Plant & Food™ Research
Rangahau Ahumāra Kai

# Introduction of APSIM Grapevine model

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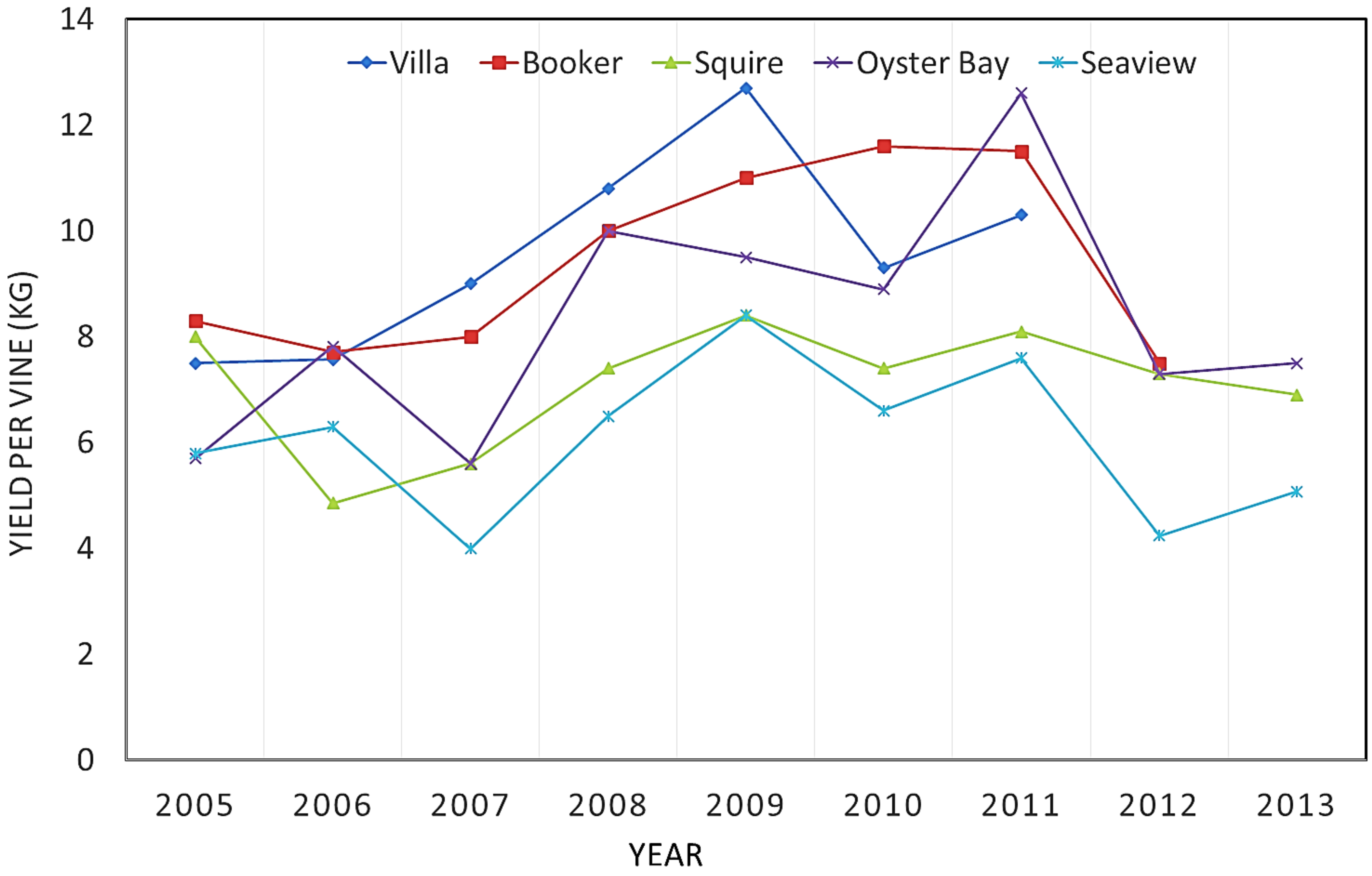
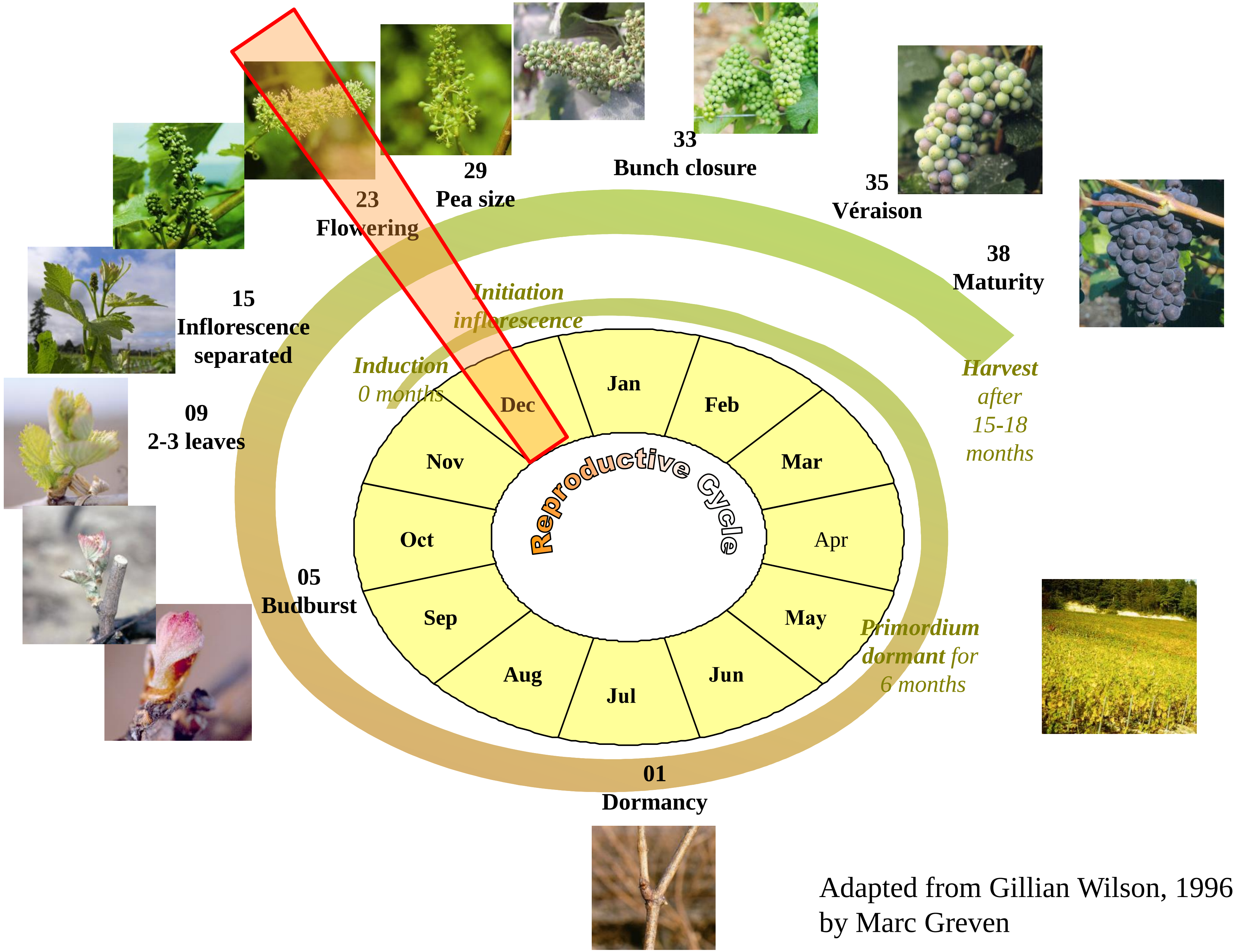
# Objectives

- Capture seasonal yield variations
- Understand the long-term dynamics of yield and carbohydrate reserves of certain pruning systems
- Capture the effects of vineyard management on yield and carbohydrate dynamics, e.g. summer pruning
- Assess environmental footprints, e.g. water and nitrogen

