



Optimising genetic gain in canola breeding – the model comes to life

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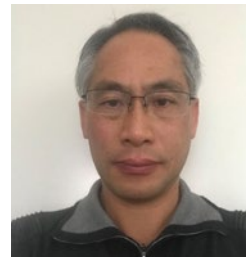
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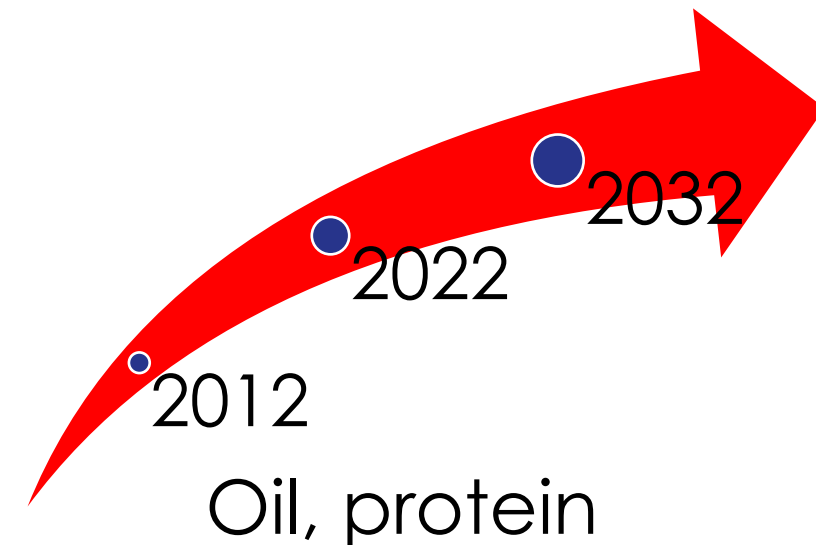
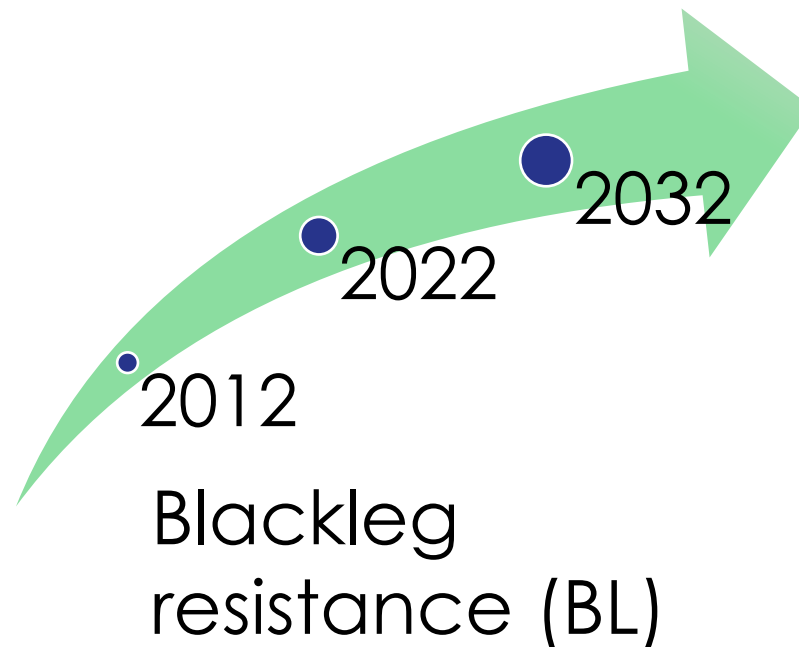
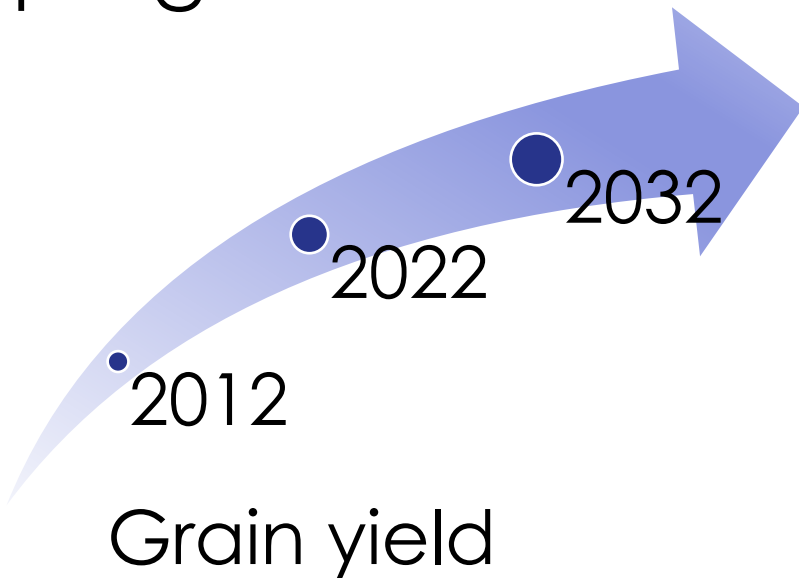


Dr Olaf Sass
NPZ Germany



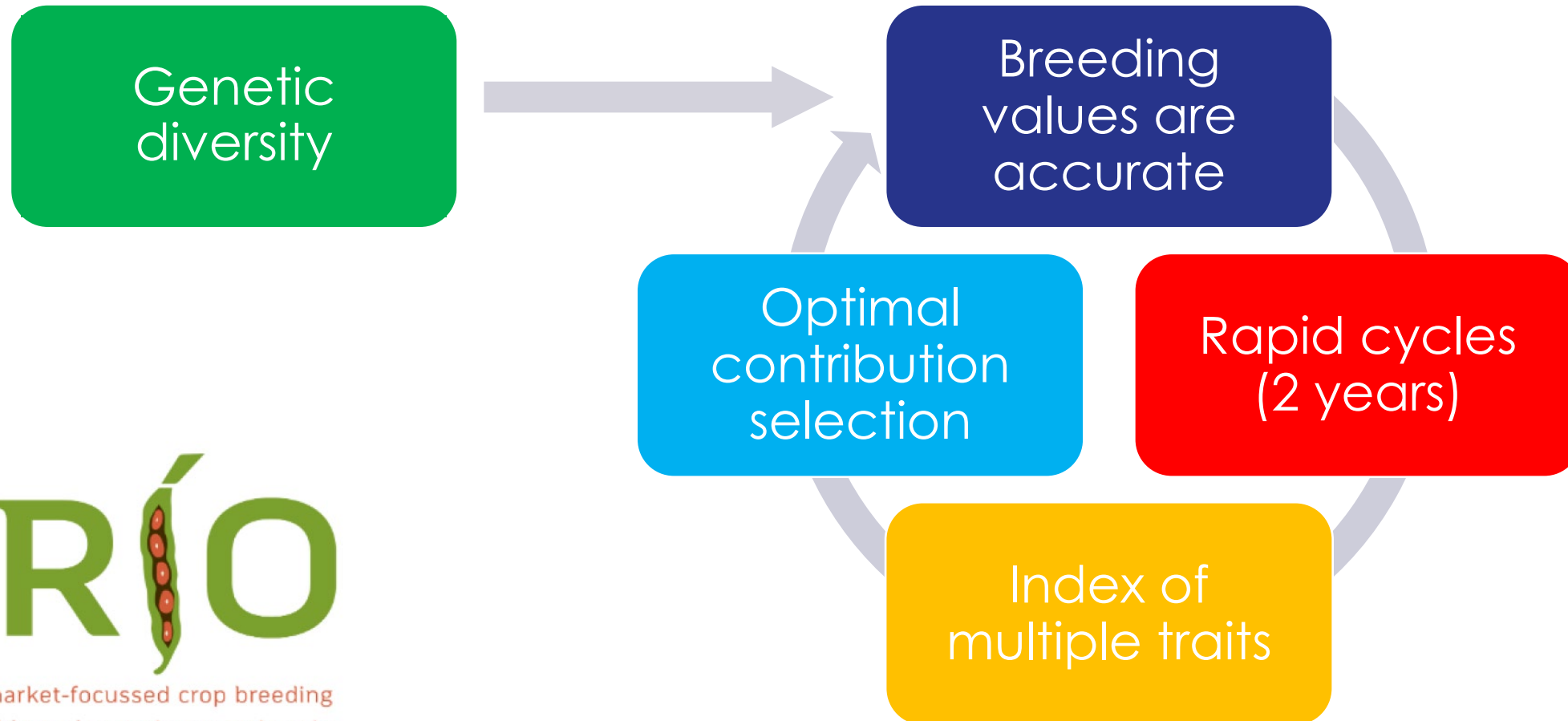
Our goal

...is to optimise long-term genetic gain for important quantitative traits inside a global spring canola breeding program



Our method

...begins with genetic diversity and follows four principles:



BRIO

Rapid and market-focussed crop breeding
for sustainable and superior genetic gain

Modeling BRÍO in a selfing crop

The BRÍO method was modelled over 30 cycles of rapid recurrent selection for 5 medium-to-low heritability traits:

Trait	Narrow-sense heritability	Starting value \pm standard deviation
Grain yield (t ha^{-1})	0.3	1.5 ± 0.25
Disease resistance (%)	0.3	100 ± 20
Stem strength (mm)	0.3	1.2 ± 0.3
Flowering time (days)	0.5	80 ± 20
Heat tolerance (units)	0.3	30 ± 1

