

Optimum Flowering Time of Canola: Response to Climate Change and Genotypic Variation

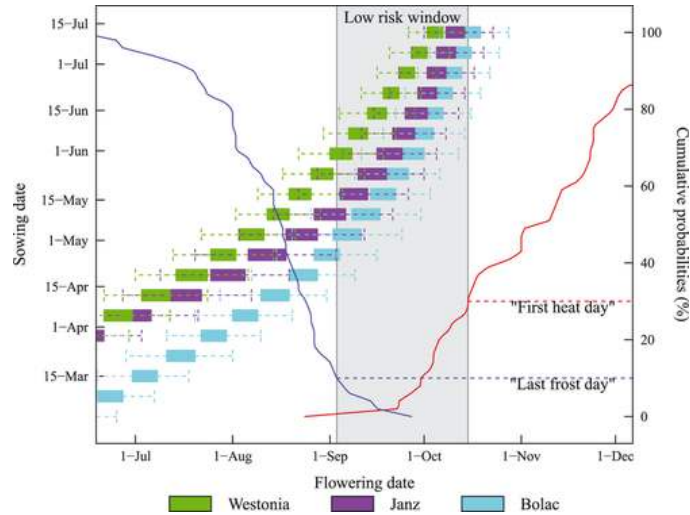
Bangyou Zheng, Pengcheng Hu, Di He, Jeremy Wish, Julianne Lilley

CSIRO Agriculture and Food

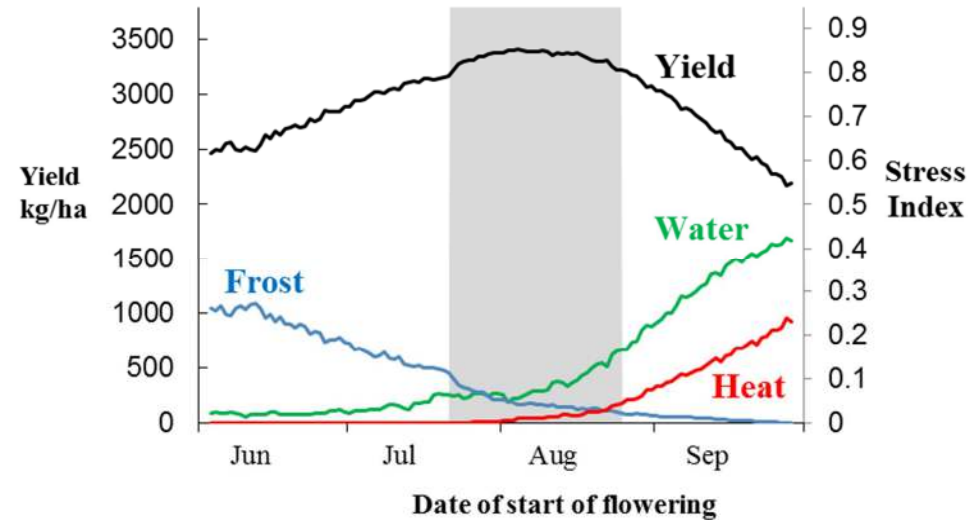
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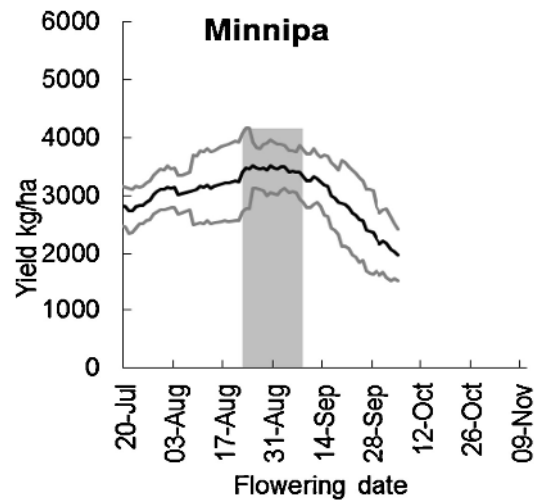
Optimum flowering period limited by abiotic stresses



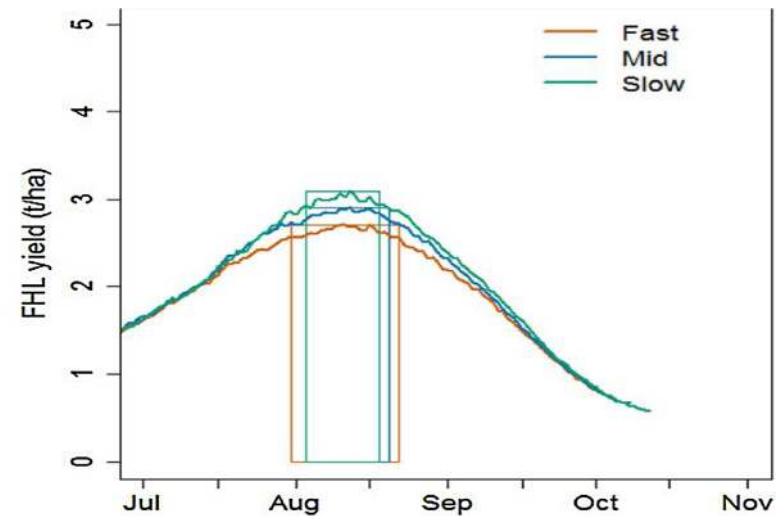
Wheat, Zheng et al. 2012



Canola, Lilley et al. 2017, 2019



Wheat, Flohr et al. 2017

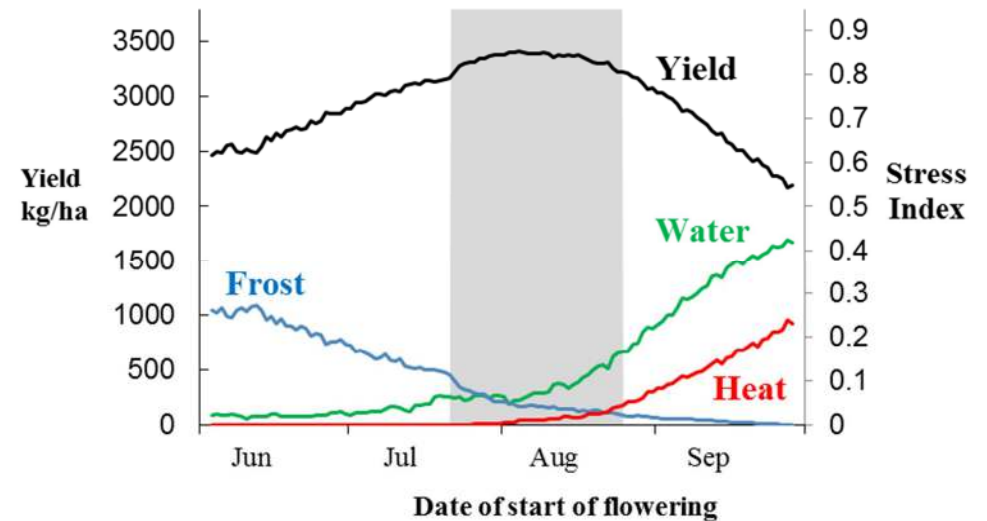


Wheat, Chen et al. 2020

Barley Liu et al, 2020; Wheat, Hu et al. 2021, etc

Optimum flowering period limited by abiotic stresses

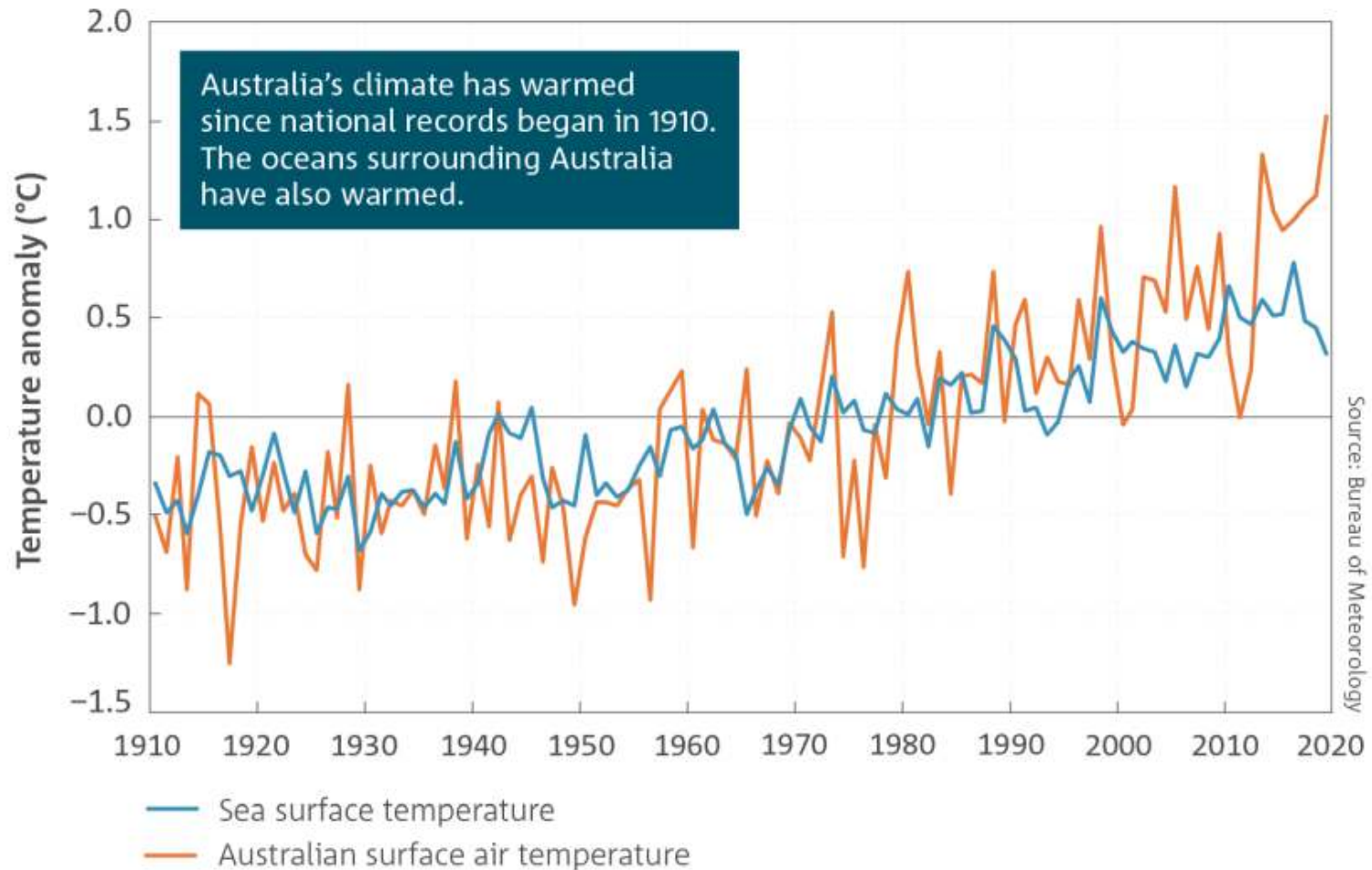
- Frost
- Heat
- Drought
- Genotypic response
 - Sensitive to growth stage
 - Sensitive to temperature