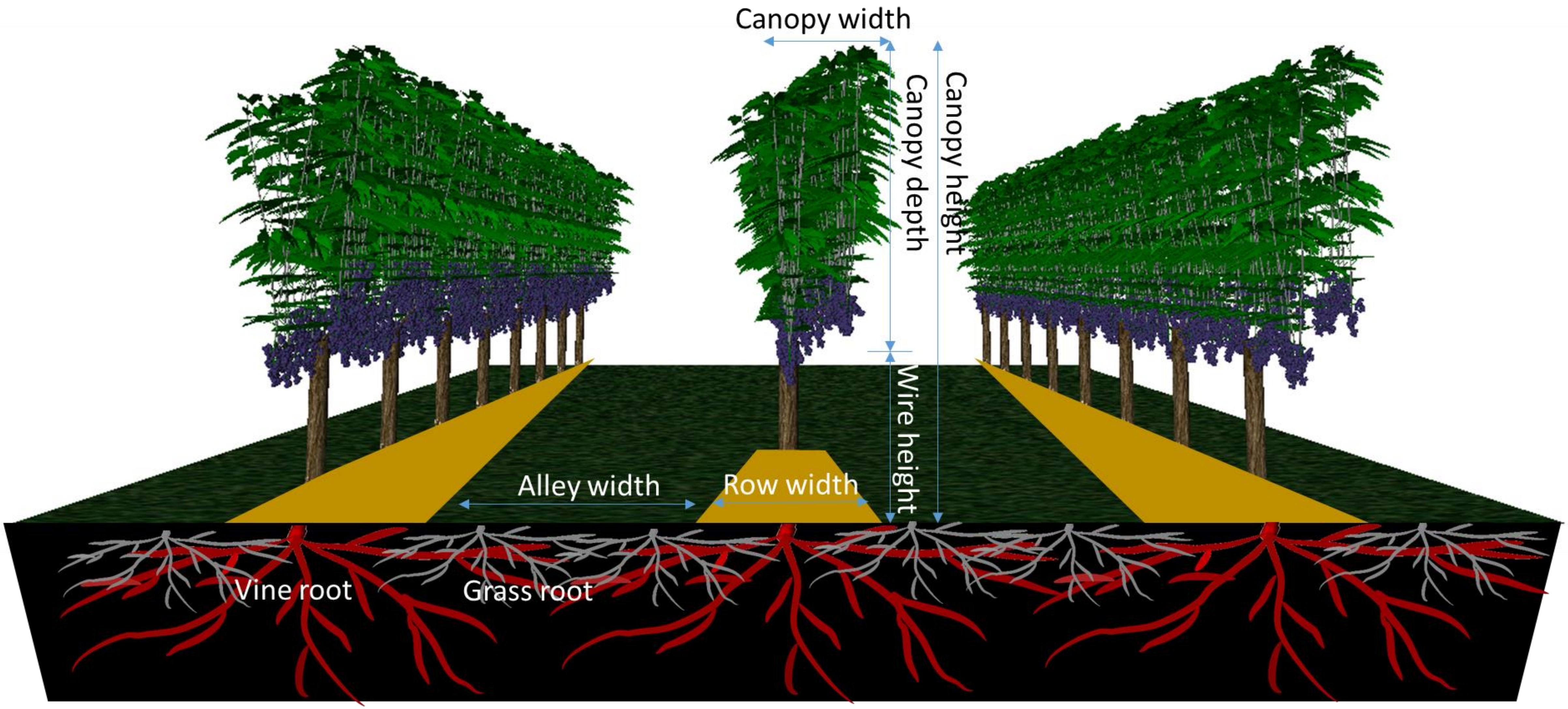
# Seasonal yield variation of 4-cane pruned vines