Model output – grain yield (t/ha)

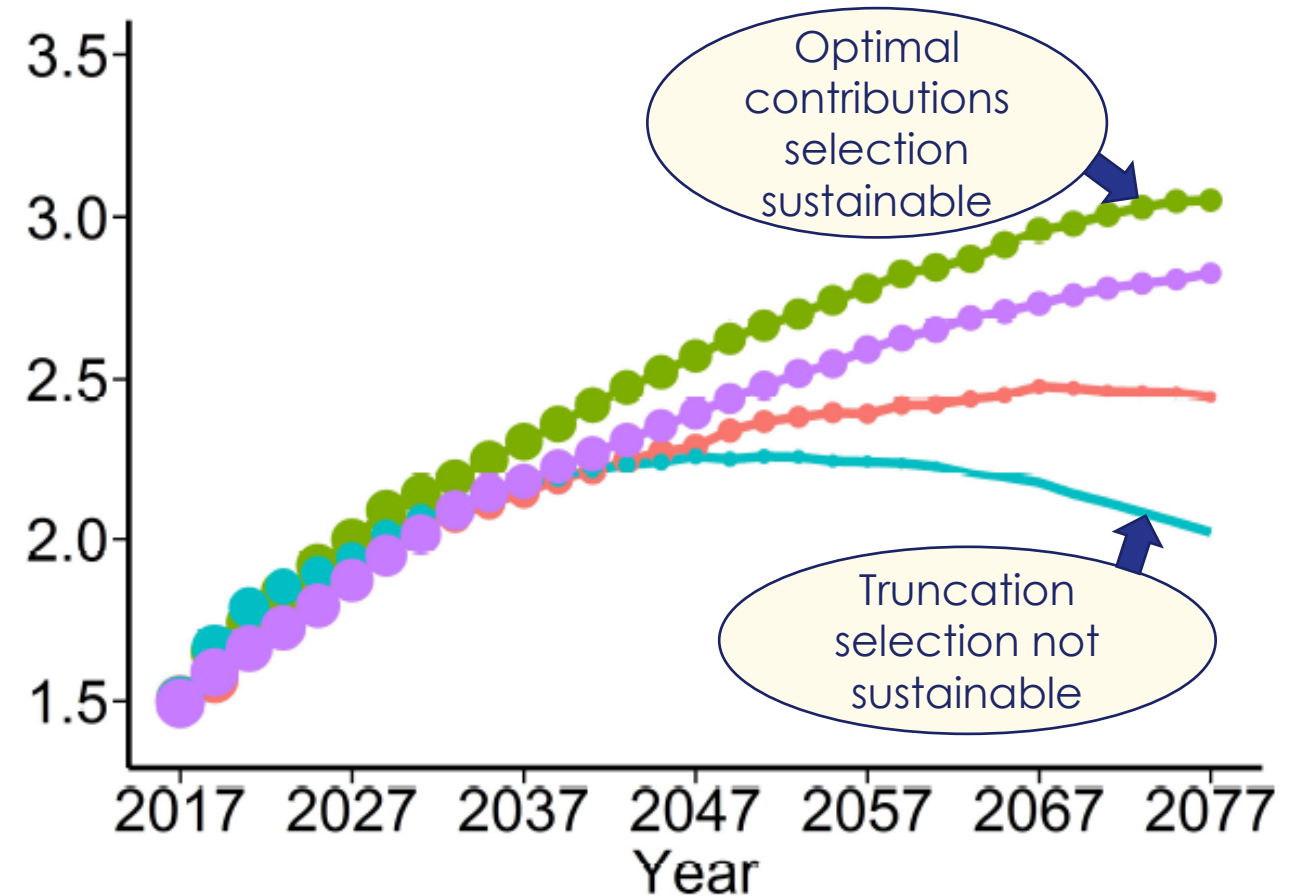
Two year cycles

Optimised crossing designs
generated by OCS

Sustainable genetic gain in
GY over 60 years

First 20 years:

GY = 47 kg ha⁻¹y⁻¹ (3.1% y⁻¹)



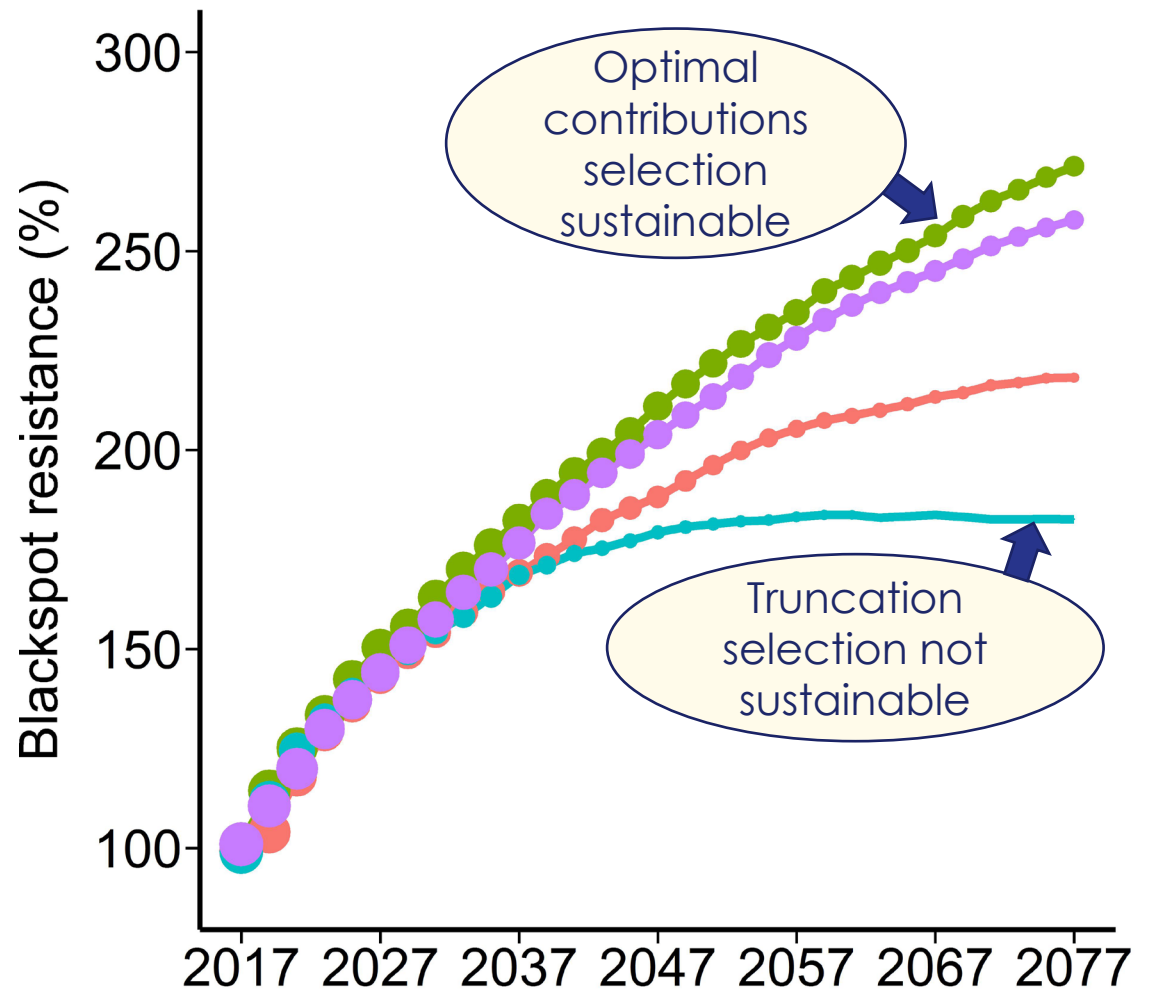
Model output – disease resistance (%)

In addition to GY,
genetic gain also in
disease resistance and
three other traits over
60 years

