Uncertainty in canola phenology modelling induced by cultivar parameterization

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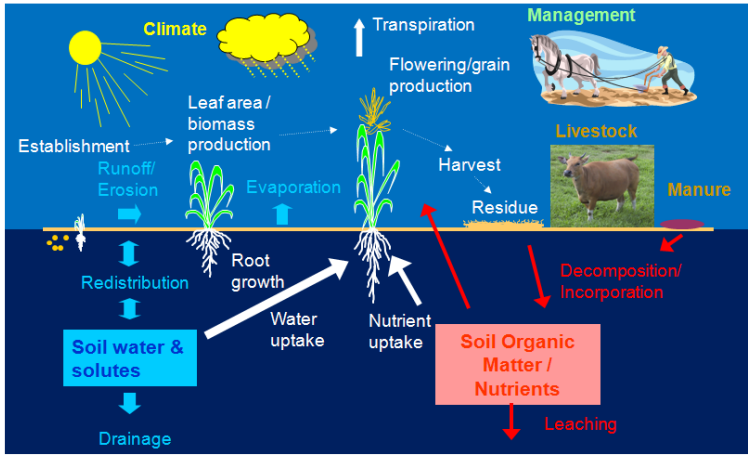
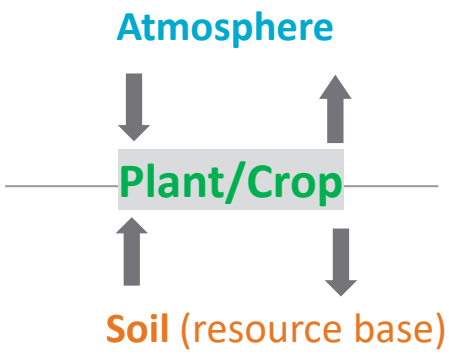
Soil-Plant Systems Modelling

A soil-plant system:

- Responds to variations in climate, soils and management practices
- Produces food for human and/or animals – **Productivity**
- Controls flows/fluxes of water, carbon, nutrients etc – **Environmental Impacts**



SPA Continuum



Key Science Disciplines

- Climatology/meteorology
- Crop science
- Crop breeding
- Agronomy
- Agroecology
- Soil sciences

Wang (2019) Soil-Plant Systems Modelling, - Better modelling of G x E interactions, Canberra

APSIM-Canola application

Yield Gap Analysis

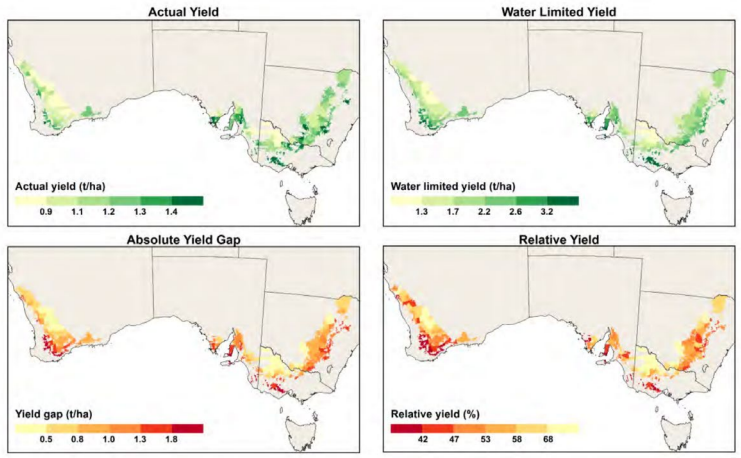
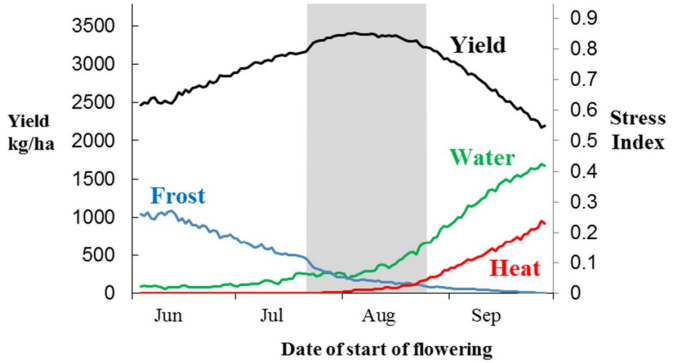
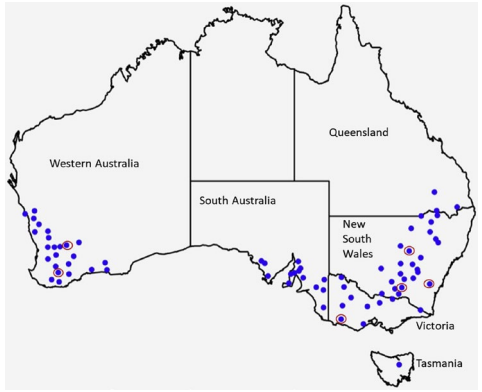