Adapted from Gillian Wilson, 1996
by Marc Greven

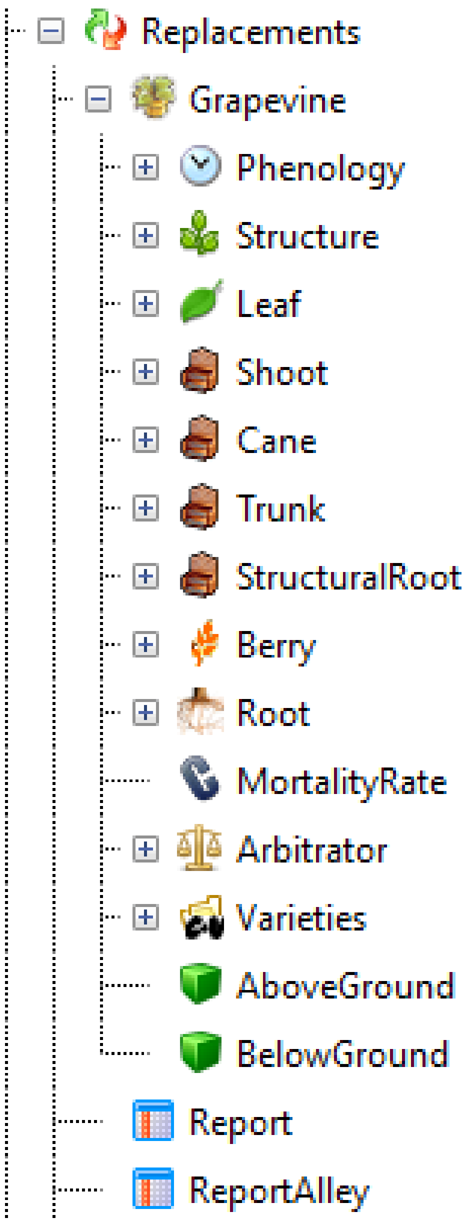
# Vineyard setup

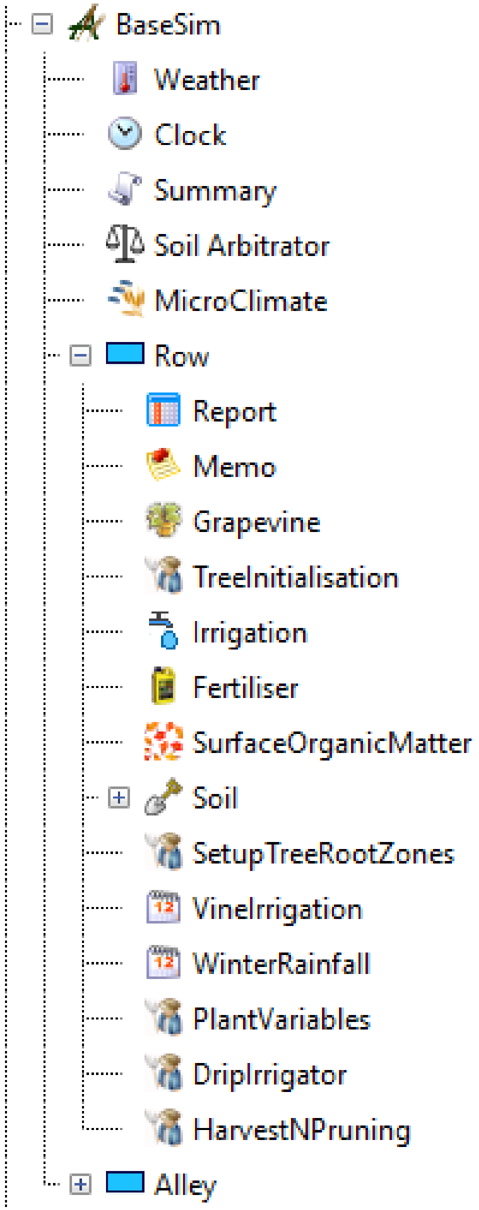


# Features of the grapevine model

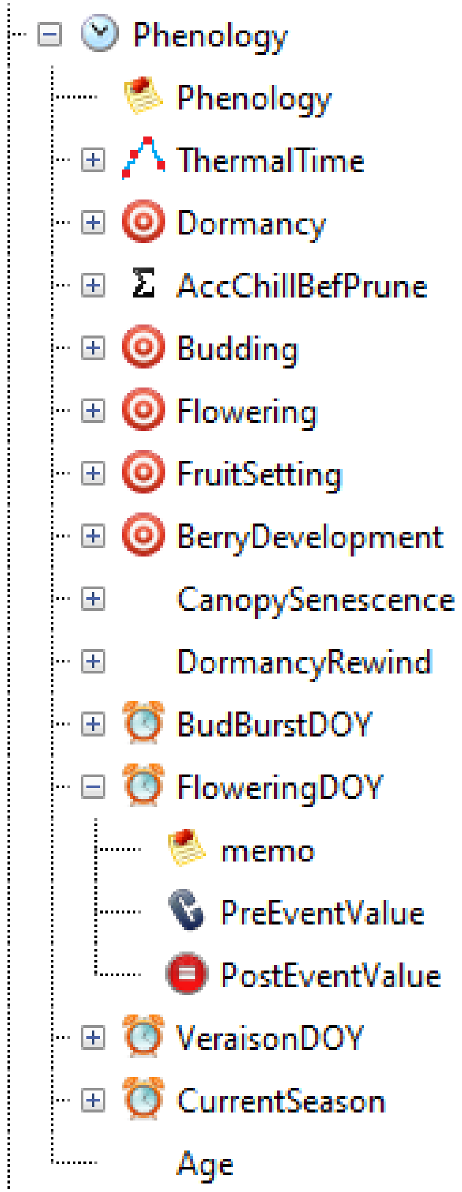
- A vine and inter-row strip configuration to represent the vineyard setup
- An adapted phenology method to represent the perennial fruit corps
- Row crop light interception method
- A new carbohydrate allocation method to represent reserve as a competing sink
- Yield module to capture seasonal variation
- Flexibility in setting different retained node number, canopy height, canopy width, initial plant status etc.

# APSIM grapevine model user interface



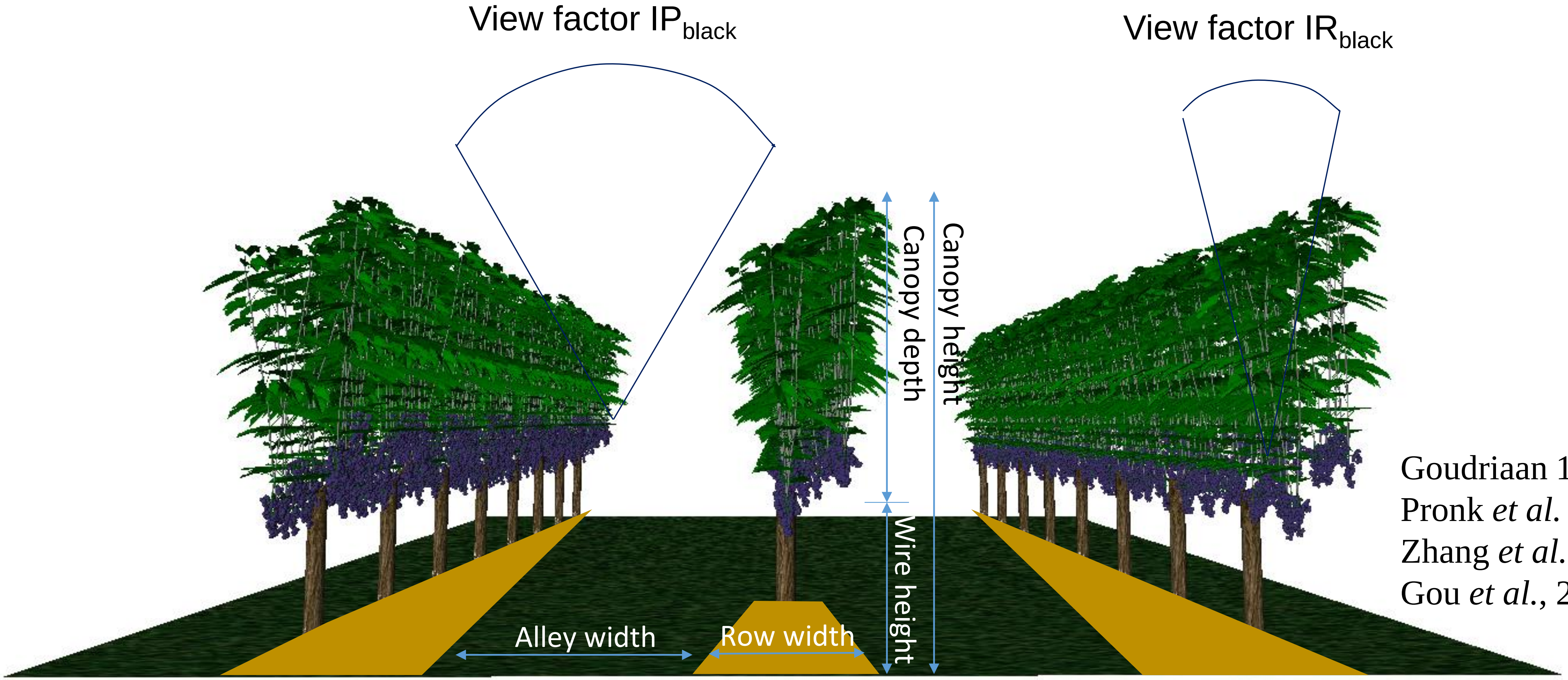



# Phenology module




- Phenology cycle starts with dormancy phase triggered by a critical photoperiod in autumn
- Go through the subsequent phenophases sequentially
- Returns to dormancy for a new cycle
- Each phase has one target and one progression
- Progression can be calculated using different methods of interpolation and response to the daily max and min temperature

# Row crop light interception method




Goudriaan 1977;
Pronk *et al*. 2003;
Zhang *et al*., 2008;
Gou *et al*., 2017;

# A new carbohydrate allocation method

» Priority and relative allocation

$$Prop[o]_c = \frac{Demand[o]_c * q[o]_c}{\sum Demand[o]_c * q[o]_c}$$

» Non-structural carbohydrate demand

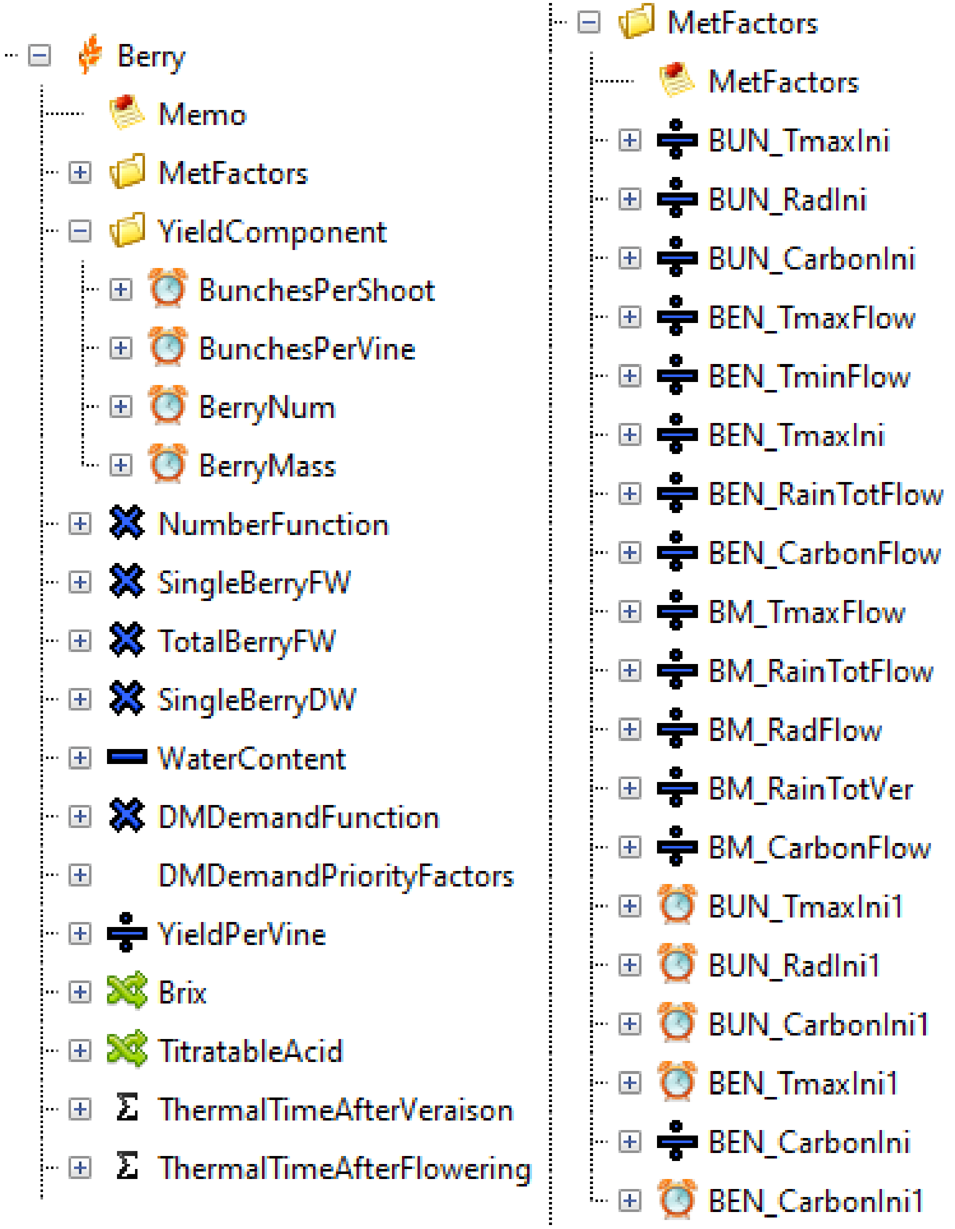
» $\frac{dNonStructuralDM_i}{dt} = q_{NSC,i} * k_{syn} *$