Canola, Lilley et al. 2017, 2019

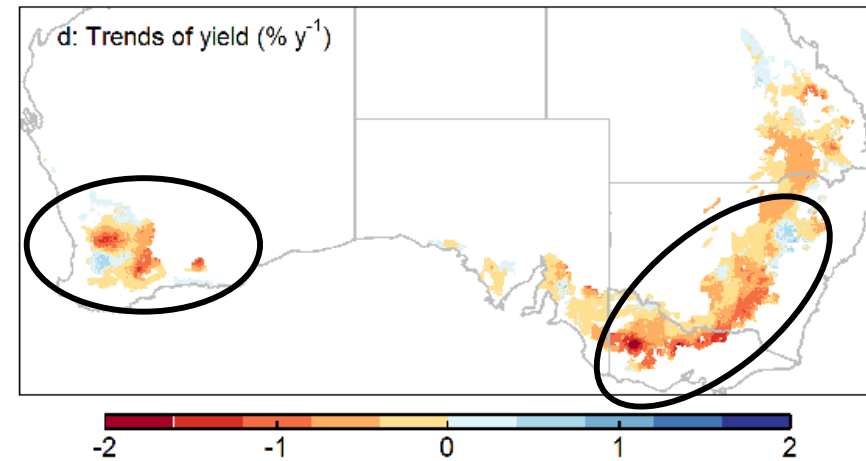
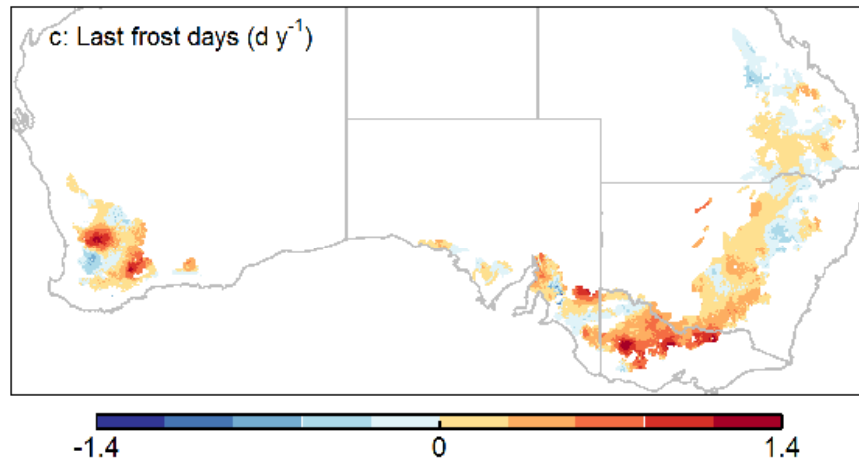
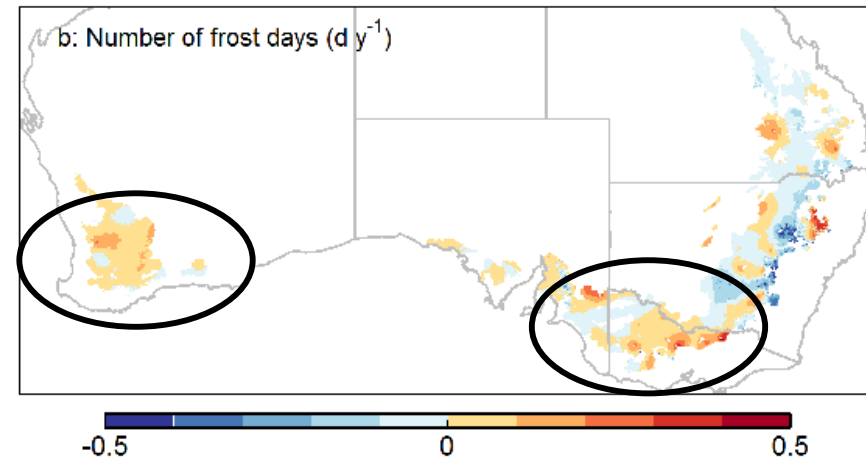
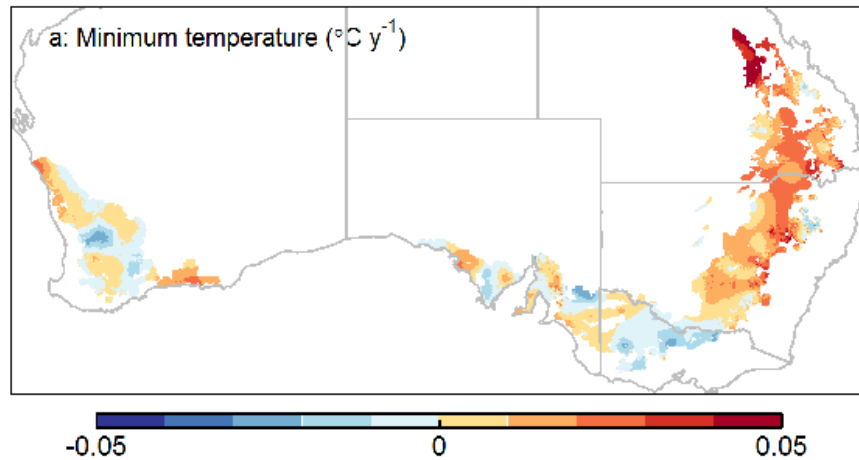
- More Genotype (phenology)?
- Climate Change?

Climate change in Australia



www.climatechangeinaustralia.gov.au

More frost stress even warmer climates



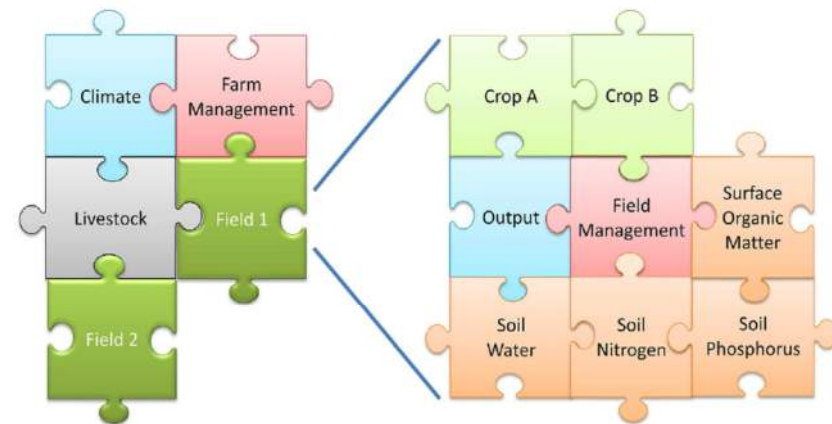
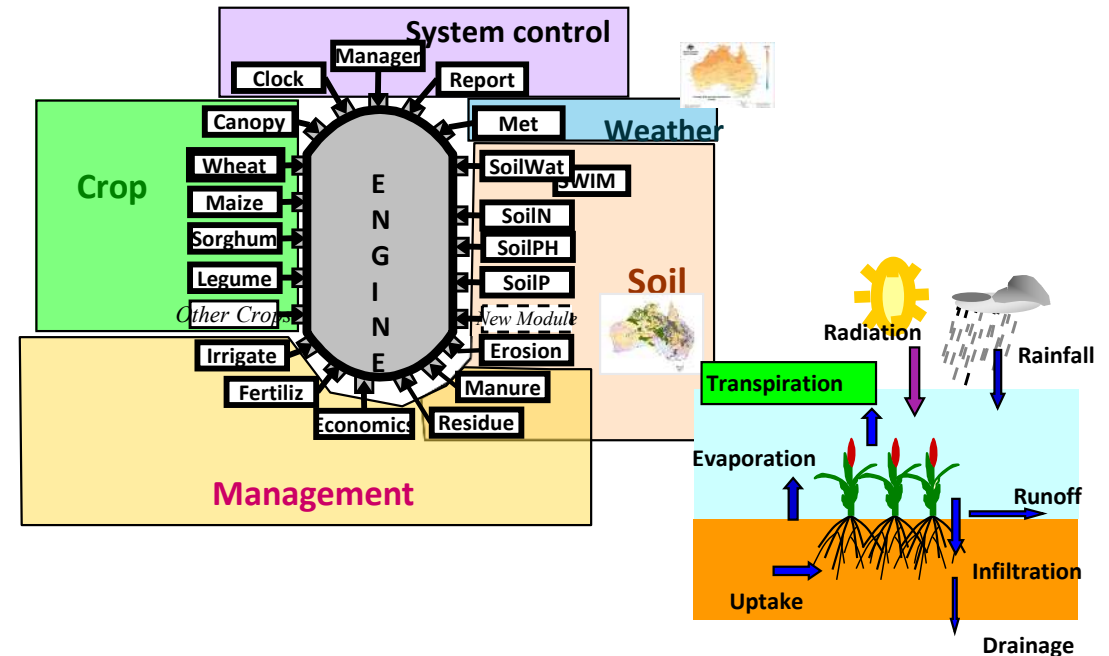
Frost events are defined as $T_{\min} < 0^{\circ}\text{C}$

Yield impacts estimated for medium cultivar Janz sown at 1st June.