Figure 3: Actual and potential Australian dryland canola yield and yield gaps. 17-year averages (1996 to 2012) are shown for each statistical local area (SLA). The large spatial and temporal variability has been mapped at SLA scale and is available at www.yieldgapaustralia.com.au

Optimal Sowing and Flowering Periods





Dual Purpose Cropping

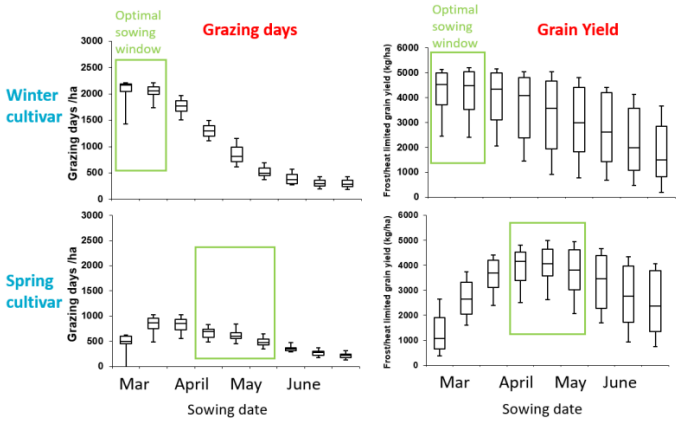


Figure 5: Simulated forage and grain yield over 50 years from dual-purpose canola across a range of sowing dates at Young, NSW. Box plots show seasonal variability and risk.

Lilley et al (2018) APSIM-Canola : A physiological context to improve canola agronomy, AusCanola

Research needs

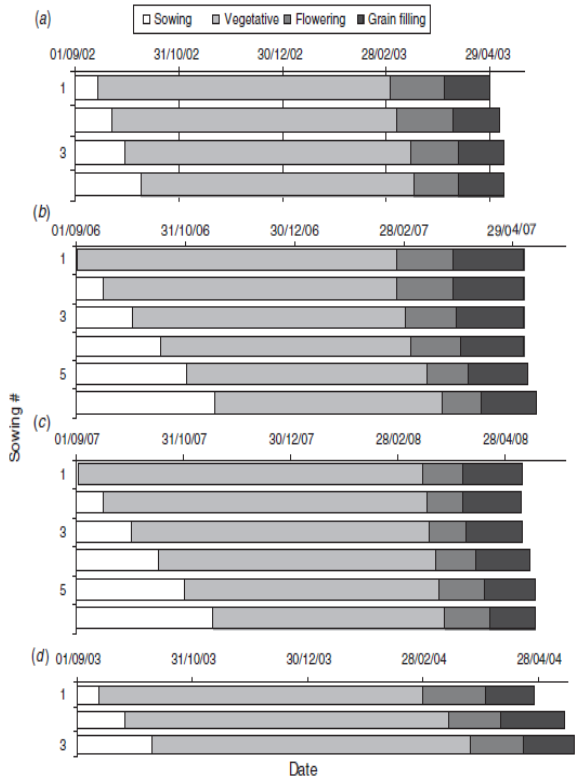
Uncertainty in canola phenology modelling induced by parameterization/cultivar characterisation

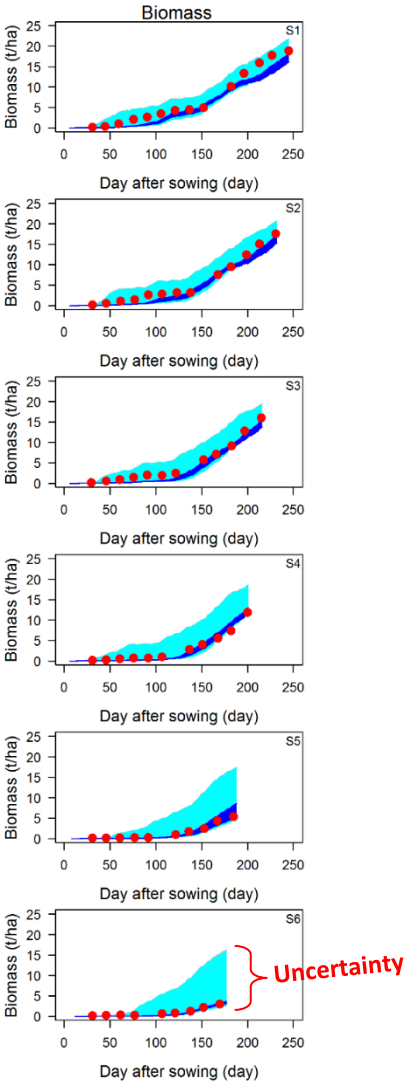
- Robustness of parameters?
- Uncertainty in simulated phenology?
- Its impact on simulated biomass/yield?