$$\left(C_{max,NSC} * StructuralDM_i - NonStructuralDM_i\right)$$

$$k_{\mathrm{syn}} = k_{\mathrm{max}}\left(1 + \frac{t_{\mathrm{e}} - t}{t_{\mathrm{e}} - t_{\mathrm{m}}}\right)\left(\frac{t}{t_{\mathrm{e}}}\right)^{\frac{t_{\mathrm{e}}}{t_{\mathrm{e}} - t_{\mathrm{m}}}}$$

Buwalda 1991;
Cieslak et al., 2011

# Yield module




| Yield component | Factors | Thermal days before 50% flowering | Thermal days after 50% flowering |
|---|---|---|---|
| **Bunch number per vine** | TmaxIni | 15.90 | 1.27 |
| | RadIni | 10.42 | 0.14 |
| **Berry number per bunch** | TmeanFlow | 7.08 | 0.02 |
| | RainTotFlow | 10.50 | 2.69 |
| | TmaxIni | 7.92 | 30.37 |
| **Berry weight** | TmeanFlow, RainTotFlow, RadFlow, RainTotVer | | |
| **Bunch weight** | TmeanFlow, RainTotFlow, RainTotVer | | |

Zhu et al., 2011

# Berry composition

- Total soluble solids was calculated based on the ratio of berry dry weight to fresh weight

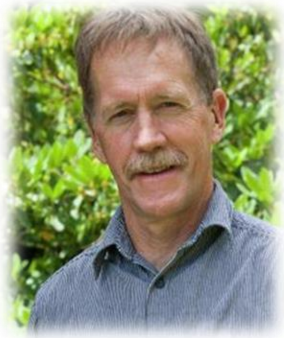
$$TSS = (0.944 - \text{waterContent})/0.082$$

- Total titratable acid concentration

$$TA(t) = TA_{\min} + TA_{\max}\exp(-rt)$$

Garcia de Cortazar-Atauri et al, 2009;
Duchêne, et al., 2014

# Dataset for model calibration and validation



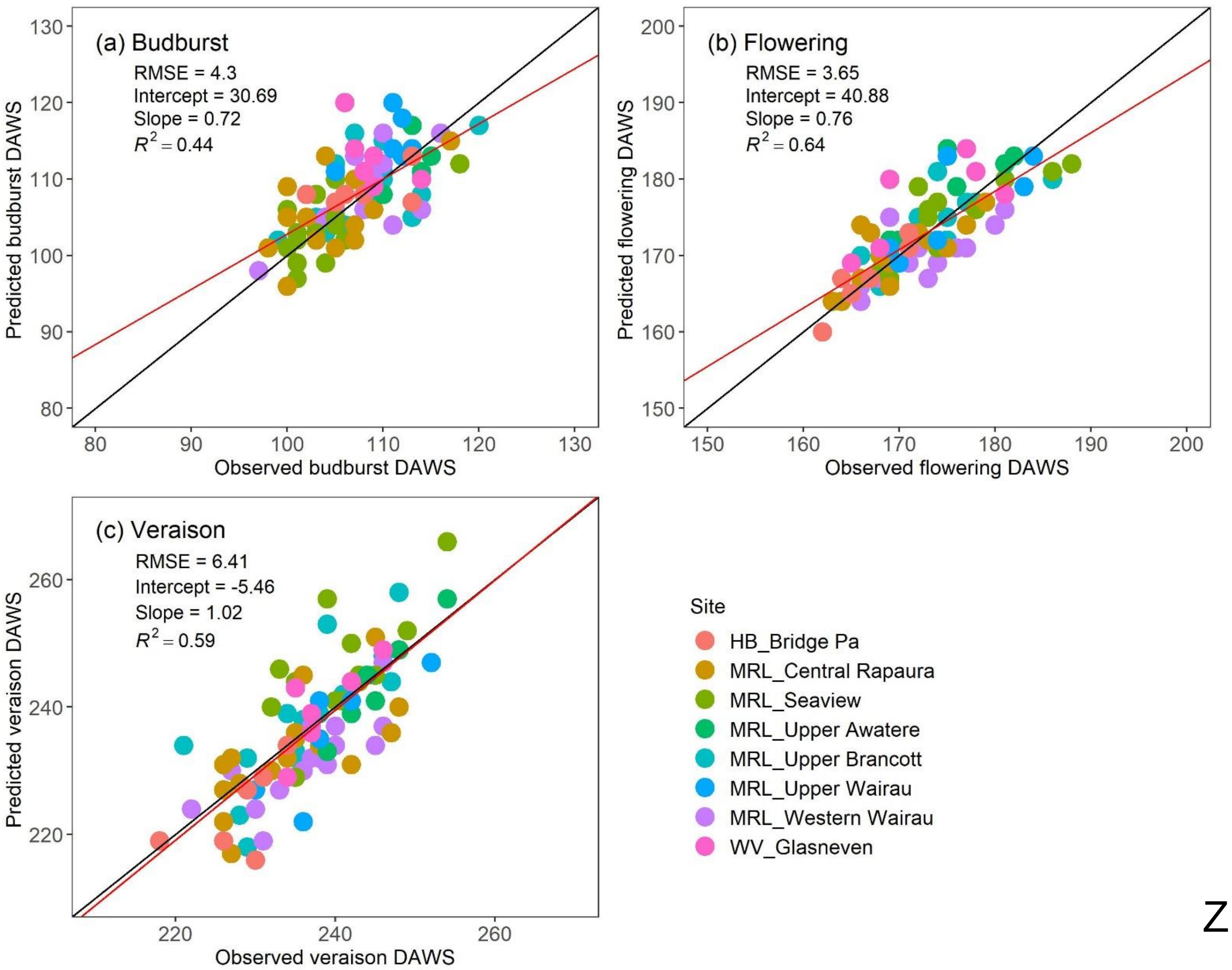

1) Regional phenology and yield monitoring (2004 to 2020)
2) Retained node number per vine (2006-2010)
3) Post-harvest defoliation (2008-2012)
4) MRL_Central Rapaura (2001-2005)