APSIM Next Generation

Inputs

- Climate
 - Radiation
 - Temperature
 - Rainfall
 - Evaporation
- Soil
 - Depth
 - Water holding capacity
- Management
 - Genotype/Crop
 - Sowing dates
 - Fertiliser application
 - Irrigation

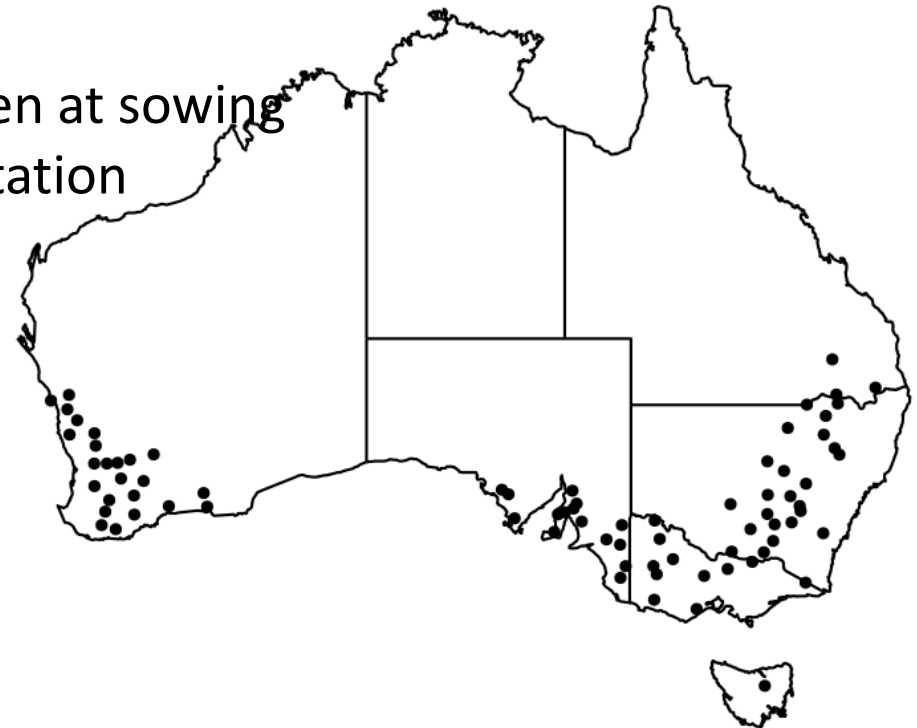


Holzworth et al. 2014

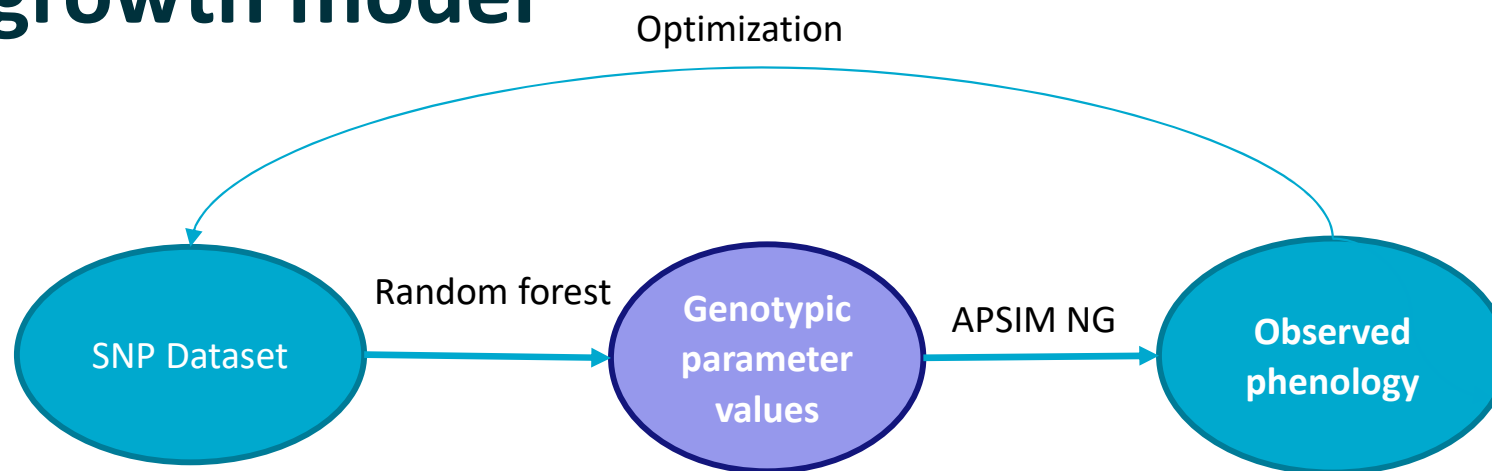


Simulation setup for OFP

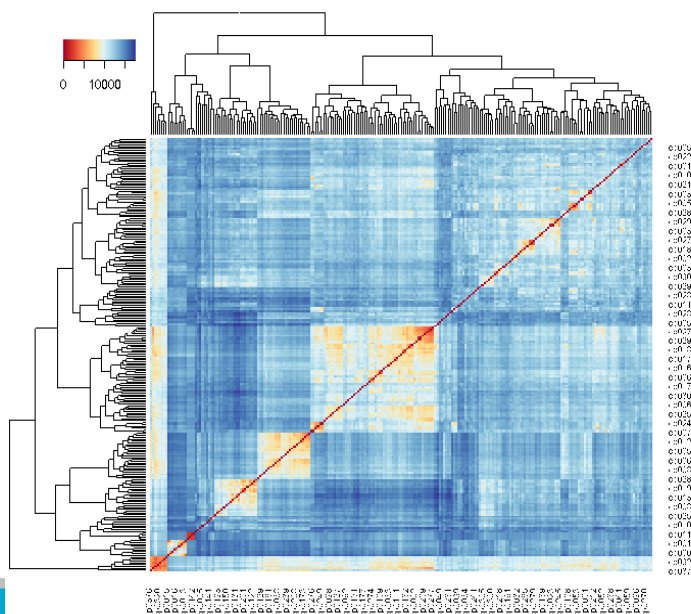
- 77 sites across grain regions
- Canola model in APSIM NG
- Weather data from SILO from 1940 to 2023
 - Drop off predictions before 1957
- Selected soil profiles
- Sowing from 15 March to 15 July
- 152 cultivars parameterised in Canola Phenology Project with whole genomic SNP
- Without resetting initial soil water, nitrogen at sowing
- Enough nitrogen fertilisation without limitation
- See Lilley et al. 2019 for details



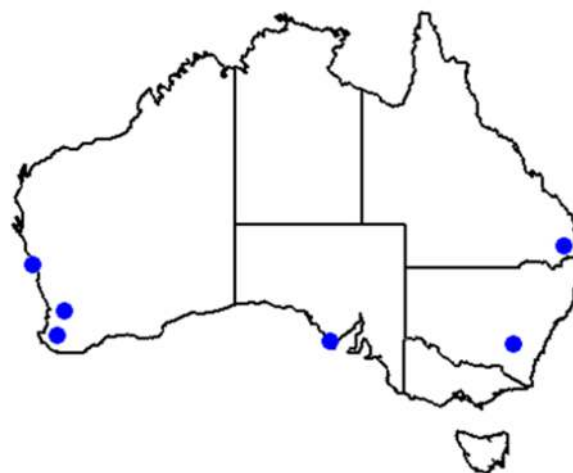
Predict phenology with genomic prediction and crop growth model