× Trial-and-error method

✓ Optimization – Grid Search

- All parameter combinations that lead to the same simulation accuracy
- Uncertainty quantified as the range of simulated biomass/yield





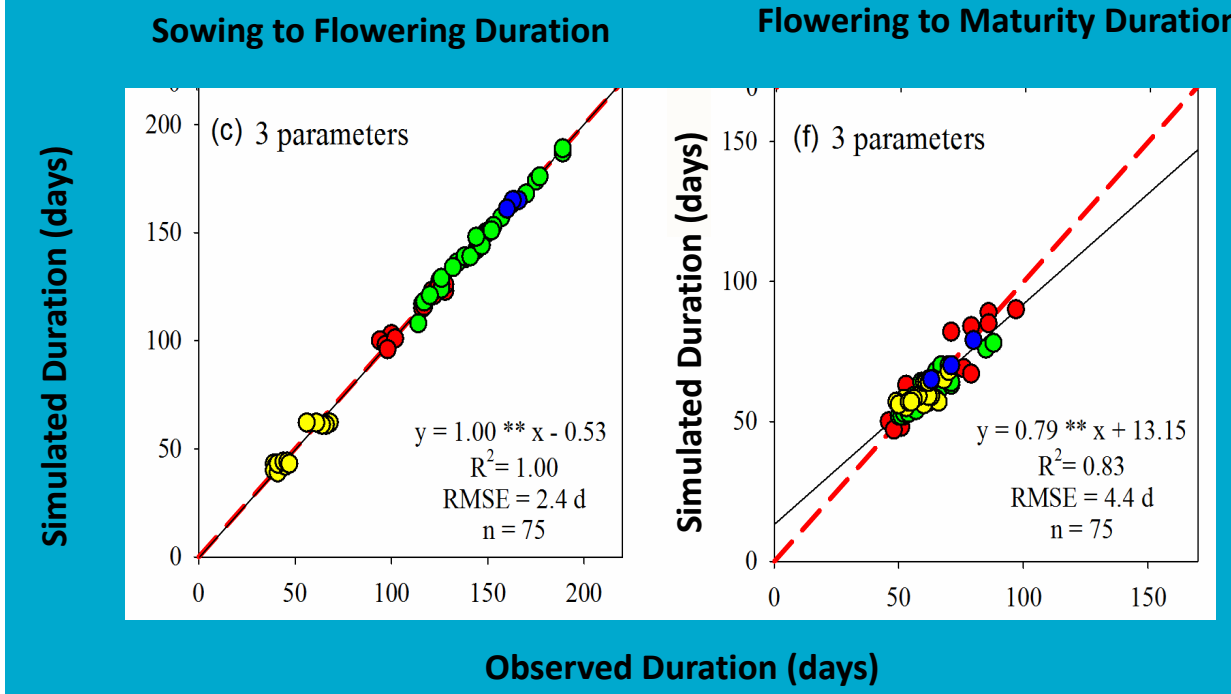
APSIM-Canola Classic Version

- Three key parameters determine flowering date and maturity date
  - Vernalisation sensitivity
  - Photoperiod sensitivity

  } Duration from sowing to flowering

  - Grain filling duration → Duration from flowering to maturity

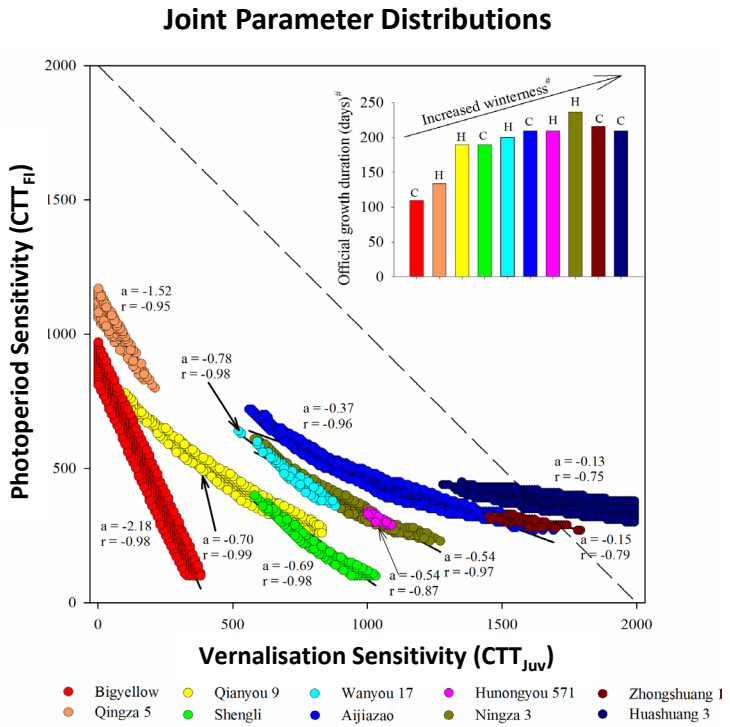
- APSIM can correctly simulate phenology
  - Error in simulated flowering dates < 3 days
  - Error in simulated maturity dates < 5 days