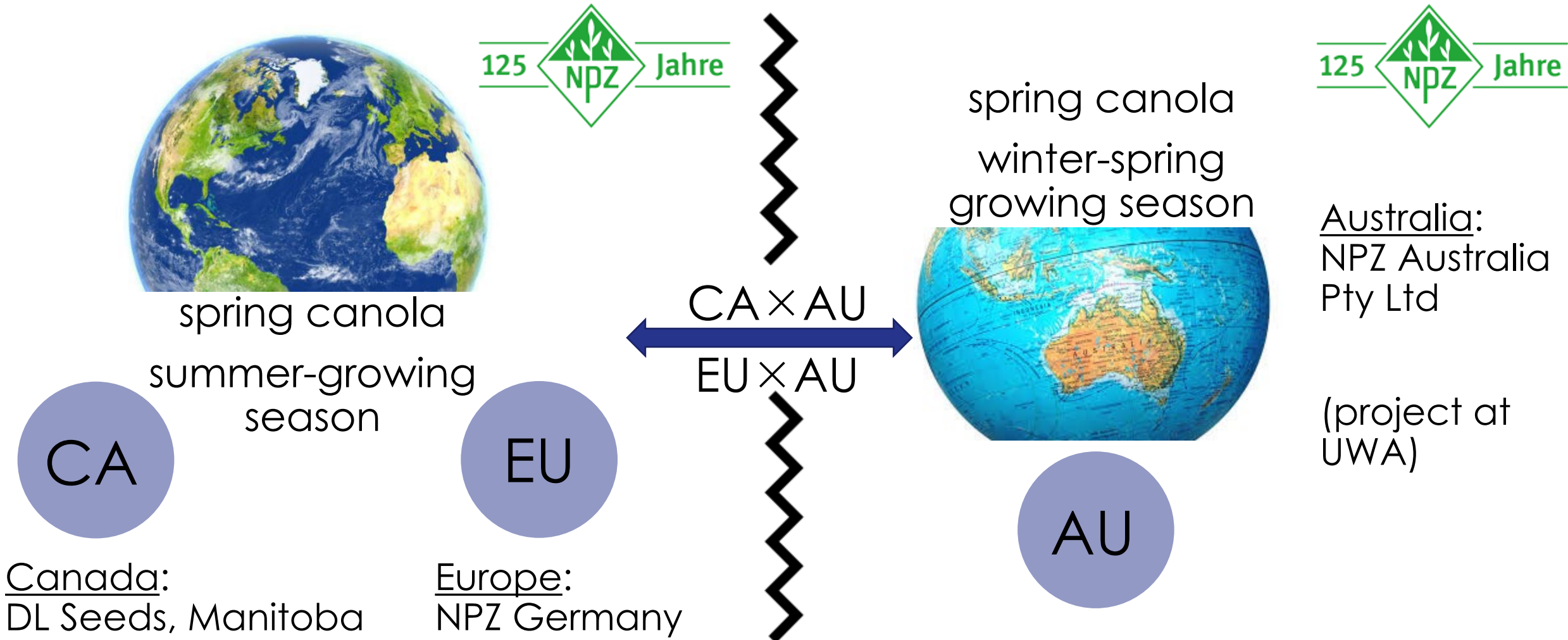
- truncation selection is
not sustainable



Rapid and market-focussed crop breeding
for sustainable and superior genetic gain

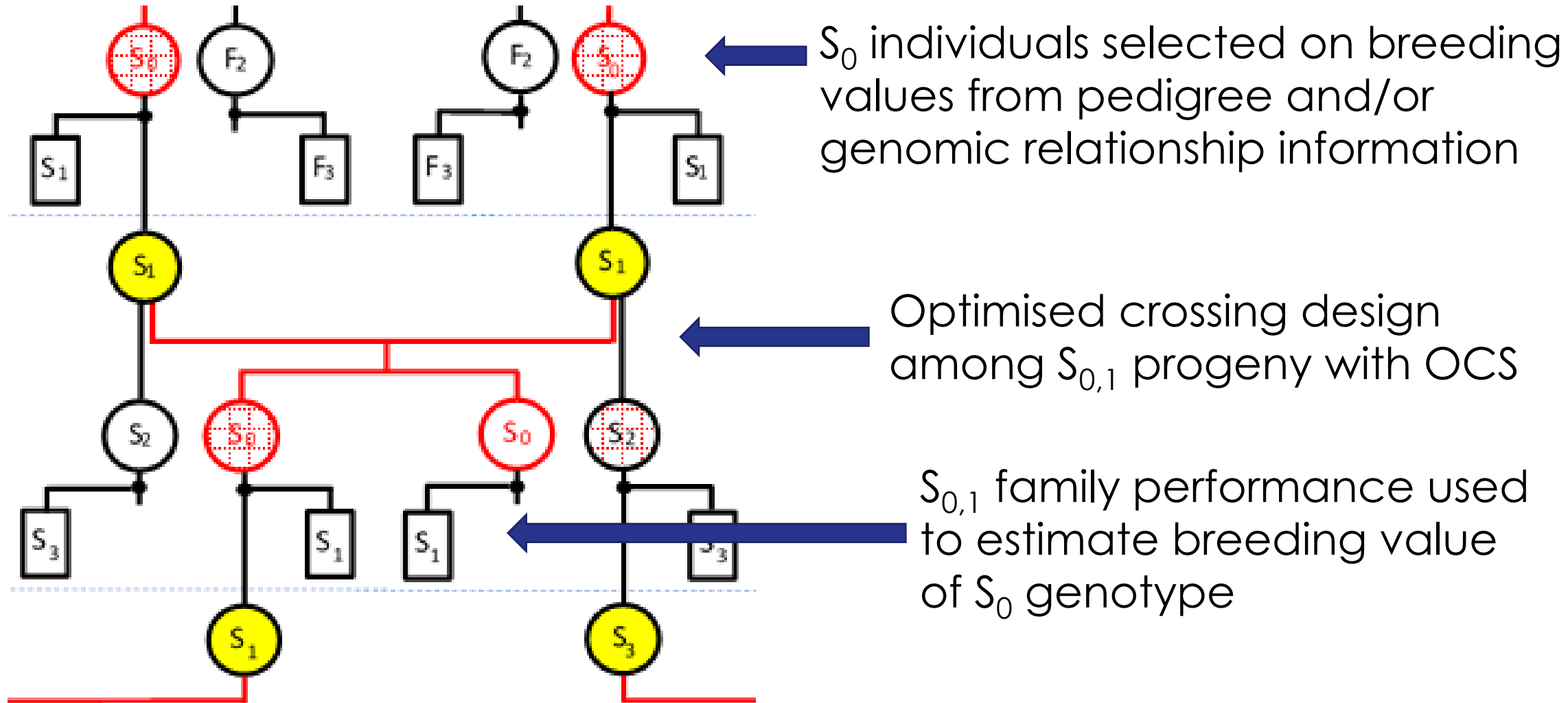


Testing the model in a global spring canola breeding program: intercrossing elite lines



Rapid cycles with $S_{0,1}$ family selection

(Walsh and Lynch 2018)



Phenotyping in Canada and Australia



Canada



Australia

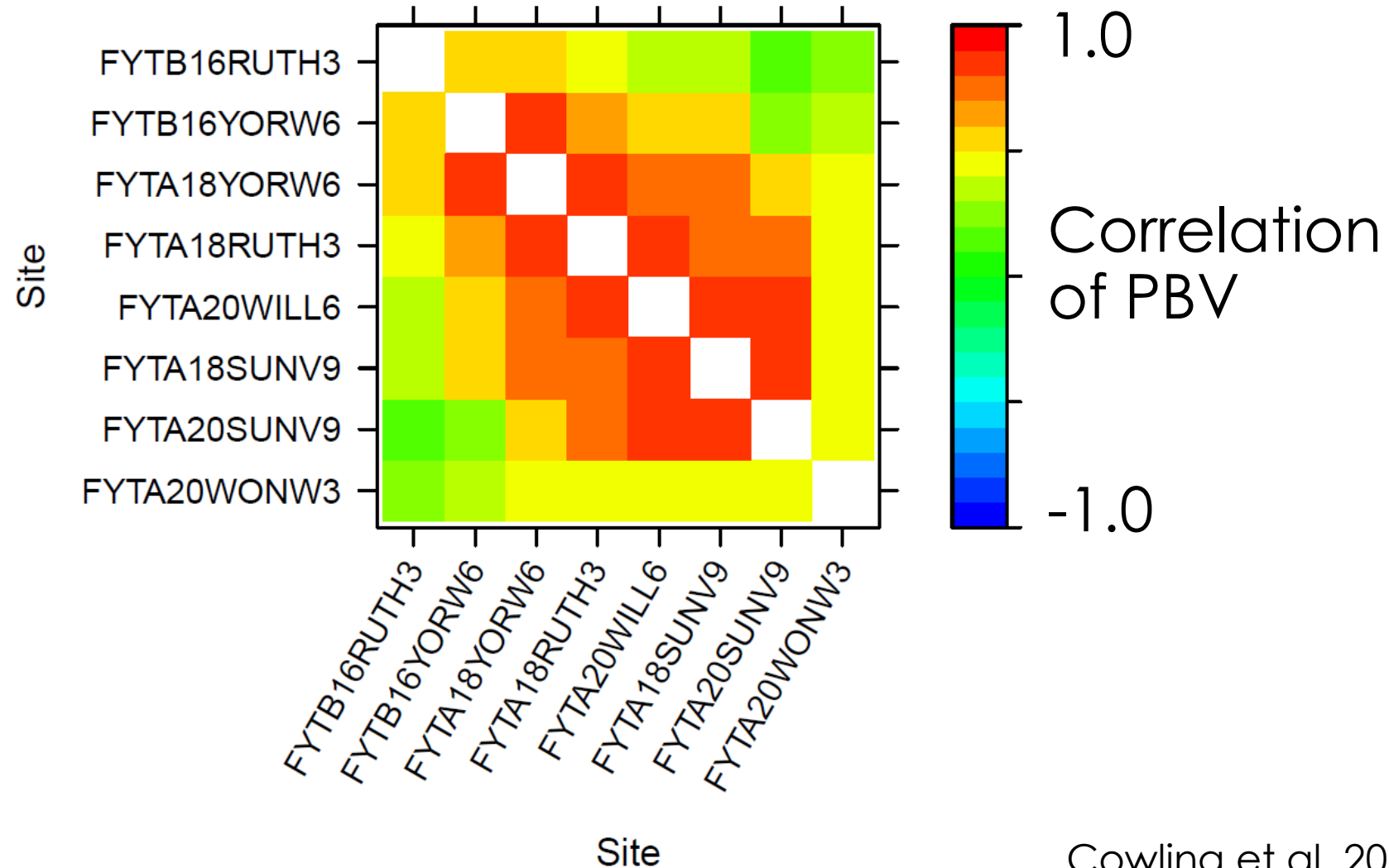
Moderate to high narrow-sense heritability of traits in AU and CA