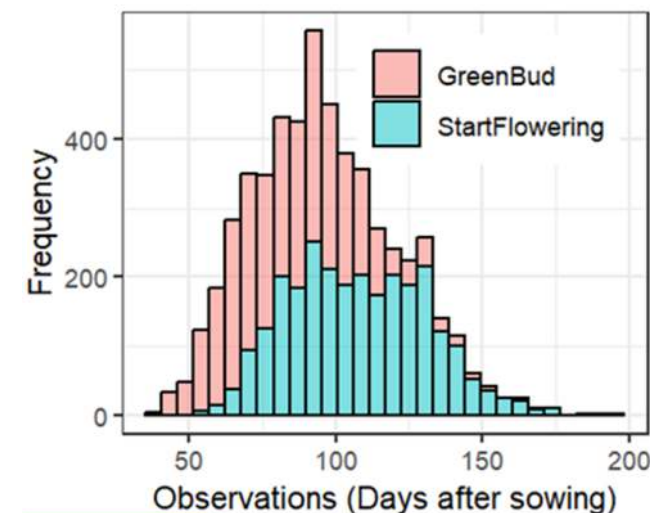
Genome wide SNPs



- 3 parameters for vernalisation time vs thermal time

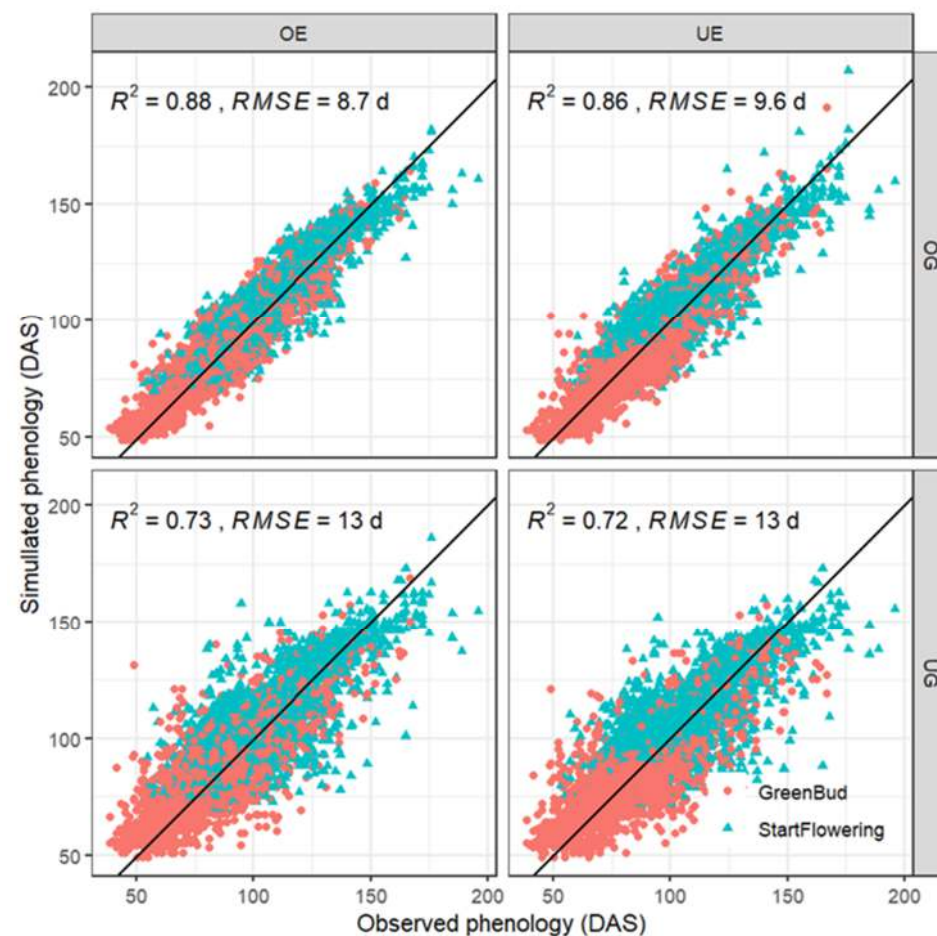


- Green Bud
- Start of Flowering

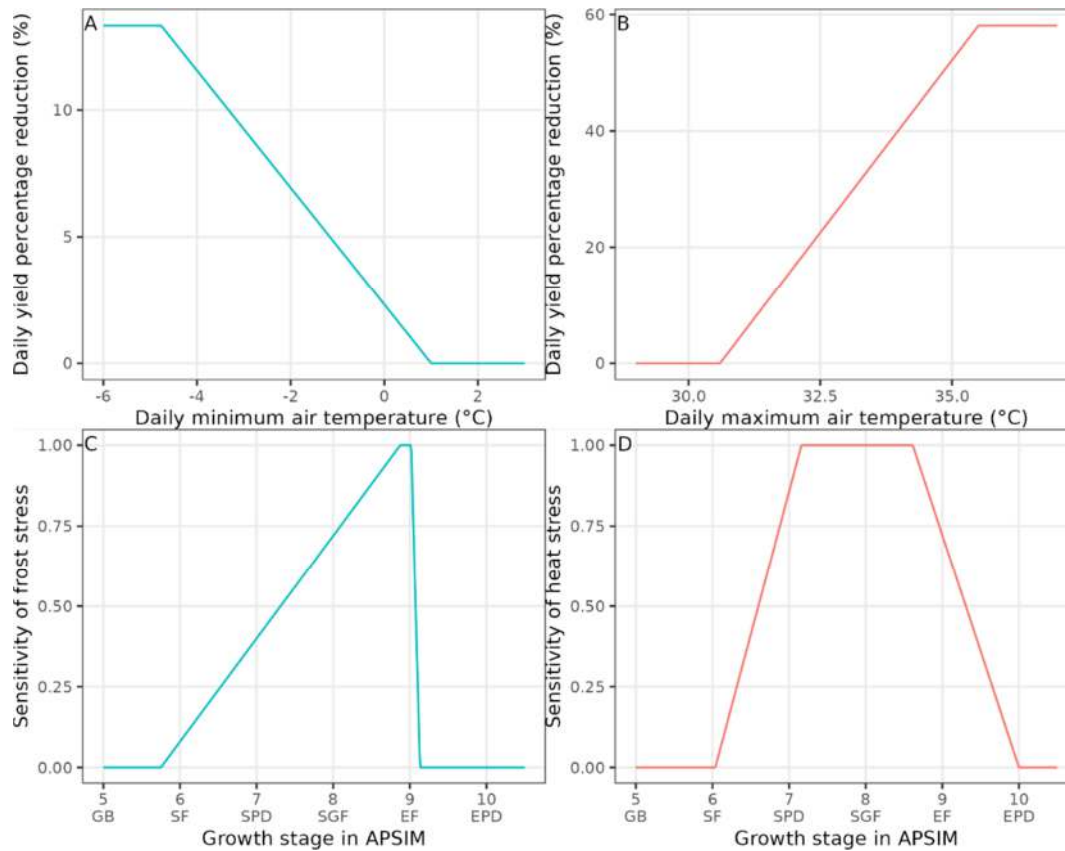


Predict phenology with genomic prediction and crop growth model

| | Observed Environment (OE) | Unobserved Environment (UE) |
|--------------------------|---------------------------|-----------------------------|
| Observed Genotype (OG) | OGOE | OGUE |
| Unobserved Genotype (UG) | UGOE | UGUE |



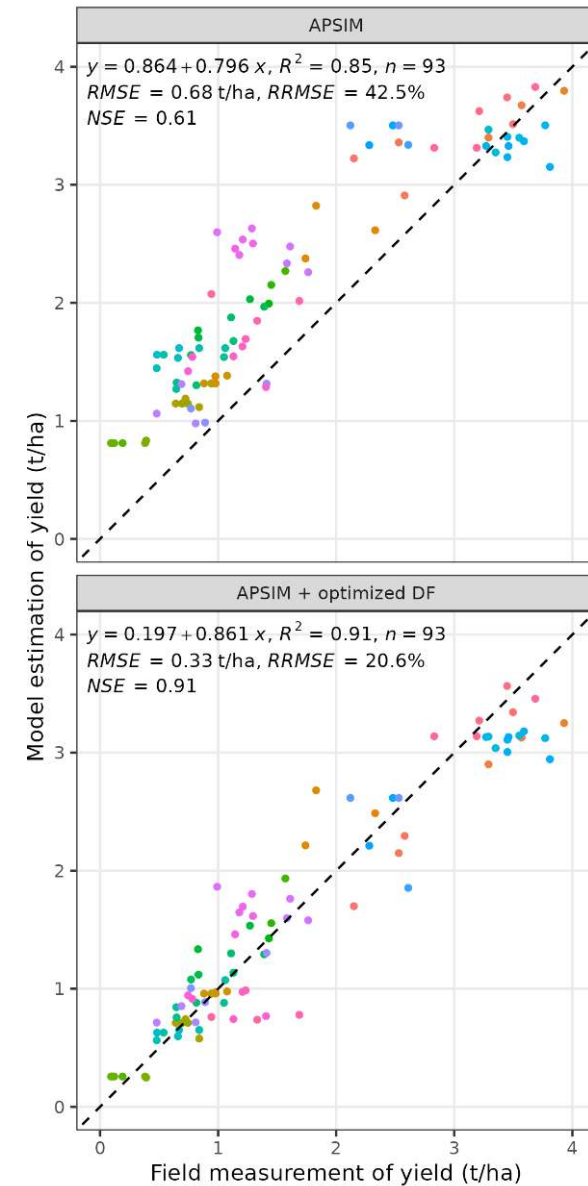
Canola yield is limited by frost and heat stress