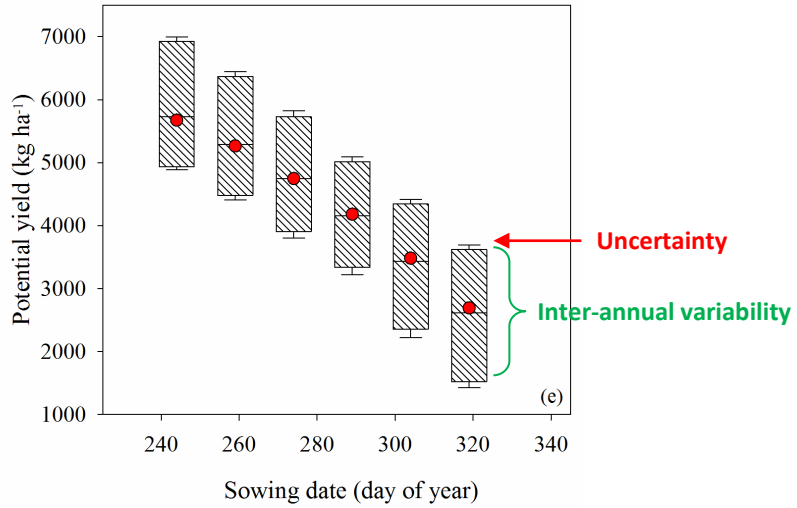


APSIM-Canola Classic Version

- Multi-parameter sets ➔ similar results (equifinality)
  - High negative correlation between vernalisation & photoperiod sensitivity
  - Need better understanding of the two processes
  - Lack of information to separate two phases

- Impact of equifinality – long-term simulation
  - Impact on simulated grain yield is small
  - Uncertainty is much smaller than inter-annual variability of yield