Trait	Narrow-sense heritability across sites in AU and CA in 2016, 2018, 2020
Grain yield (t ha ⁻¹)	0.40 (range 0.02 – 0.62)
Days to 50% flower	0.73 (range 0.60 – 0.87)
Plant height (cm)	0.52 (range 0.36 – 0.74)
Seed oil (%)	0.53 (range 0.33 – 0.65)
Protein in meal (%)	0.56 (range 0.35 – 0.74)
Glucosinolates (μmol g ⁻¹)	0.61 (range 0.18 – 0.76)
Oleic acid (%)	0.83 (range 0.65 – 0.94)
Blackleg (Phoma) resistance	0.44 (range 0.14 – 0.60)
Seed size (100 seed weight, g)	0.66 (range 0.43 – 0.77)

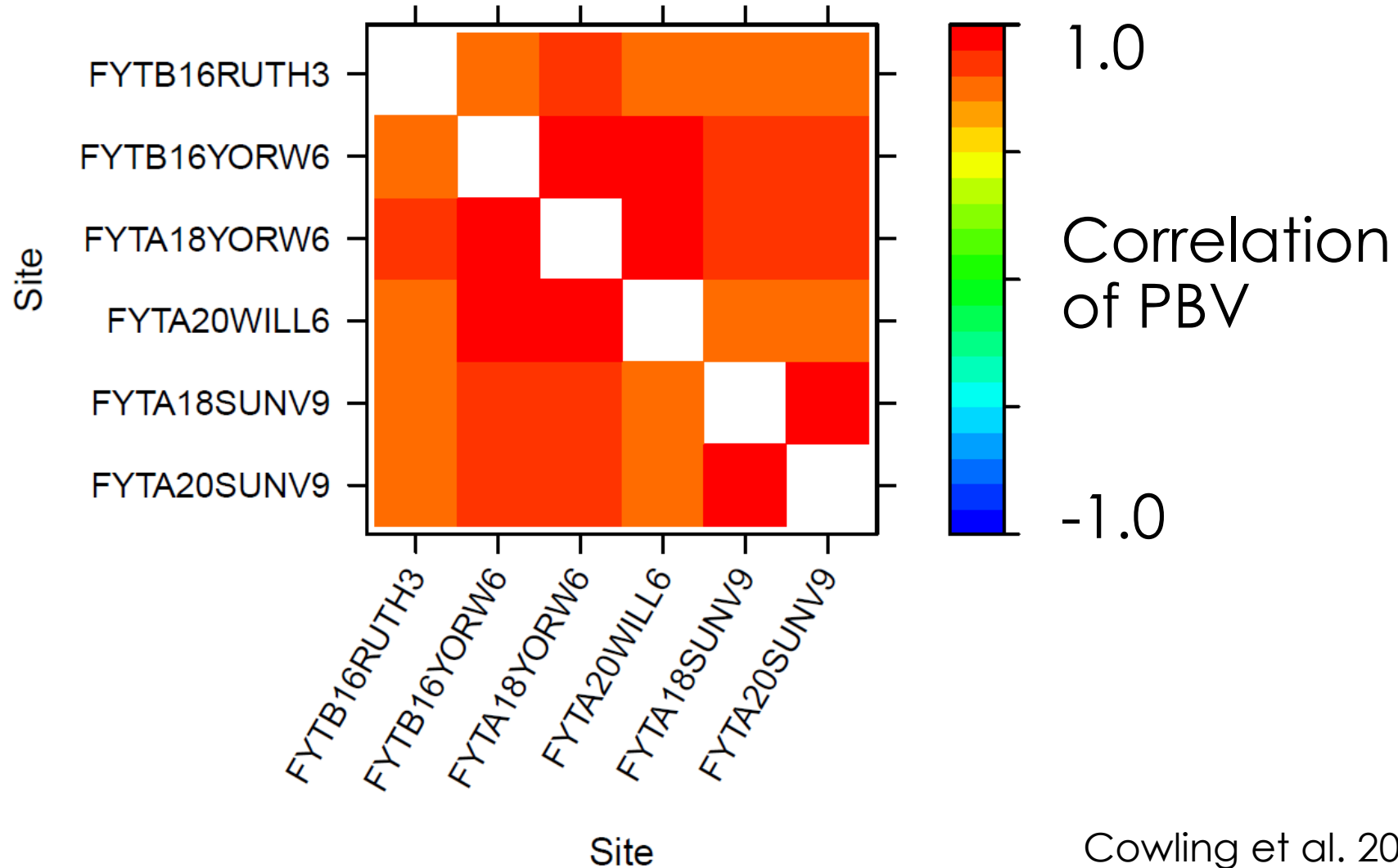
Factor analysis: grain yield

– high genetic correlations of PBV for GY across countries and cycles 2016-2018-2020