Frost

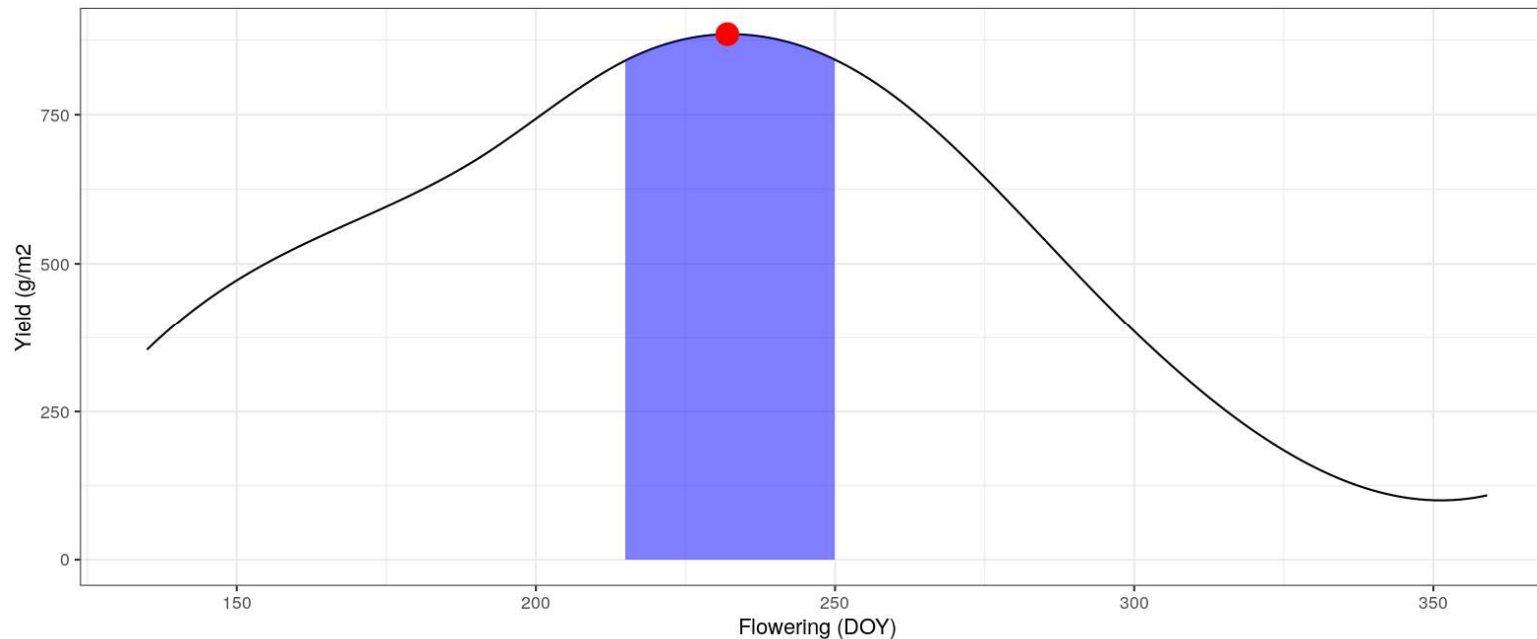
Heat

Available in APSIM NG



Calculations of Optimum Flowering Period

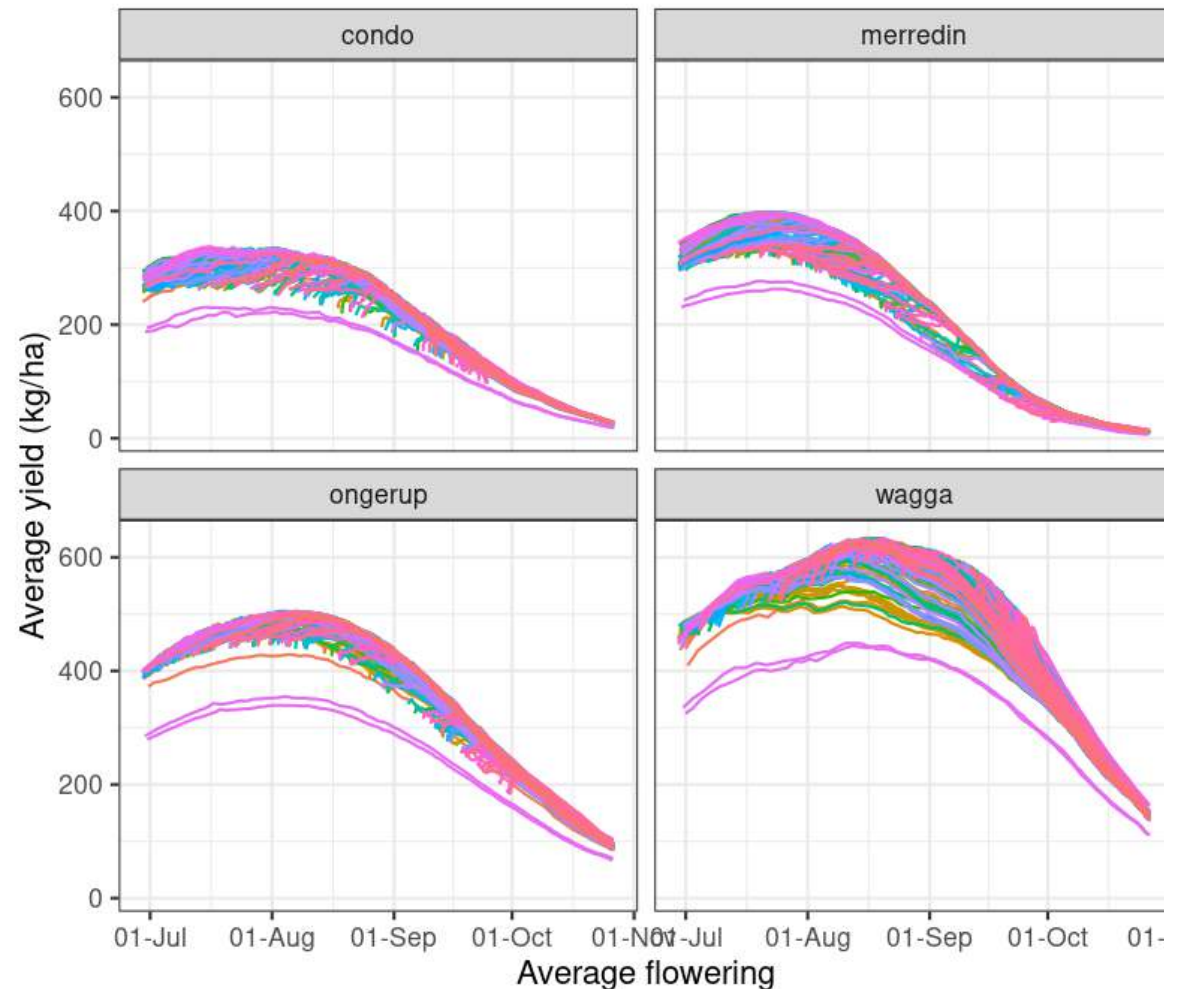
- Average flowering time and frost/heat stressed yield
 - over certain year range
- Period more than 95% of maximum yield
- For all cultivars and each cultivar



- Red point for optimum flowering time
- Blue ribbon for optimum flowering period
- Ribbon width as OFP span

Optimum flowering period with genotypic variations

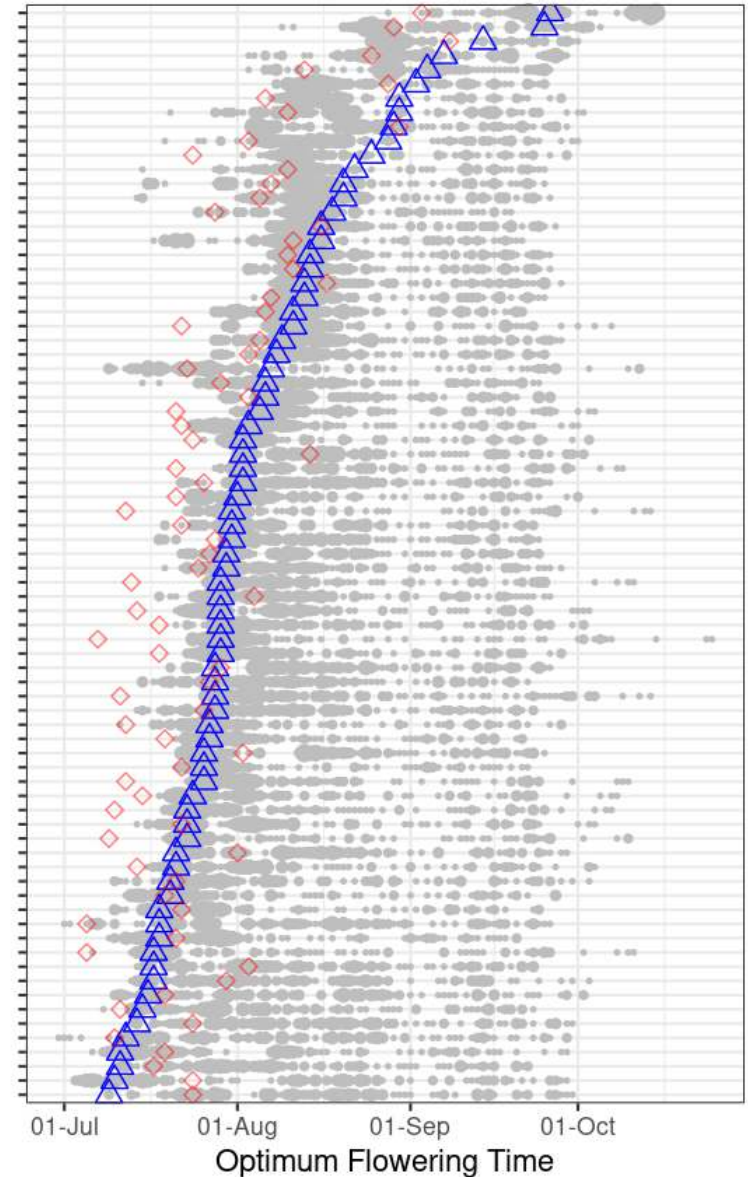
- Genotypic variations represented by cultivar phenology
- Maximum yield varied by sites and cultivars
- OFP varied by sites and cultivars
- Later OFP with lower maximum yields