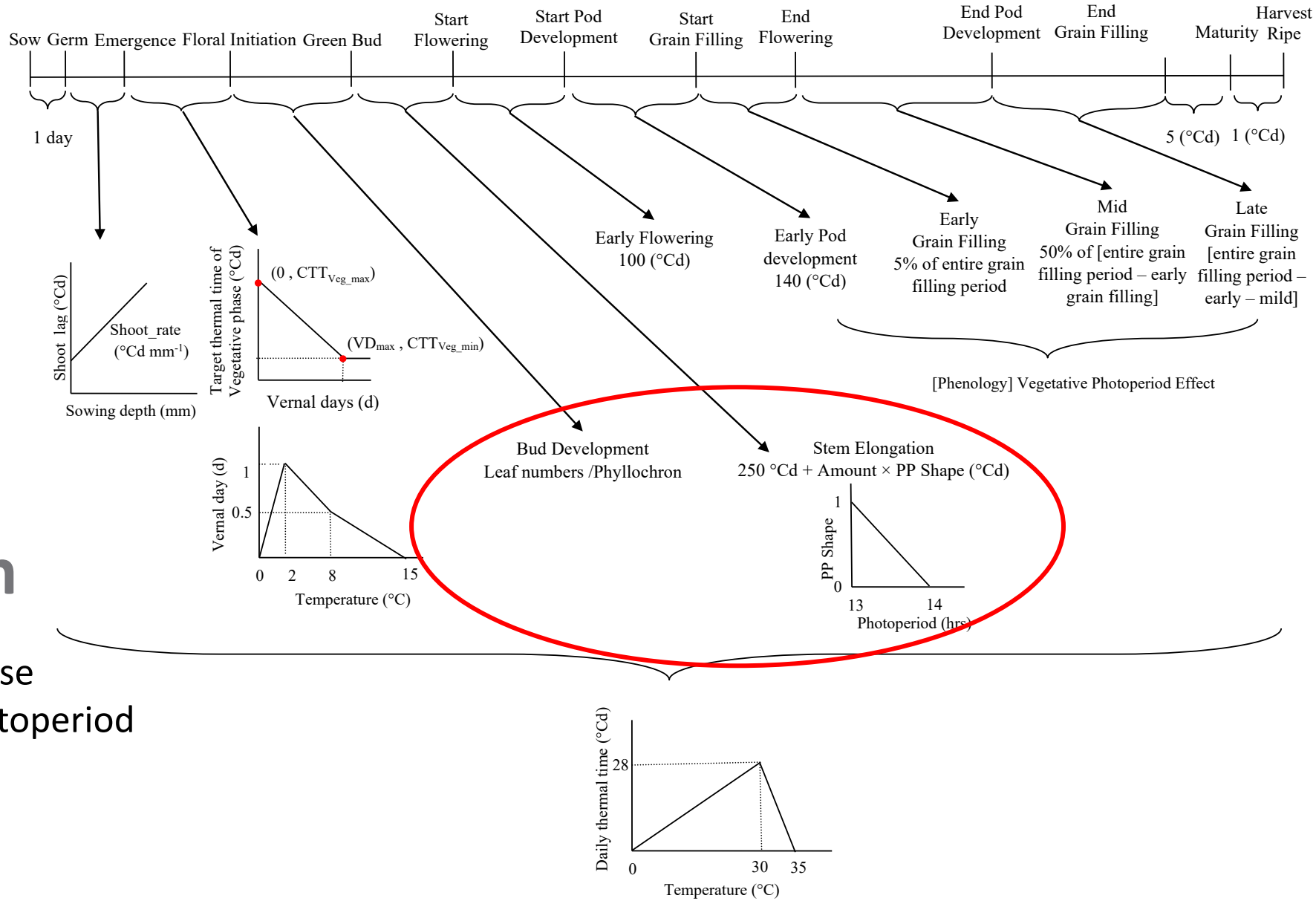




Di He, Enli Wang, Jing Wang, Julianne Lilley et al. *Agricultural and Forest Meteorology* 232 (2017): 163-175.