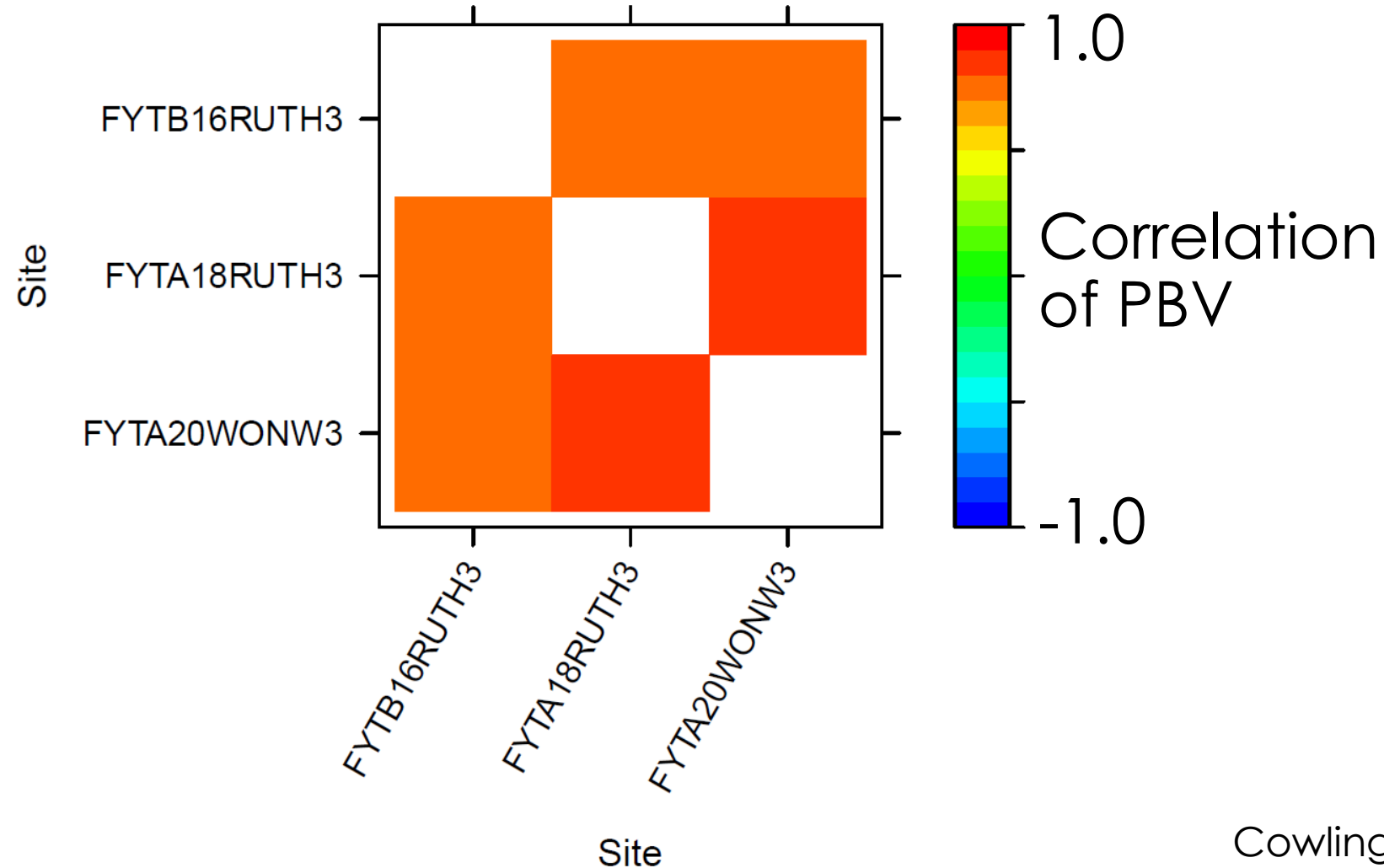
Factor analysis: seed oil%

– very high genetic correlations across countries/cycles

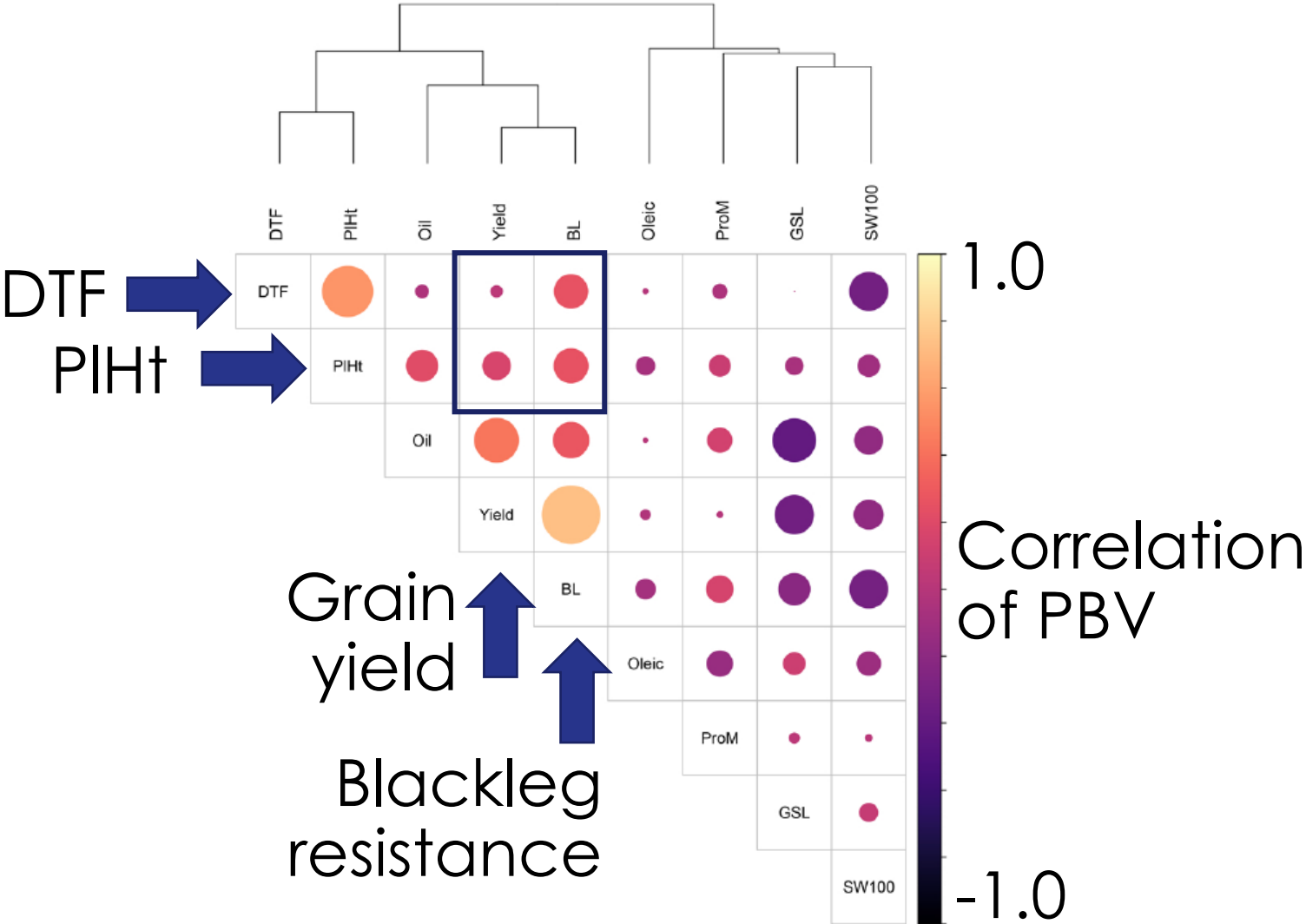


Factor analysis: blackleg resistance

– high genetic correlations across cycles 2016-18-20



Genetic correlations of PBV across traits



Late flowering (DTF) and tall height (PIHt) correlated with high grain yield and high blackleg resistance

⇒ resistant types tend to be taller and later flowering ☹️

⇒ use high negative weights on DTF/PIHt

Selection index composed of multiple traits

- with economic weights to achieve desired gains



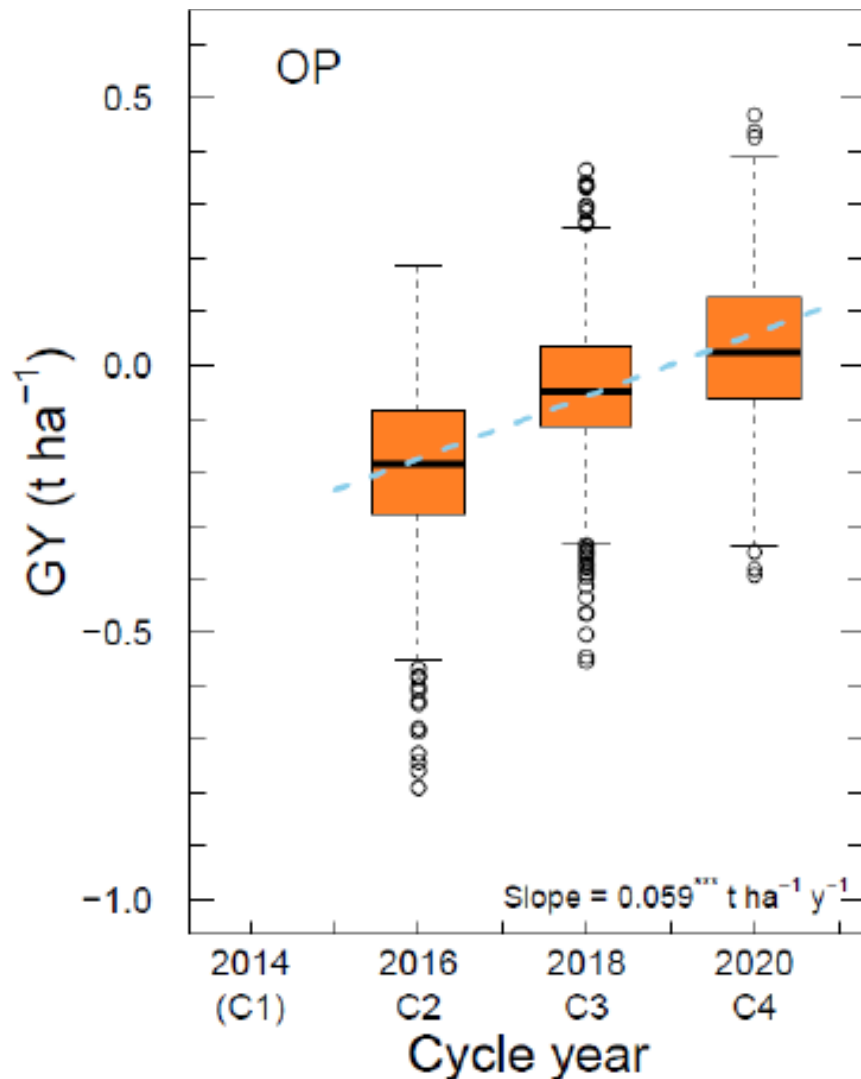
$$\begin{aligned} \text{Index (\$/ha)} &= \text{PBV grain yield (t/ha)} \times 750 \text{ \$/ha} \\ &+ \text{PBV seed oil (\%)} \times \text{economic weight} \\ &+ \text{PBV protein in meal (\%)} \times \text{economic weight} \\ &+ \text{PBV blackleg resistance} \times \text{economic weight} \\ &- \text{PBV plant height (cm)} \times \text{economic weight} \end{aligned}$$