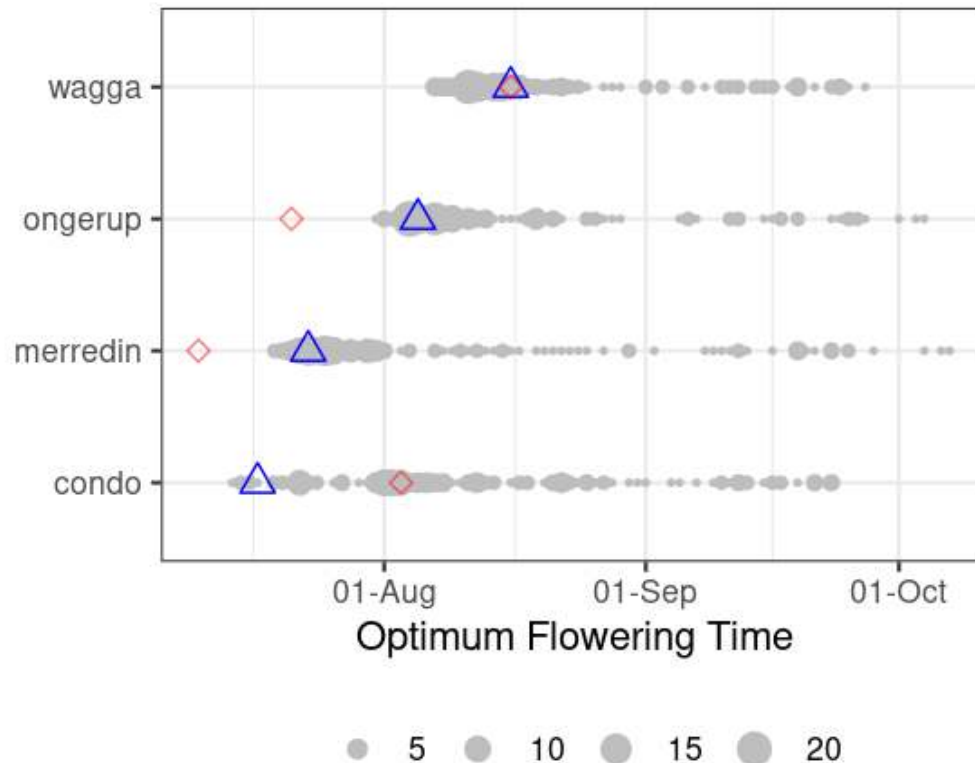
- Each line is a cultivar

Genotypic variation of OFP Mid-Point

- Red diamonds in Lilley 2019
- Blue triangles for all cultivars
- Gray circles for each cultivar
 - Size varied by cultivar number
- OFP from early July to October
- Big variation of OFP among cultivars

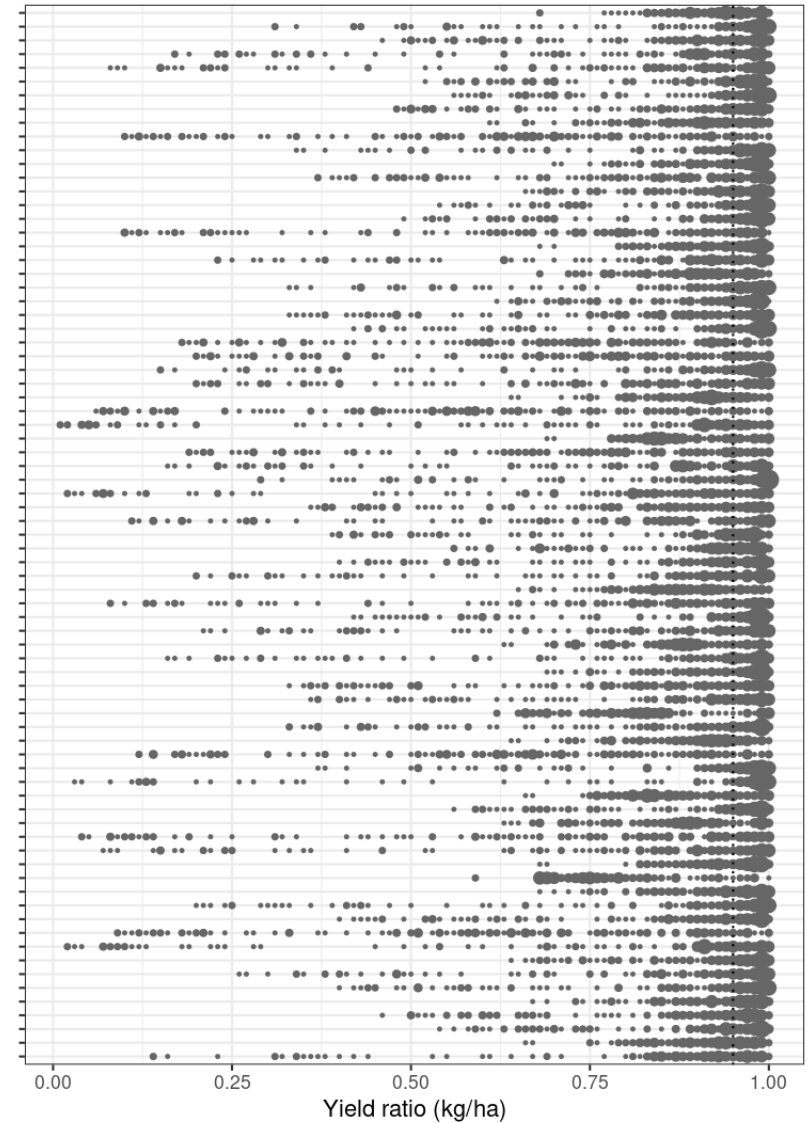
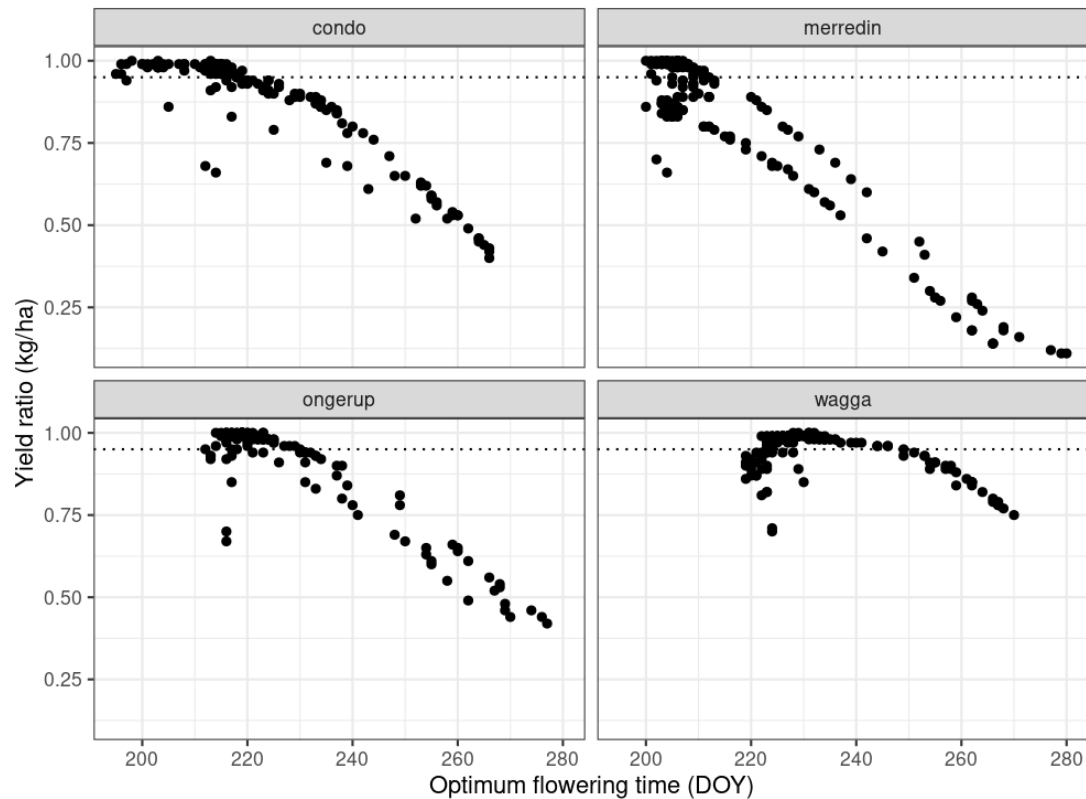


Genotypic variation of OFP Mid-Point



- OFP difference with values in Lilley 2019
 - APSIM Classic vs NG
 - Three cultivars vs 152 cultivars
 - 2017 vs 2023
 - Reoptimised DF
 - Yearly vs average yield