# Long-term phenology and yield monitoring

# Dataset for model calibration and validation

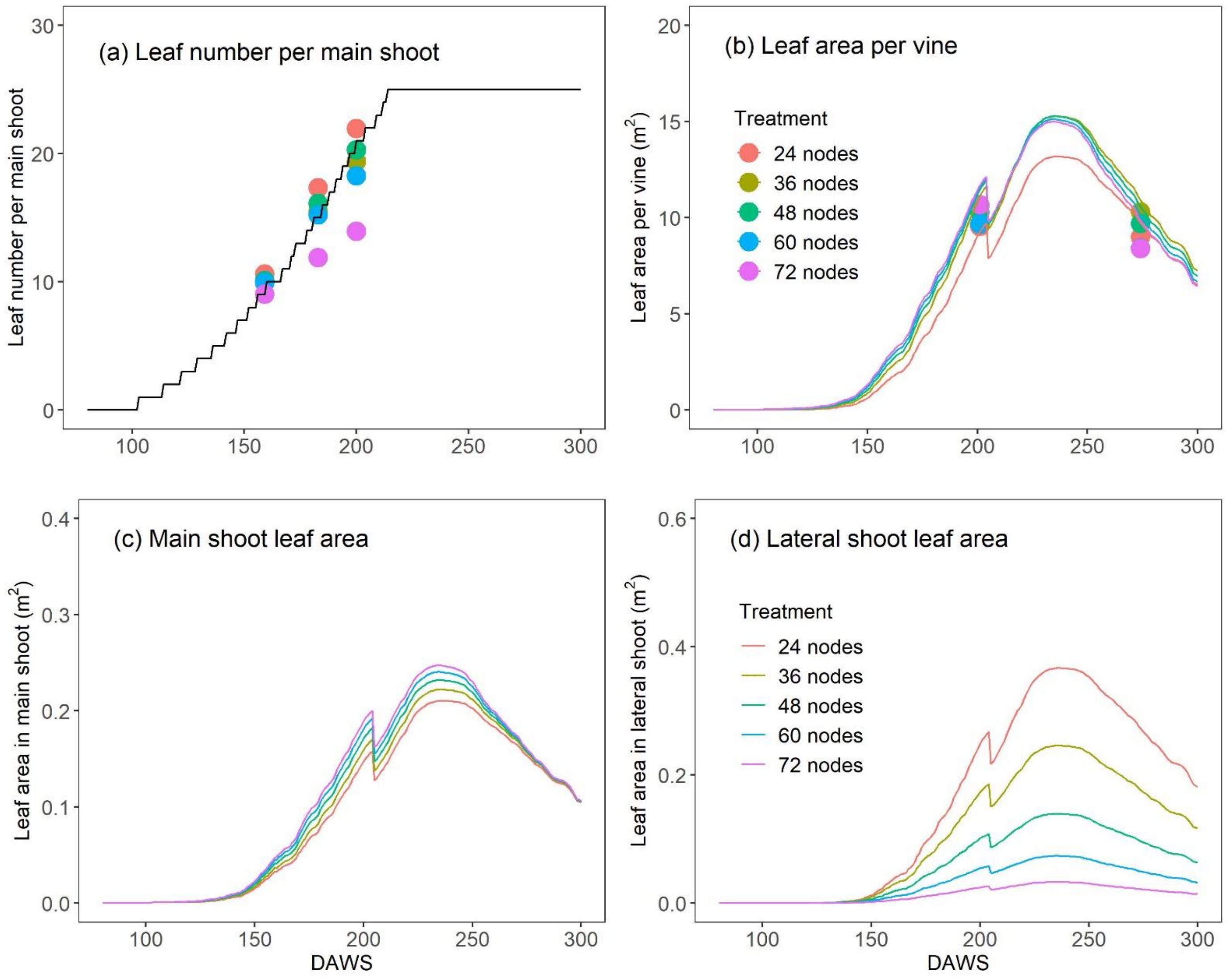
1) Regional phenology and yield monitoring (2004 to 2020)
2) Retained node number per vine (2006-2010)
3) Post-harvest defoliation (2008-2012)
4) MRL_Central Rapaura (2001-2005)