APSIM-Canola Next Generation

- New Bud Development Phase
- Default no response to photoperiod



Dataset and Calibration strategies

❑ Dataset

- 6 sites
- 17 cultivars
- 81 growing seasons
- Up to 3 sowing dates each year

❑ Calibration strategies

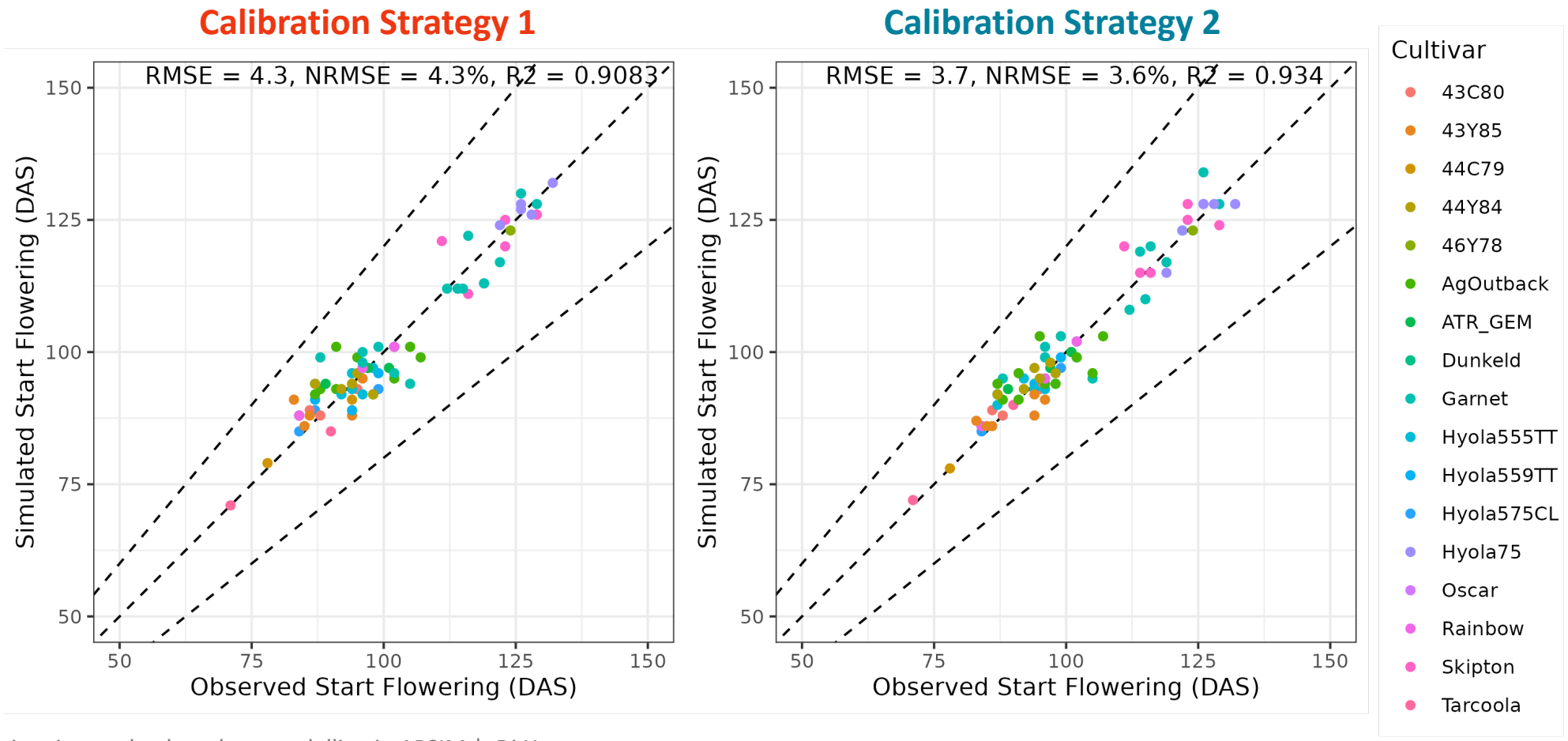
- **Strategy 1**

  a *pair of vegetative parameters – Vernalisation sensitivity*
- **Strategy 2**

  a pair of vegetative parameters – Vernalisation sensitivity

  leaf appearance rate – Bud development phase

Model performance

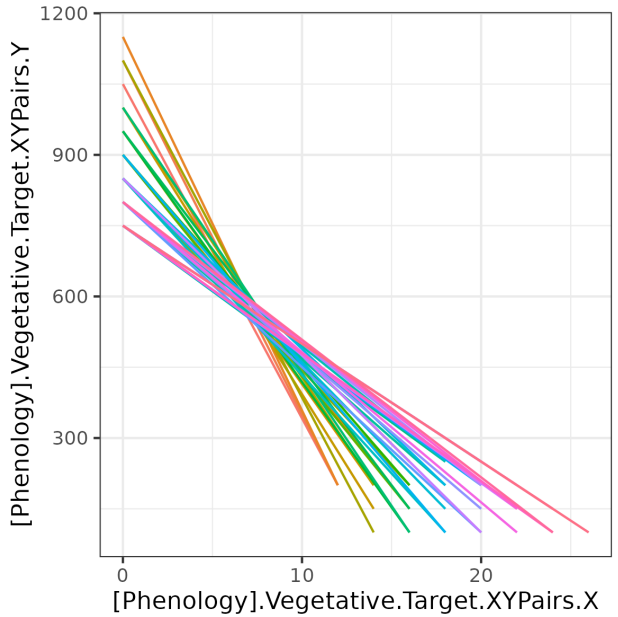


Parameter equifinality

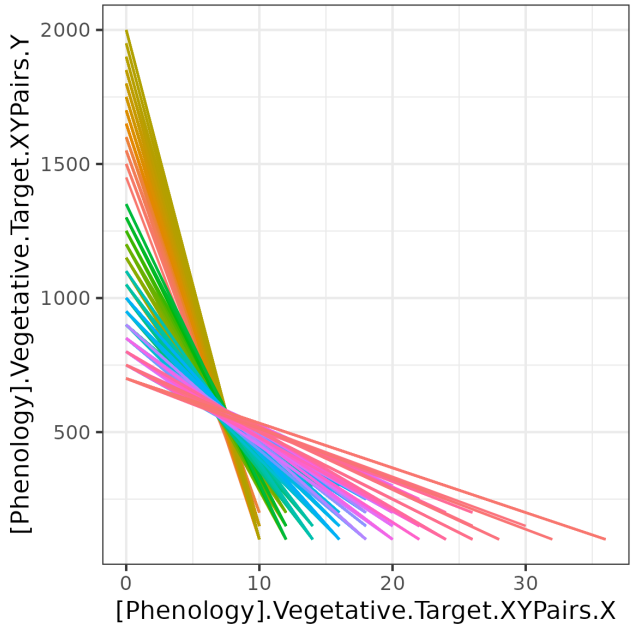
- Multiple combinations of parameters leading to the same simulation accuracy of flowering day

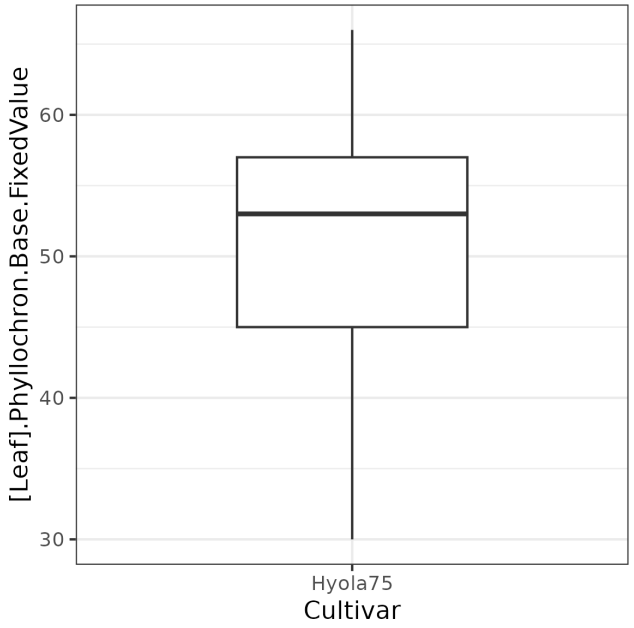
  Difference in simulated flowering day < 1 day (Hyola 75)