Varied Potential Yield vs OFP



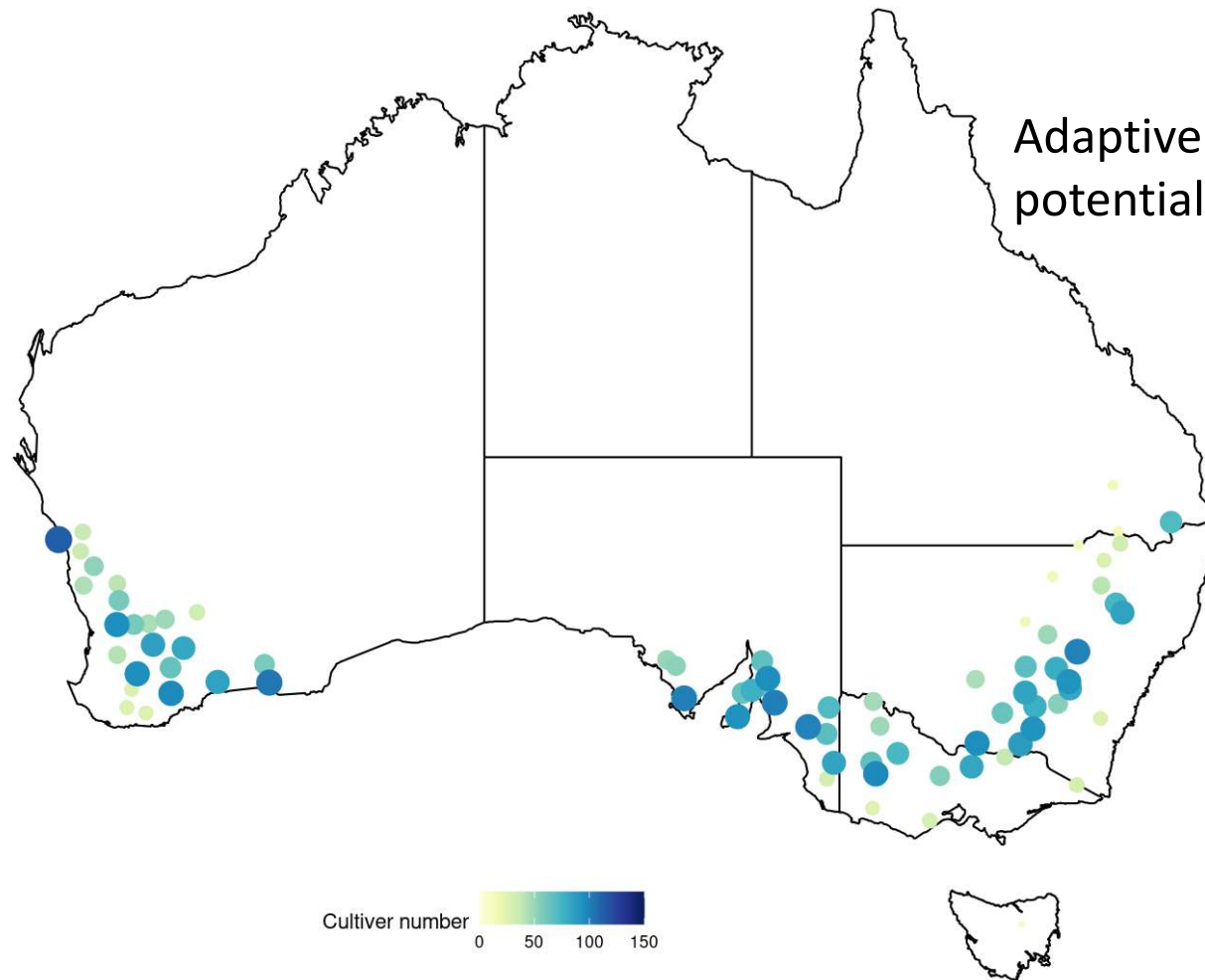
- Yield ratio = max yield of a cultivar / all cultivars
- Each point for a cultivar

• 10 • 20 • 30 • 40 • 50

Size varied by cultivar number



Varied Potential Yield

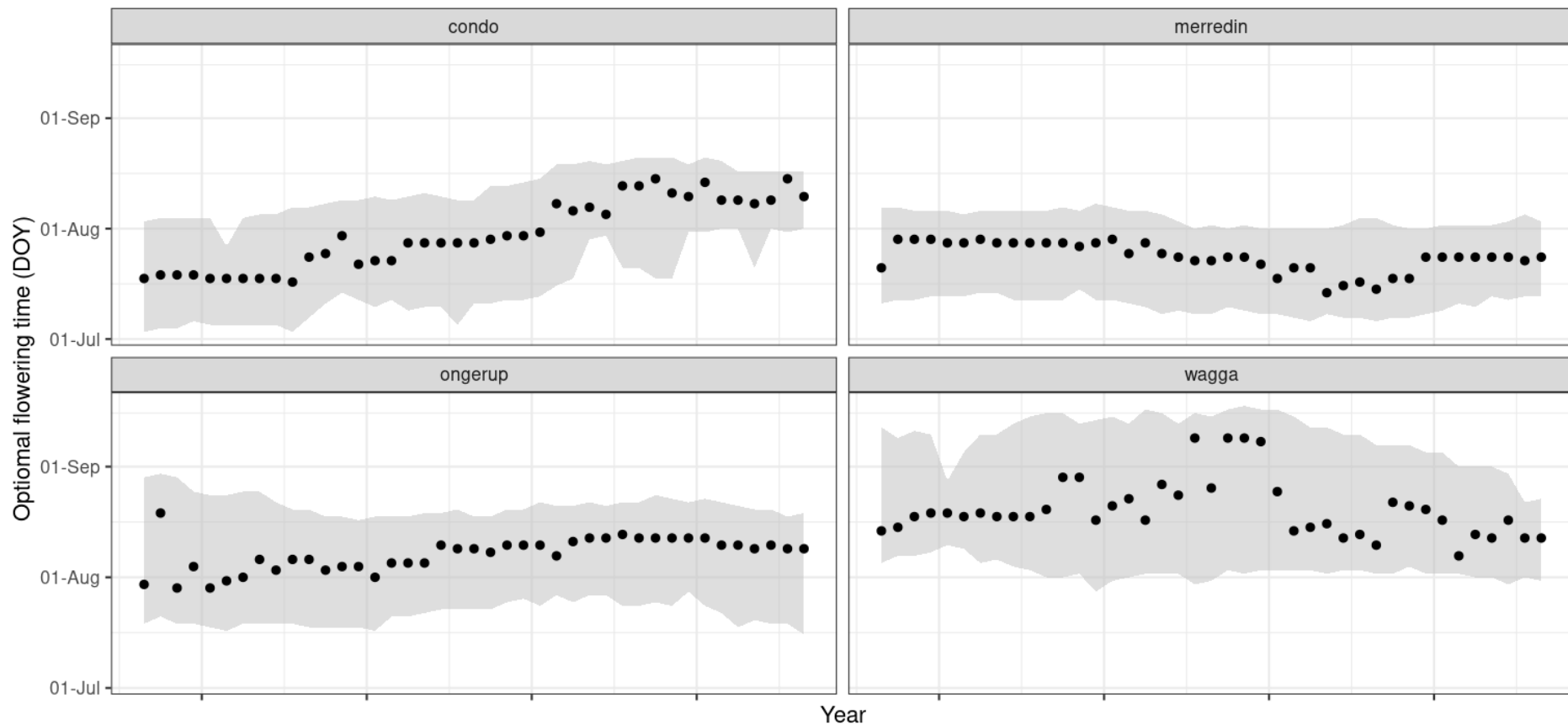


Adaptive cultivars can achieve >95% potential yield of all cultivars

Less adaptive cultivars in QLD, north NSW, north/south WA, TAS

Temporal trends of OFP

- OFP is calculated in 20 years moving windows from 1957 to 2023
- Temporal trends of OFP mid-point and span is calculated as linear regression
- Significance is tested with time-series auto-correlation (Santer et al. 2000)