# Phenology prediction

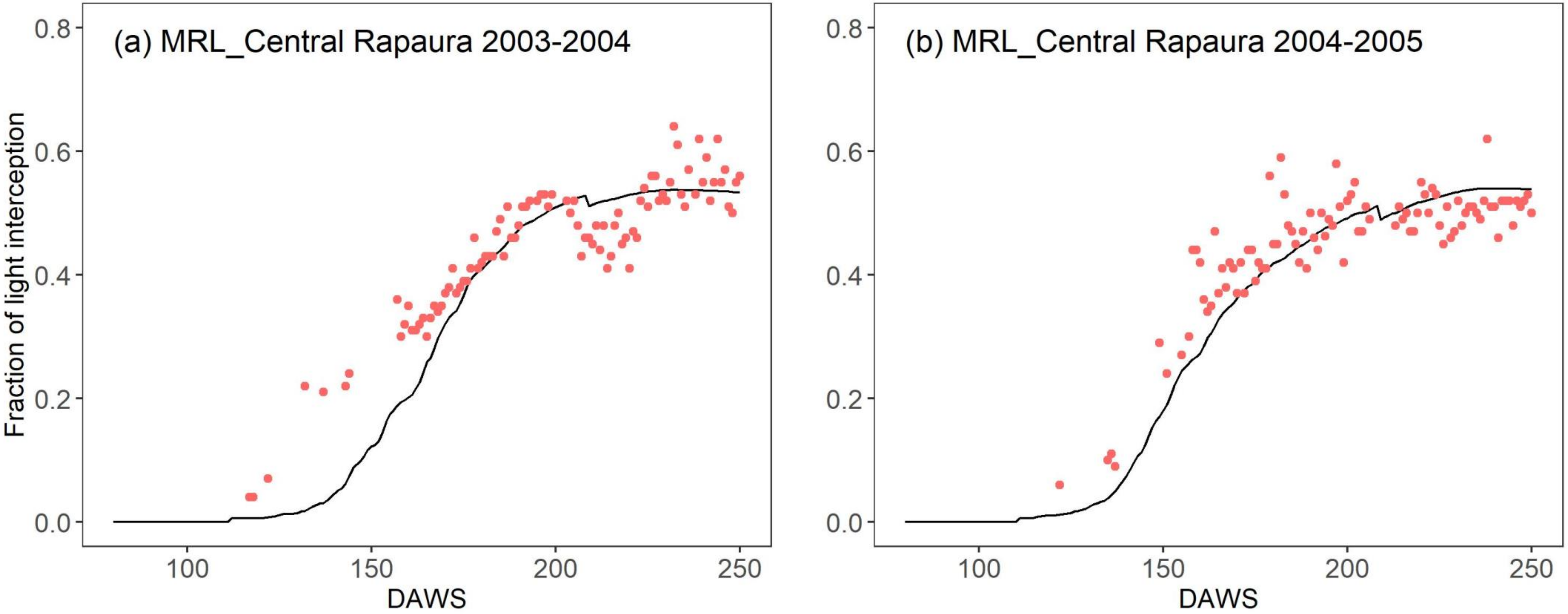



Zhu et al., in preparation

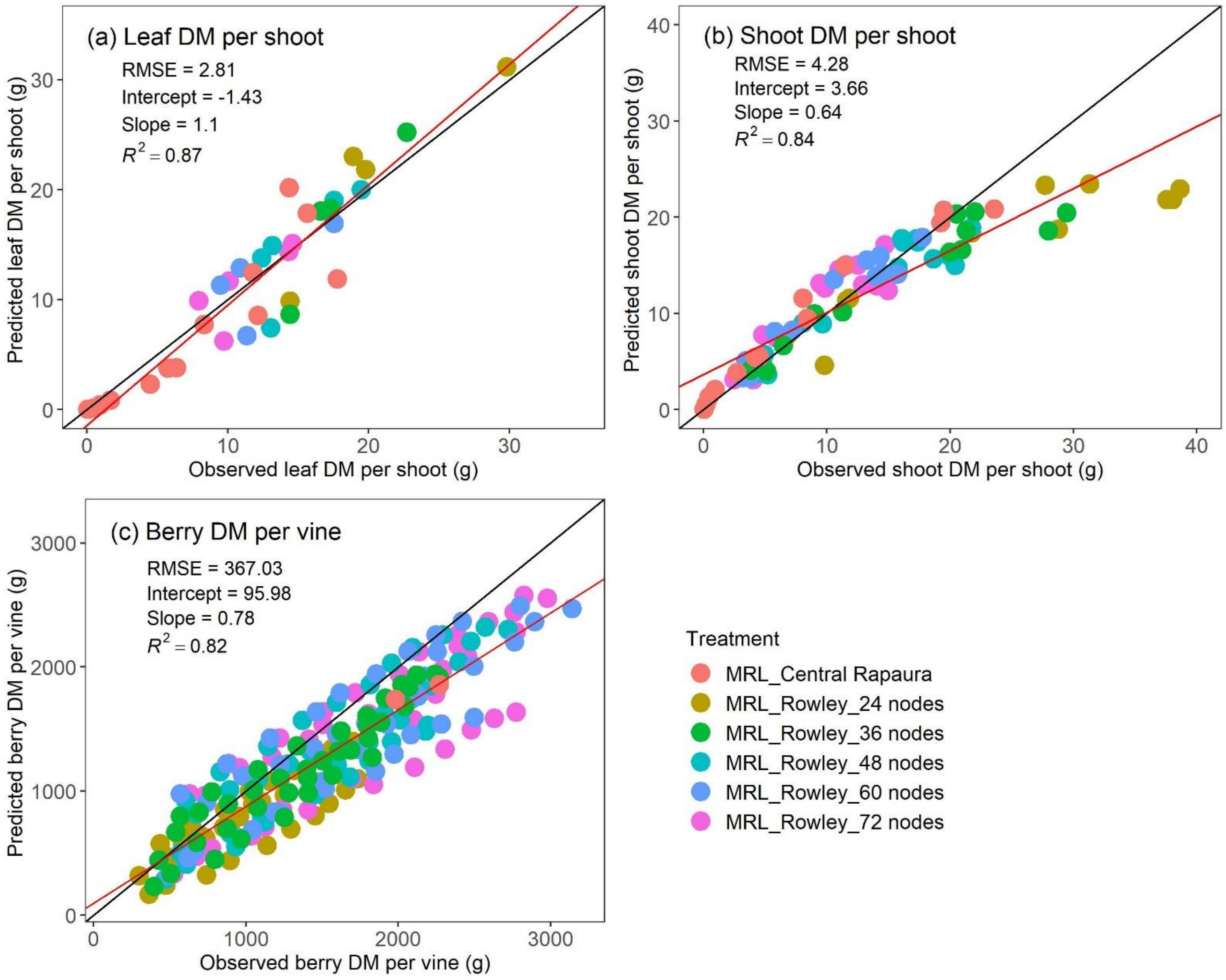
# Leaf area dynamics



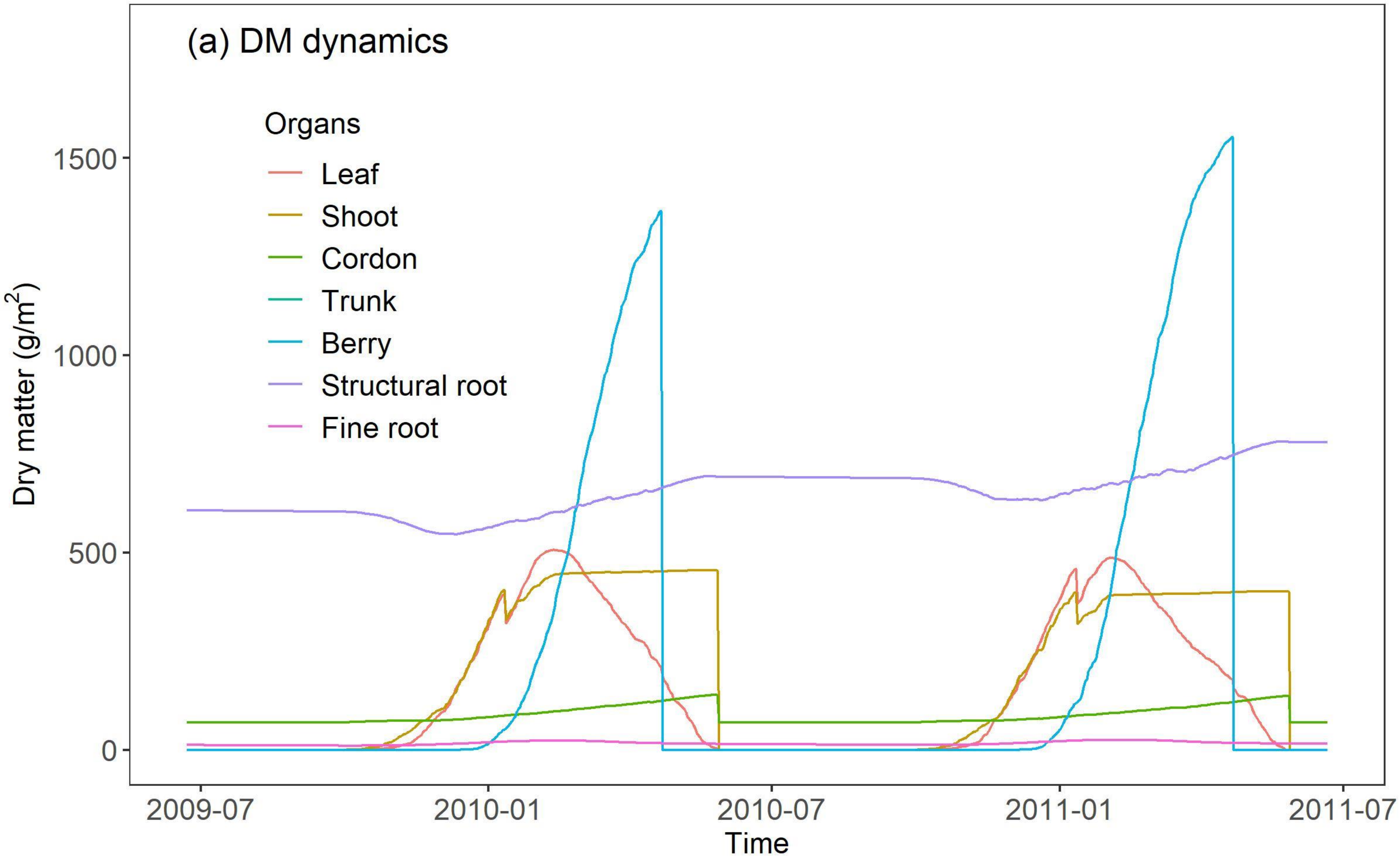
# Radiation interception



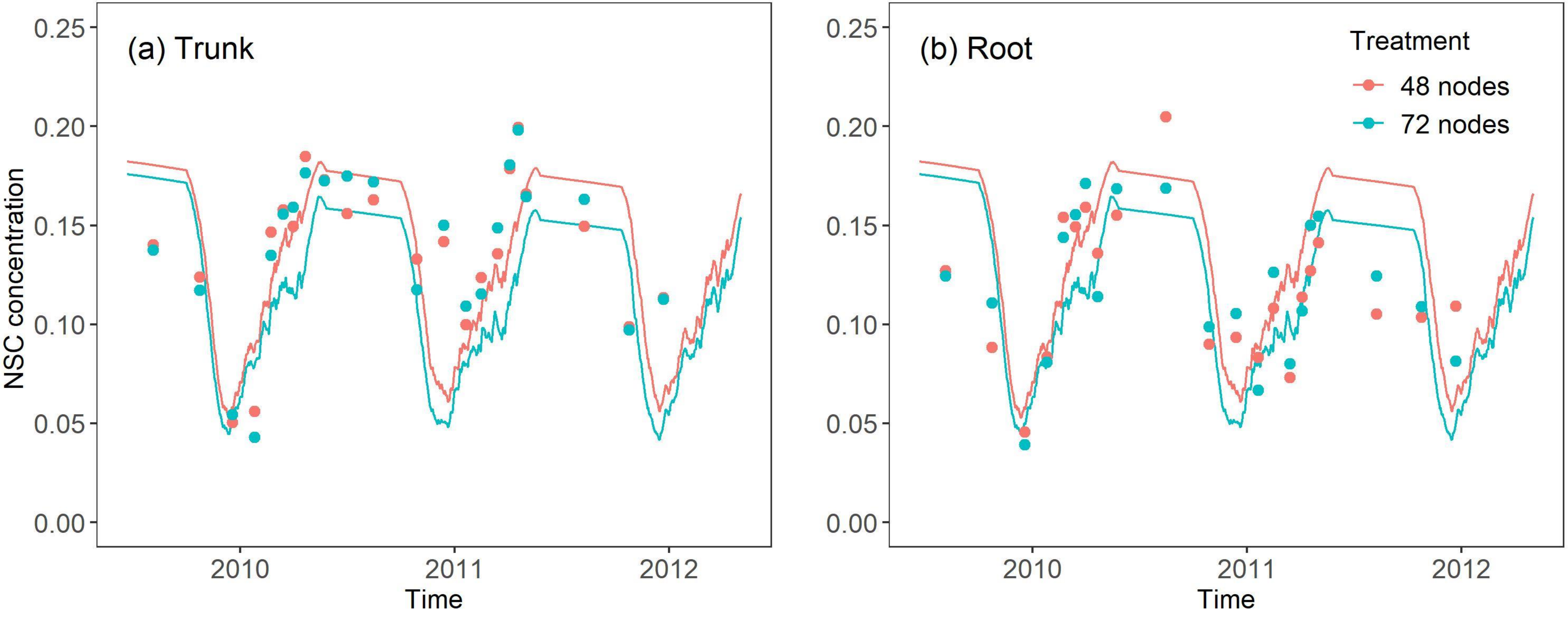