Economic weights informed by market prices and desired gains

e.g. negative weight to reduce plant height and flowering time

Genetic gain in grain yield

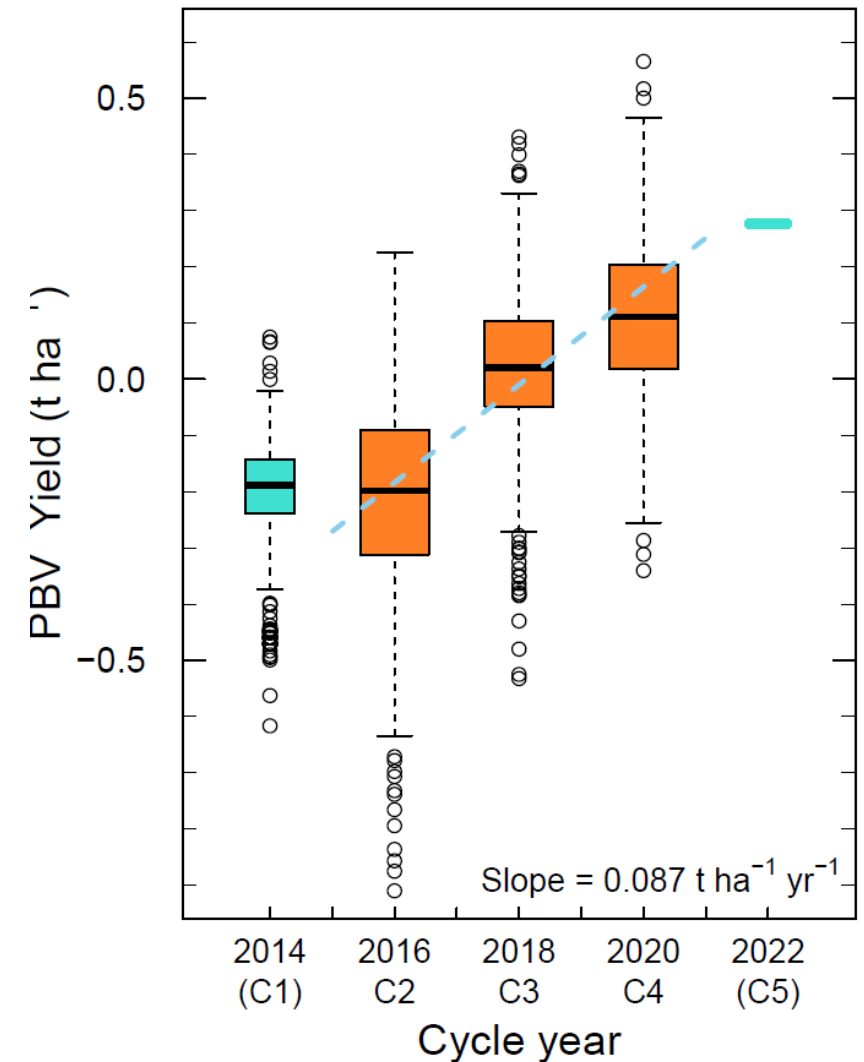
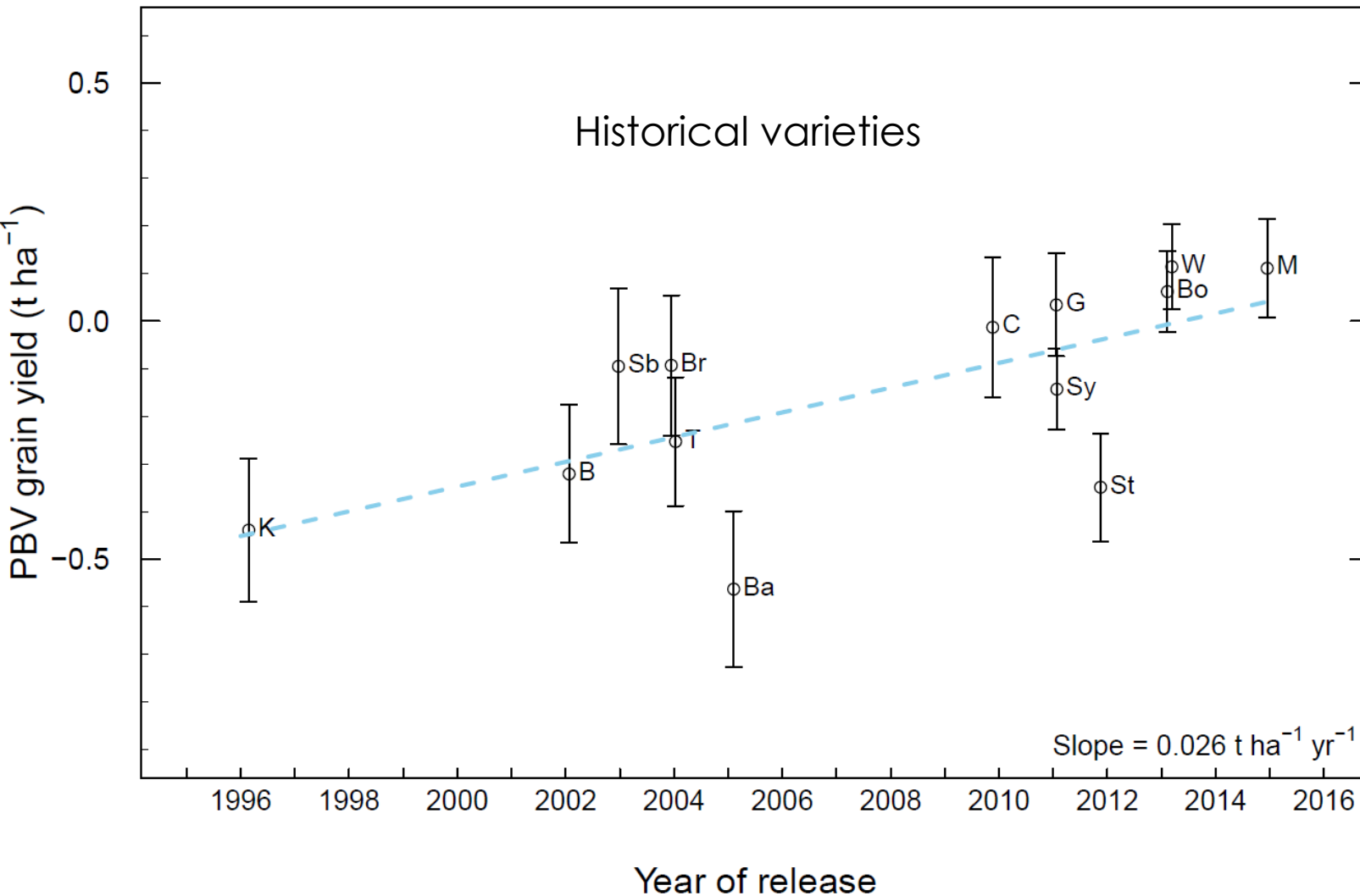
- 'Overall Performance' increases 2016-2018-2020



- slope 59 kg ha⁻¹ yr⁻¹ = 2.9% yr⁻¹
= 3 times world average for crops!!
- slope predicted to continue to cycle 5
- low achieved parental co-ancestry in cycle 4 parents = 0.088

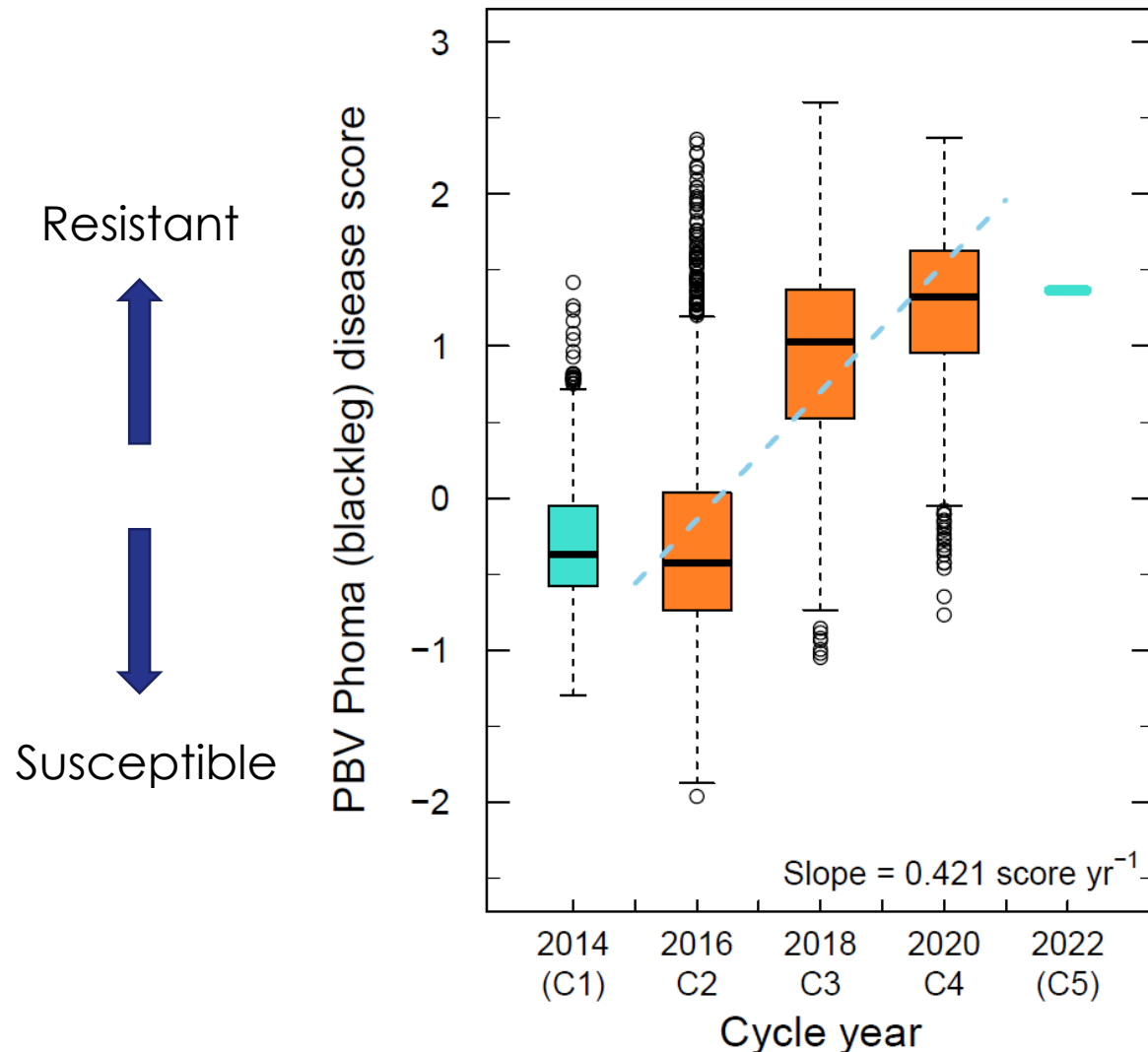
Genetic gain in grain yield compared with historical varieties