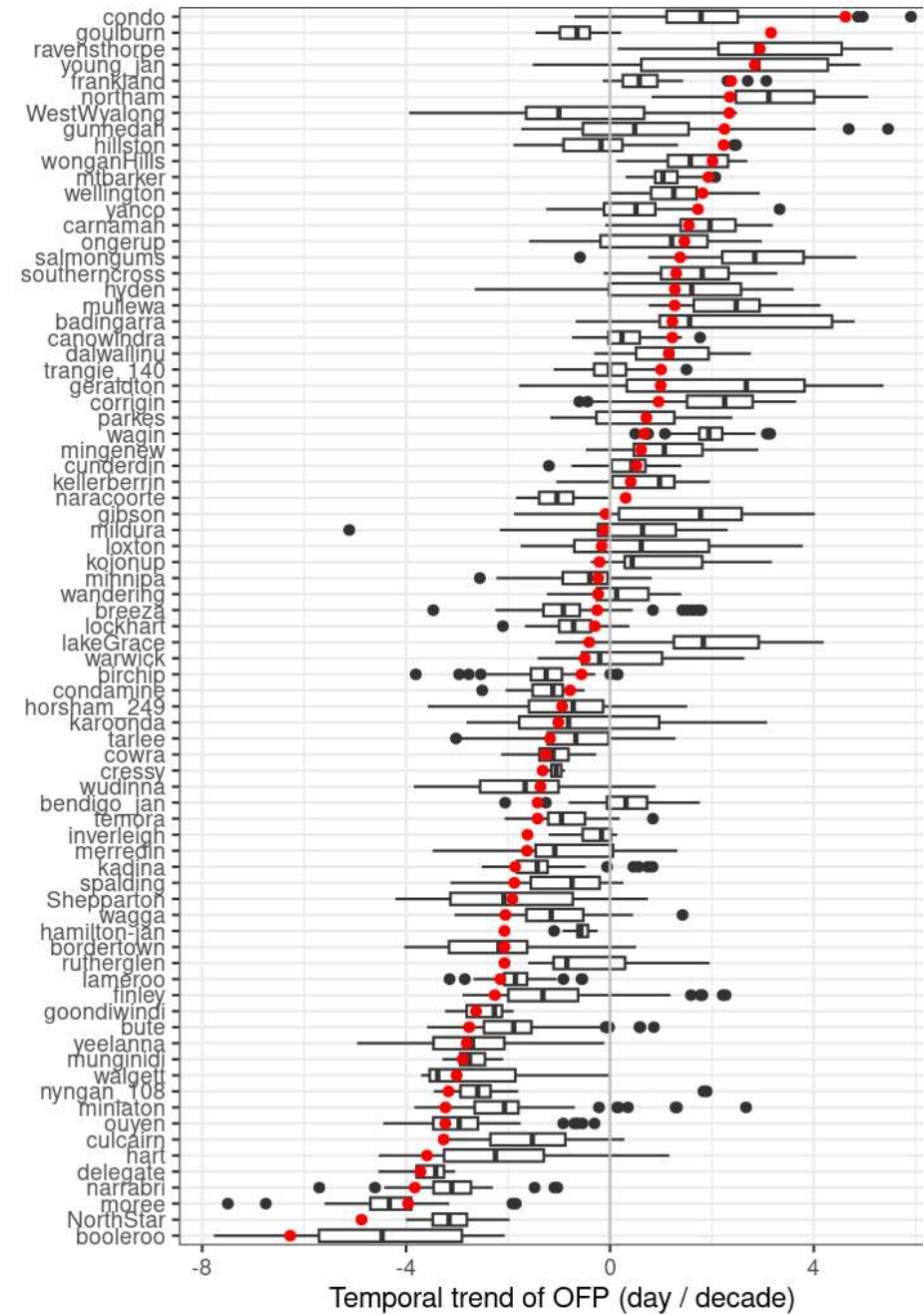
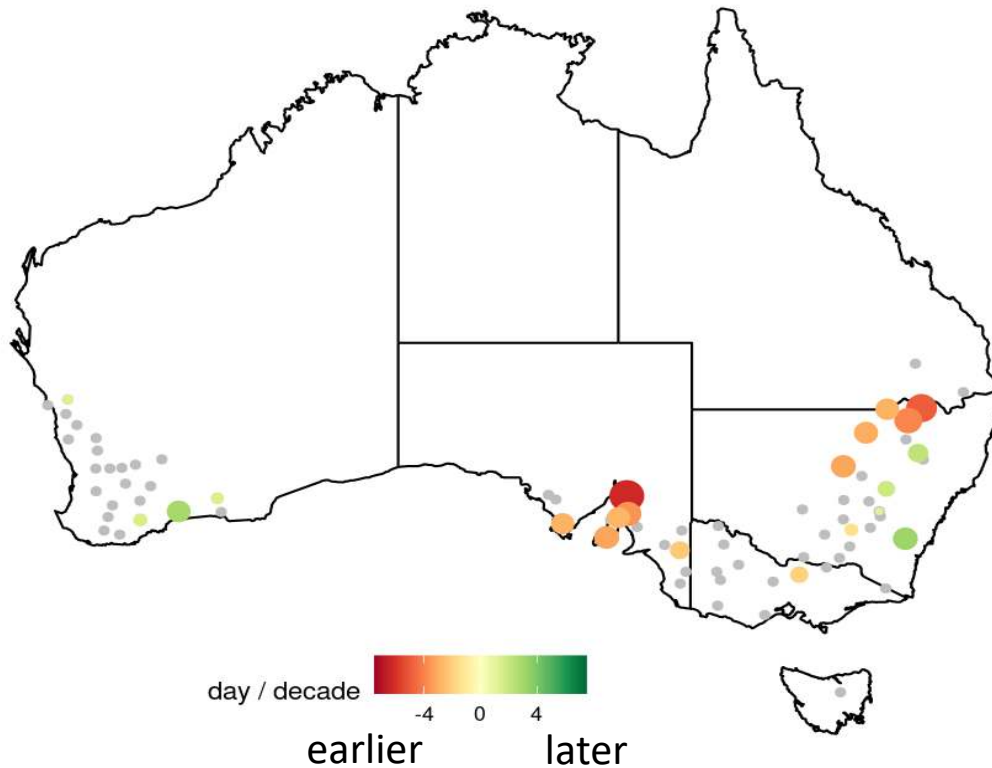


Black symbols for OFP mid-point / Gray ribbon for OFP span

Temporal trends of OFP

OFP Midpoint

- Earlier in north NSW and SA
- Later in the south NSW and WA
- Genotypic variations of temporal trends

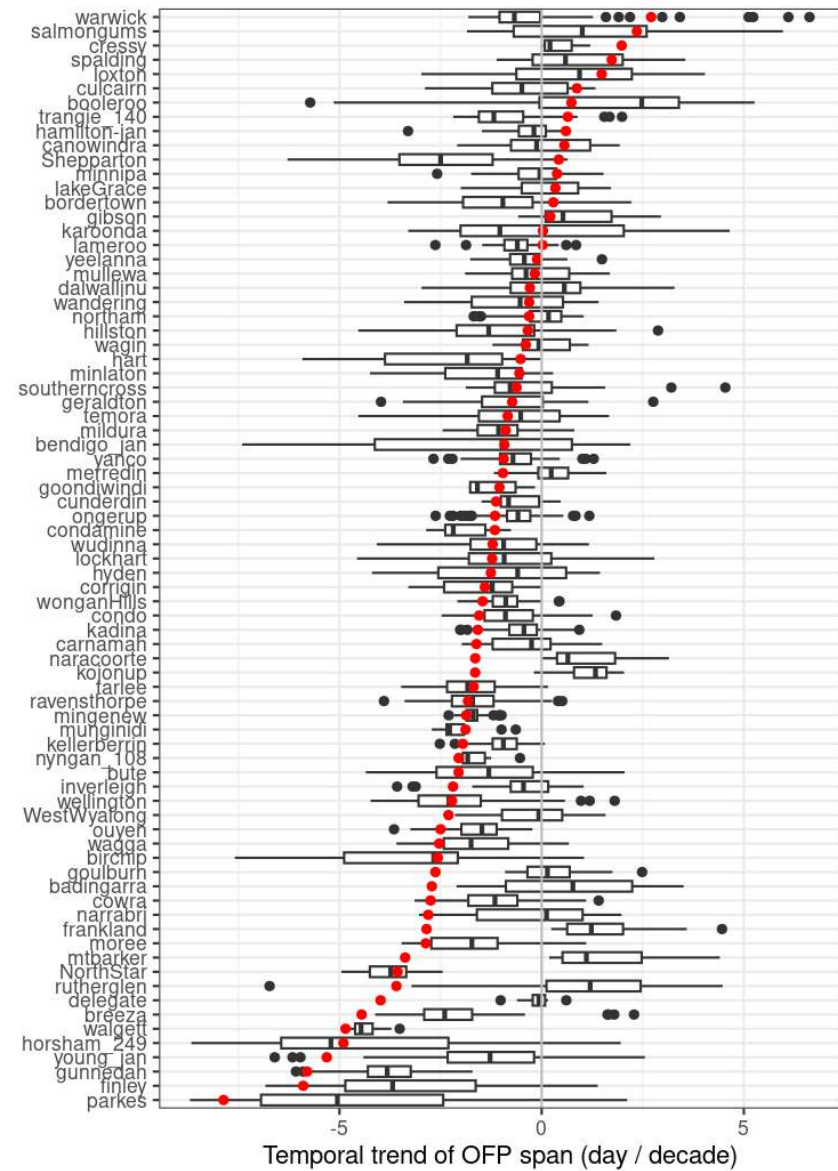
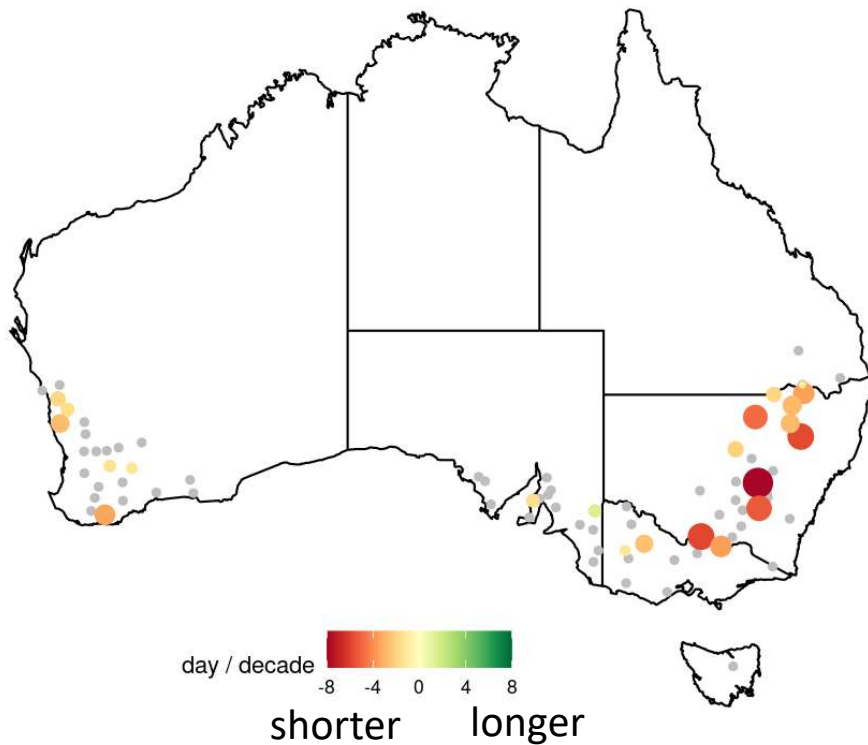


Gray points for non-significant trends

Temporal trends of OFP

OFP Span

- Shorter span in the east
- Only slightly longer in a few sites
- Genotypic variation on trends of OFP Span



Gray points for non-significant trends

Take home message and future works

- OFP varied by cultivars (phenology) and environments, but can be treated as site specific attribute to maximise potential yield
- Climate change has significantly impacted on OFP for some sites. Recent climate should be used in the future works
- Calculate OFP for new cultivars in NVT for canola, wheat and barley

Acknowledgements

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Thank you

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