# Verification of simulated dry weight



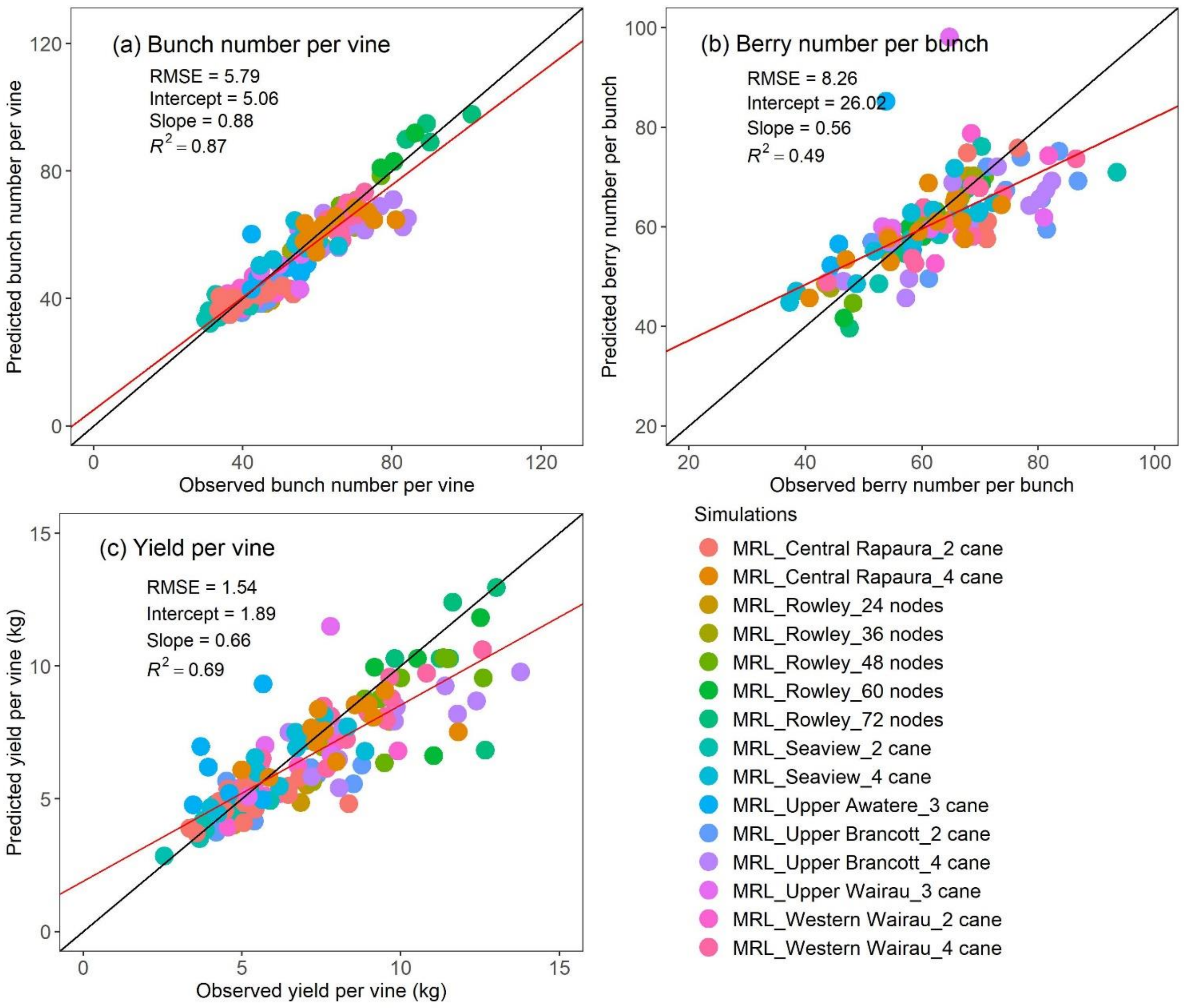
# Dry matter of different organs



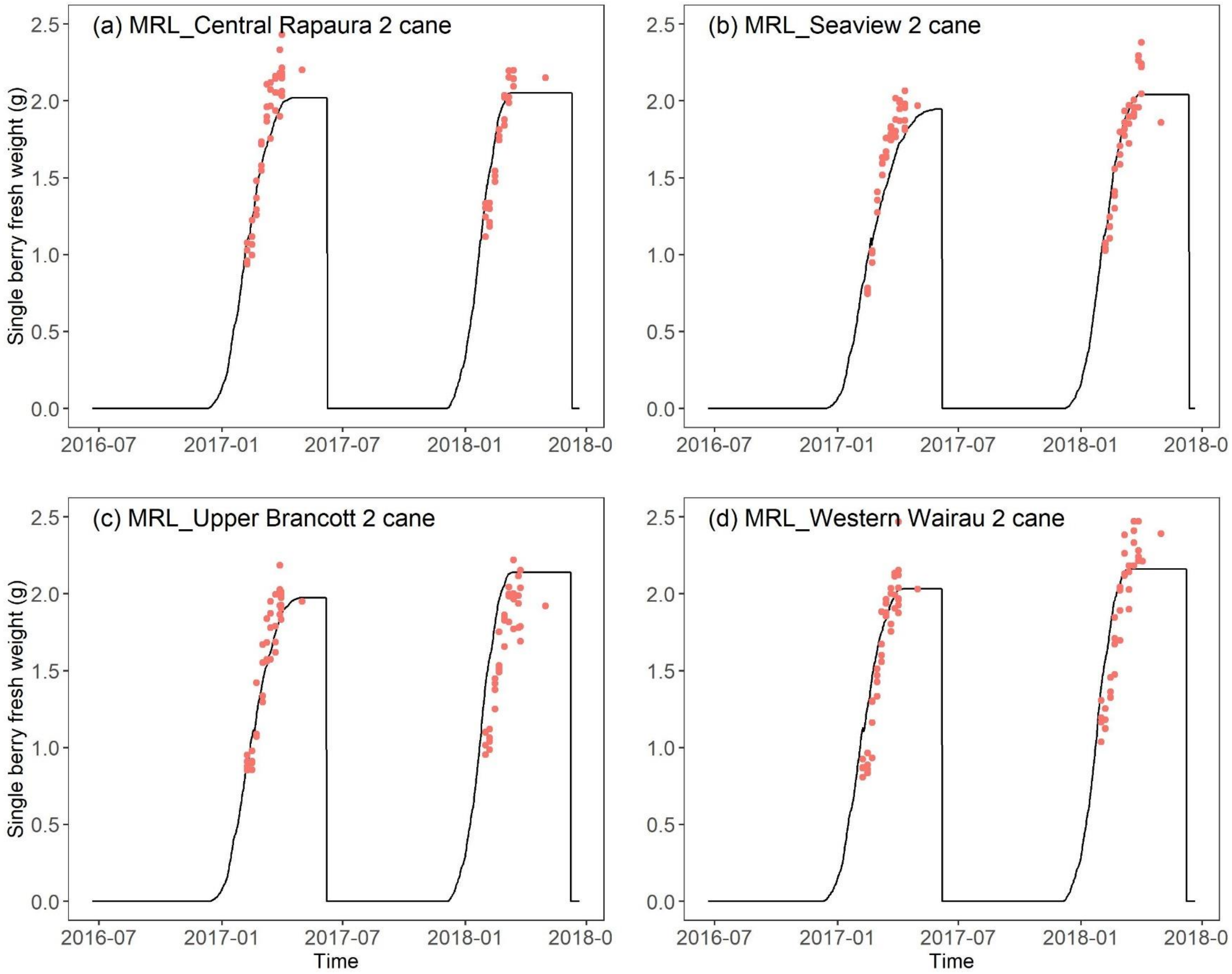
# Dynamics of non-structural concentration



