understanding CHO regulation in mango orchards; 2) next stage, explore targeted inputs (e.g., pruning, irrigation, nutrition, PGRs) to optimise

Acknowledgements

Bruno Rocha Tamelini
Zac Scobell
Dale Bennett
Ian Bally
Ryan Orr
Geoff Dickinson

This is a project of the *National Tree Crop Intensification in Horticulture Program (AS18000)*, funded by the Hort Frontiers strategic partnership initiative developed by Hort Innovation, with co-investment from Queensland's Department of Agriculture and Fisheries, Queensland Alliance for Agriculture and Food Innovation- The University of Queensland, Plant & Food Research and the Western Australian Department of Primary Industries and Regional Development, and contributions from the Australian Government.

Dr Gerhard Rossouw

Queensland Department of Agriculture & Fisheries

gerhard.rossouw@daf.qld.gov.au