Cowling et al. 2023 *Plants* 12:383



Genetic gain in blackleg resistance

- significant upward slope in PBV over cycles



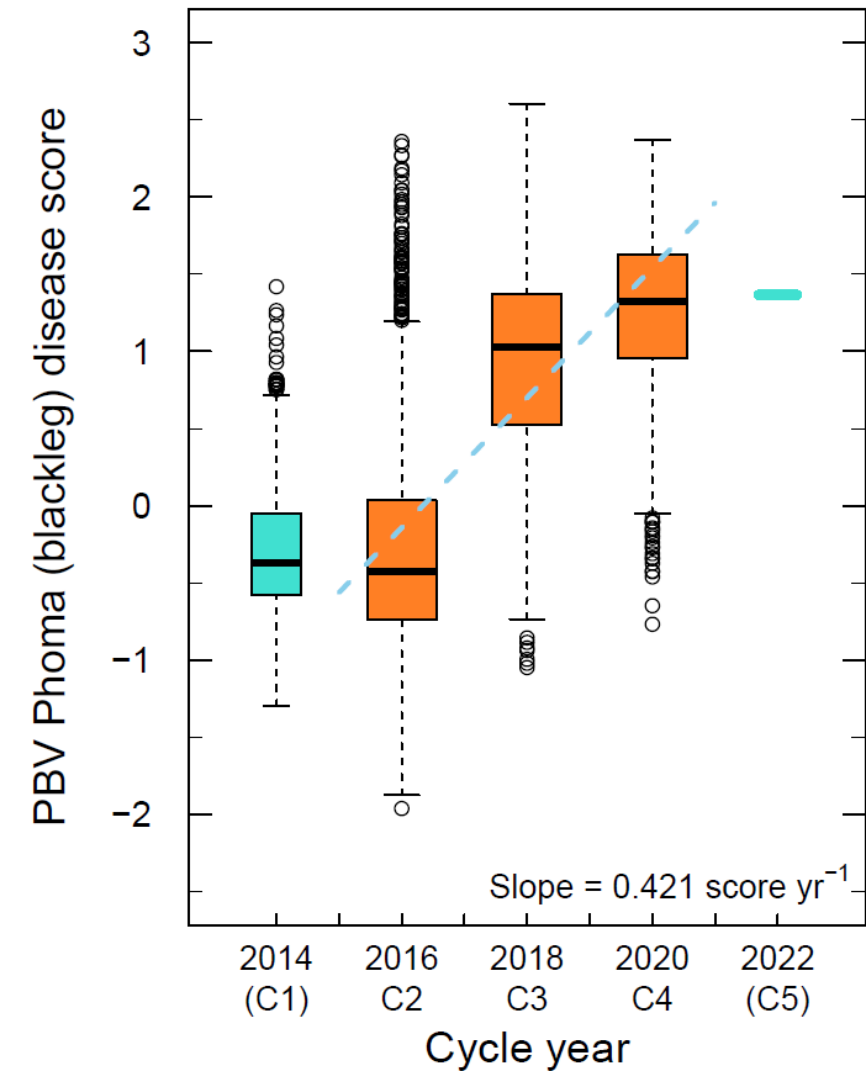
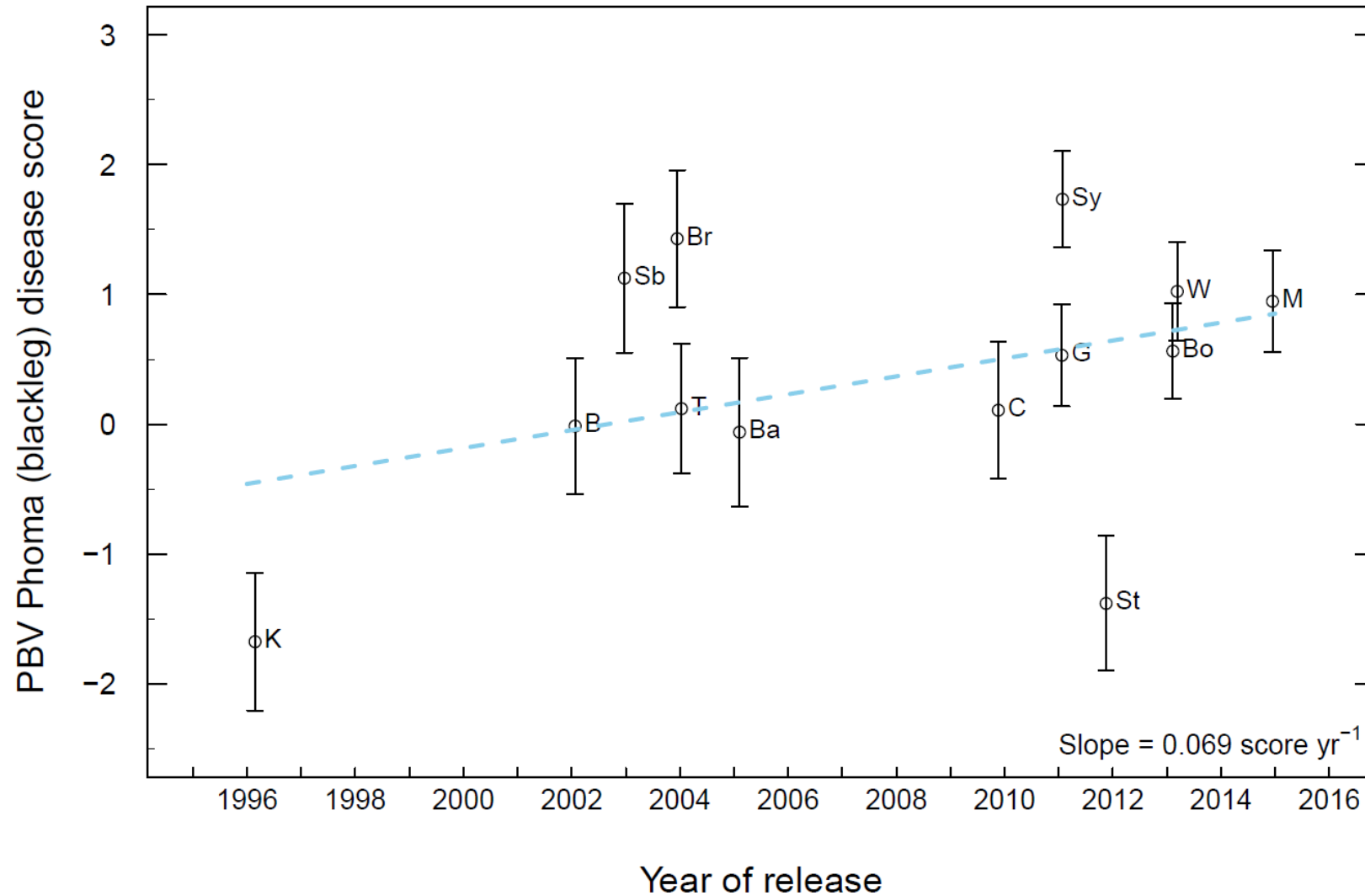
High genetic gain in PBV Phoma (blackleg) score per year:

slope 0.42 disease score units yr⁻¹
(=8.3% yr⁻¹)