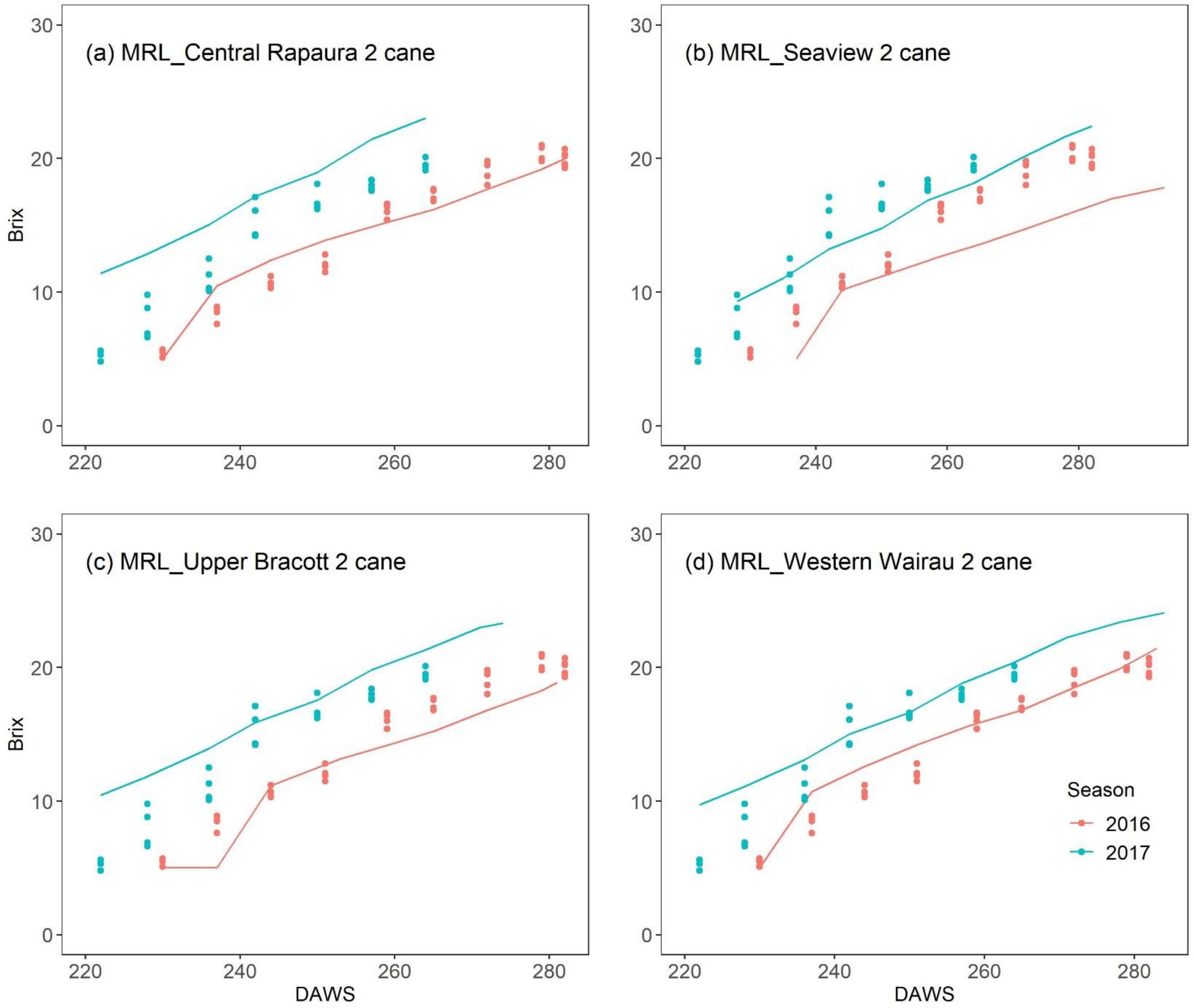
# Verification of simulated yield components



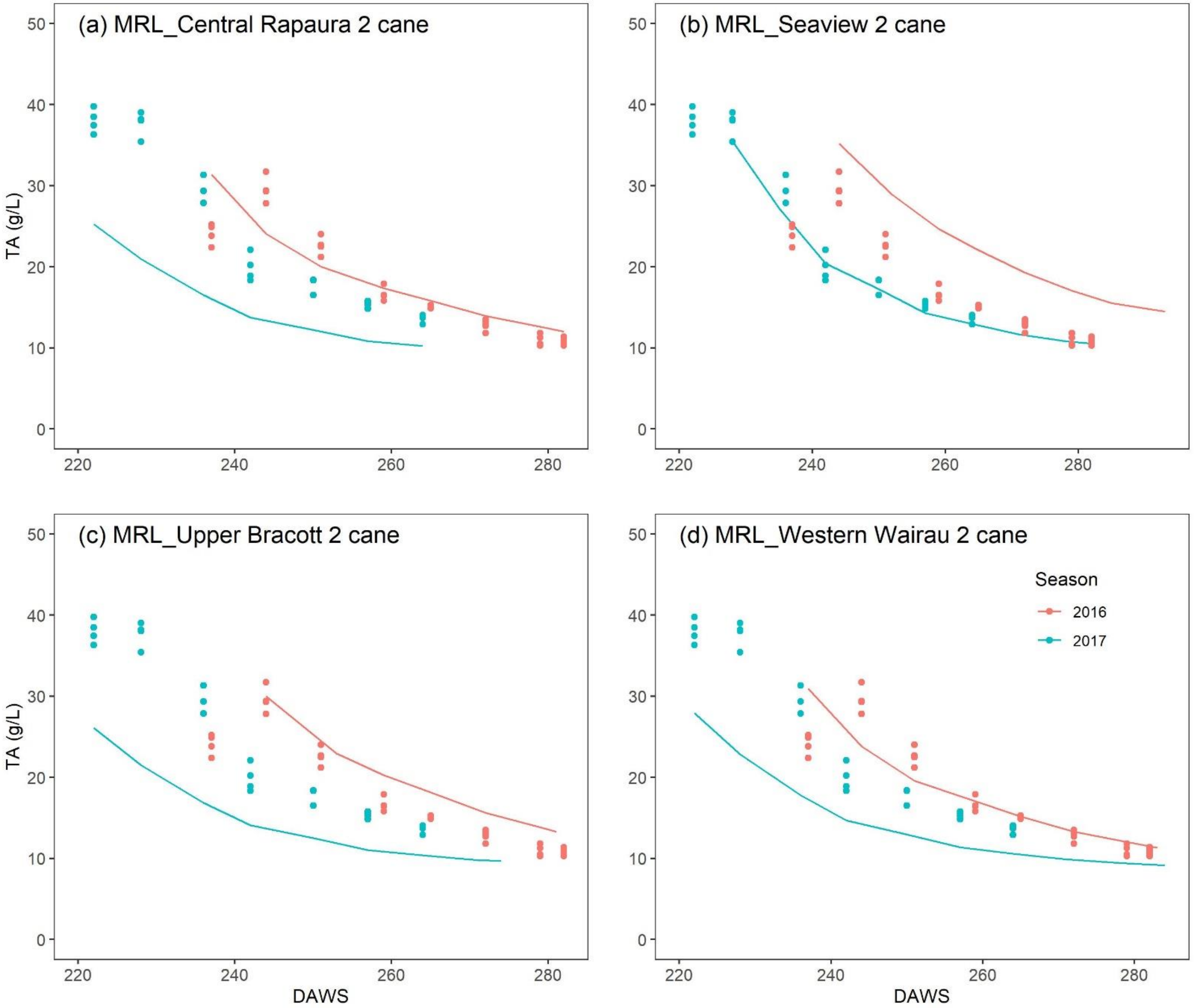
# Dynamics of berry fresh weight



# Dynamics of berry total soluble sugar



# Dynamics of berry titratable acids



# Conclusion

- The phenology module can effectively capture the variations in the phenological timing caused climatic conditions for different varieties
- The row crop light interception works well for vertical shoot positioned training systems
- The new carbon allocation module captured the dynamics of dry matter and non-structural carbon of different organs
- The yield module reflected the variations in yield components caused by climatic condition and pruning regimes
- A perennial fruit crop model framework has been developed and can be used for other perennial fruit crops as well

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