Calibration Strategy 1

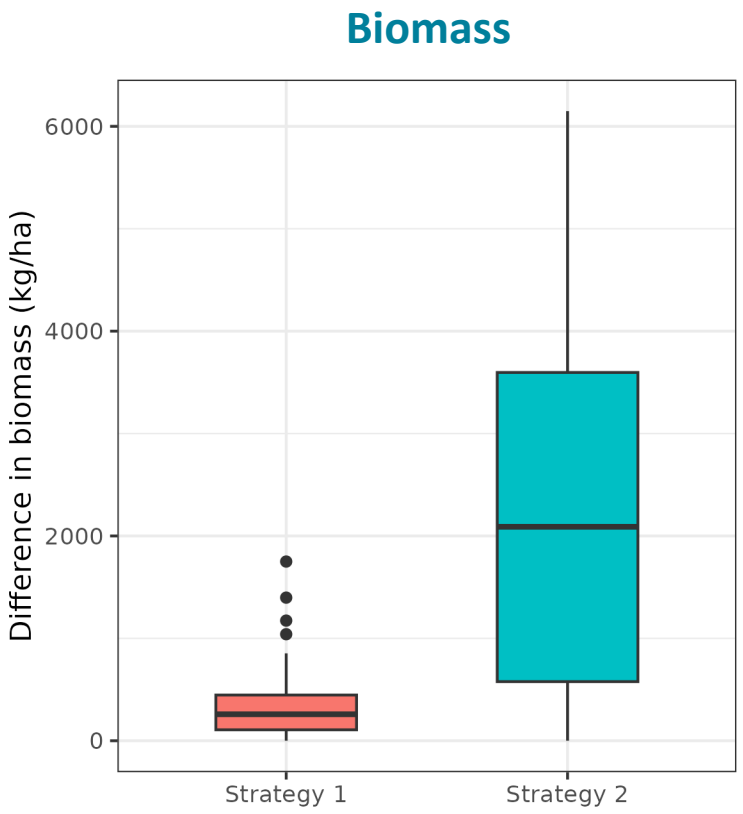


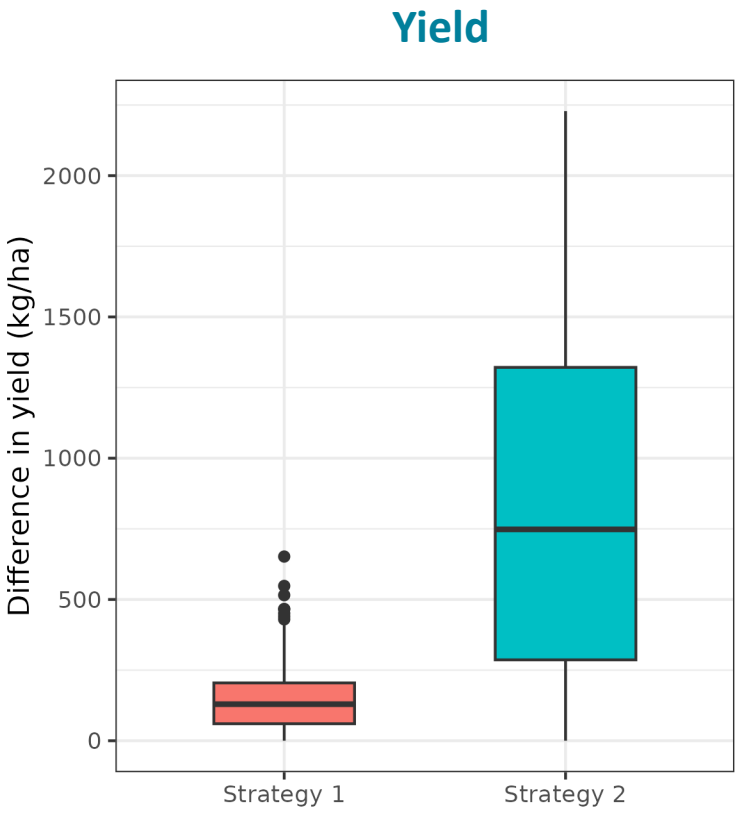
Calibration Strategy 2

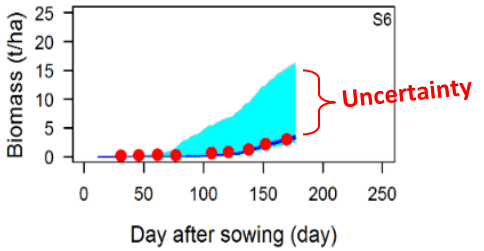




Impact on simulated biomass and yield







Calibration Strategy 1

8.3% of the observed yield

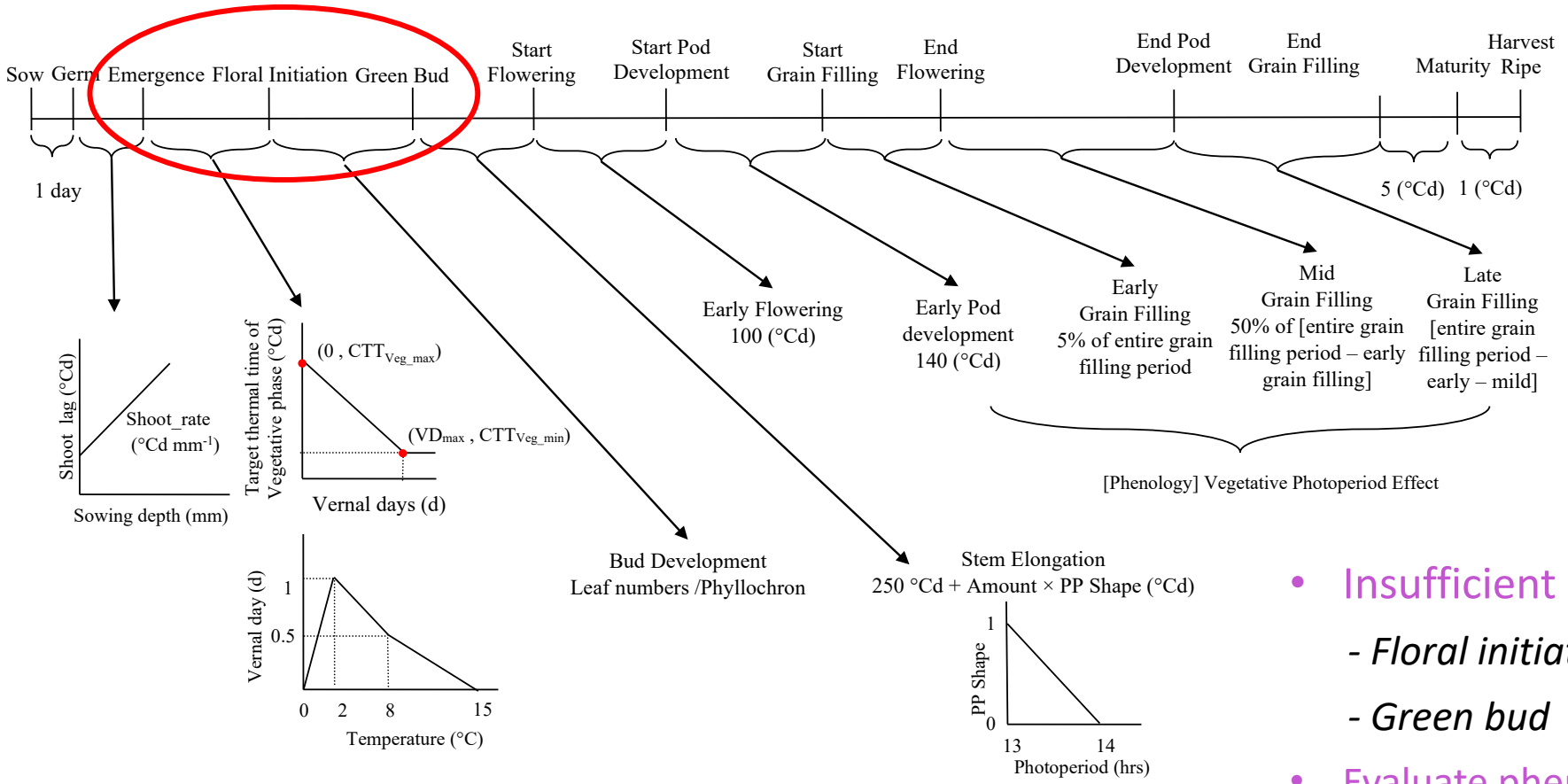
4.2% of the observed biomass

Calibration Strategy 2

46.7% of the observed yield

31.6% of the observed biomass

Why & How



- Insufficient observation
  - *Floral initiation*
  - *Green bud*
- Evaluate phenology and biomass together

Take Home Message

- Equifinality in APSIM needs to be addressed – parameters can have different values
- Potentially lead to incorrect cultivar characterisation and wrong biomass/yield simulations
- In APSIM Classic, impact of equifinality on biomass/yield is small
- In APSIM Next Generation, calibration strategy is important – tune vegetative phase only
- APSIM-Canola is robust if properly calibrated
- Know the model better & Know the cultivar better

Thank you

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