Scale = 1 (VS) to 9 (VR), and
population mean = 5.1

Genetic gain in blackleg resistance

Cowling et al. 2023 *Plants* 12:383

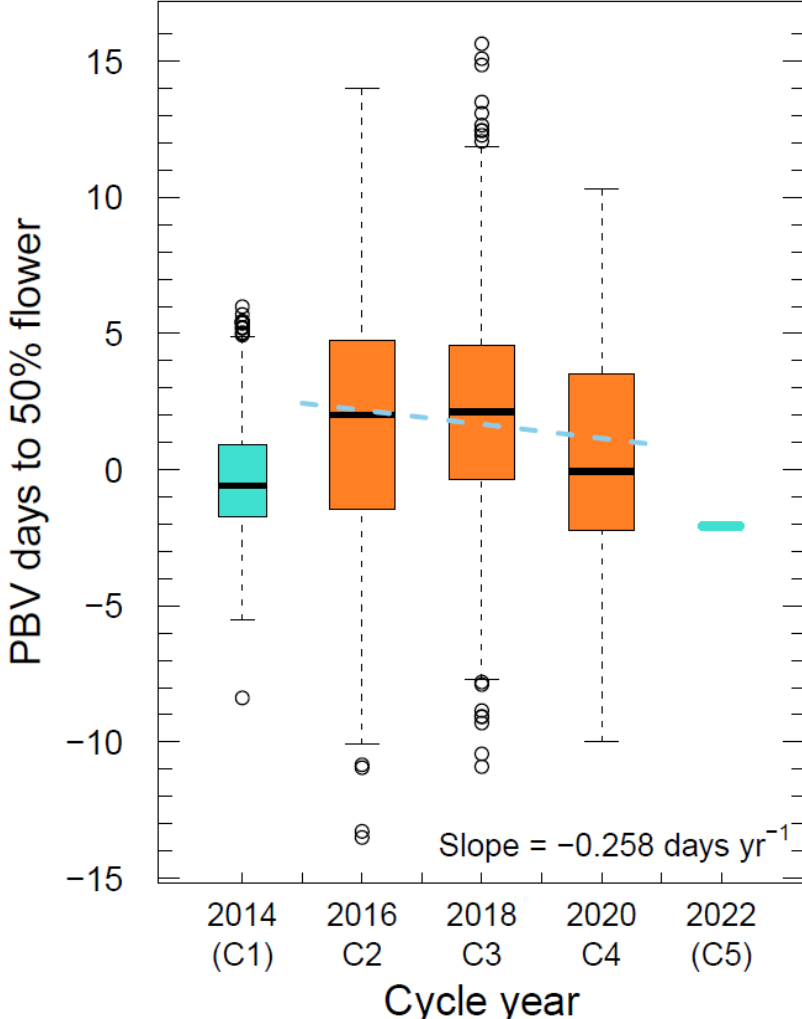
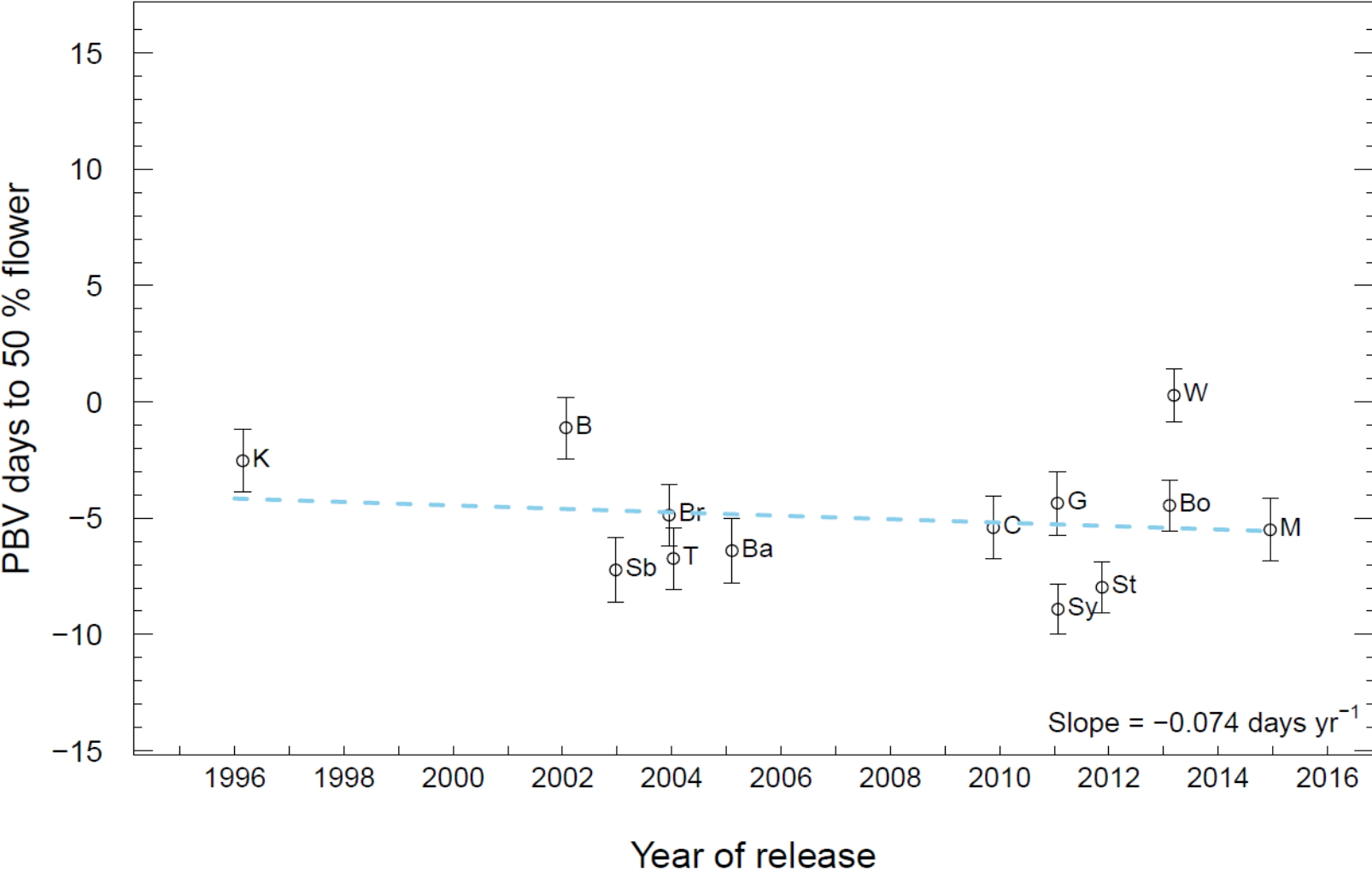


Select against late flowering

- increase weighting against late flowering in index



Cowling et al. 2023 *Plants* 12:383

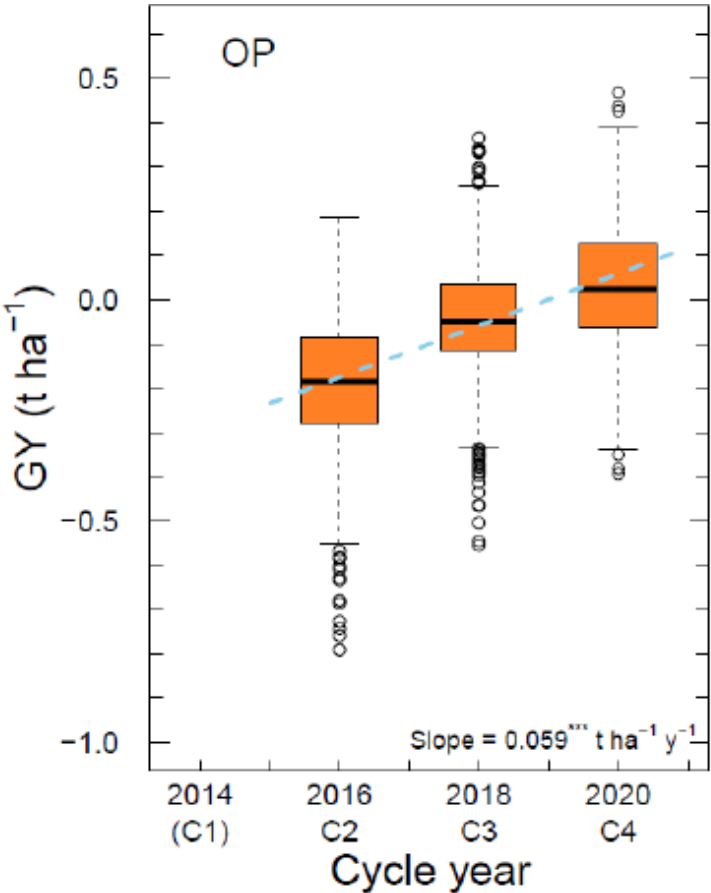
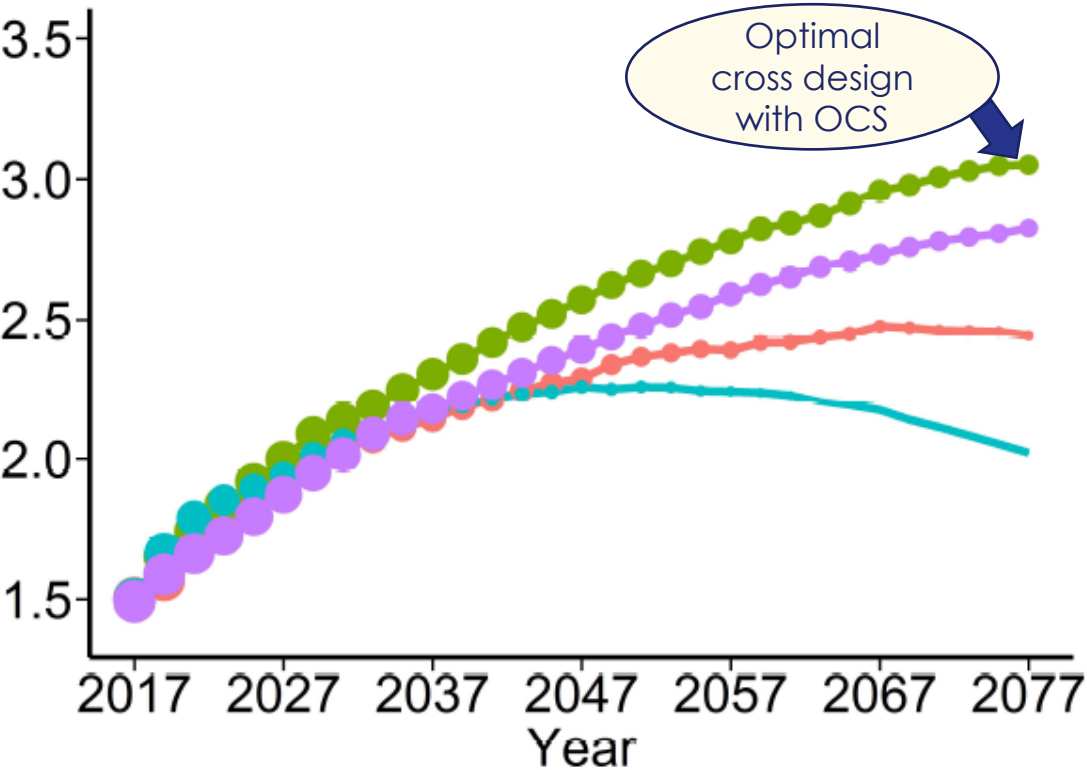


Benefits of the BRÍO model confirmed in a global spring canola program....



Model: grain yield ($t\ ha^{-1}$) 2017 - 2037
 = **47 $kg\ ha^{-1}y^{-1}$ ($3.1\% y^{-1}$)** with OCS

Reality: grain yield ($t\ ha^{-1}$) 2016 - 2020
 = **59 $kg\ ha^{-1}y^{-1}$ ($2.9\% y^{-1}$)** with OCS



Rapid and market-focussed crop breeding for sustainable and superior genetic gain

Thank you

This project would not have happened without the funding, foresight and encouragement of NPZ Lembke



Thank you also to DL Seeds who carried out the Canadian work

