Dissecting QTL for water use efficiency in Brassica oleracea

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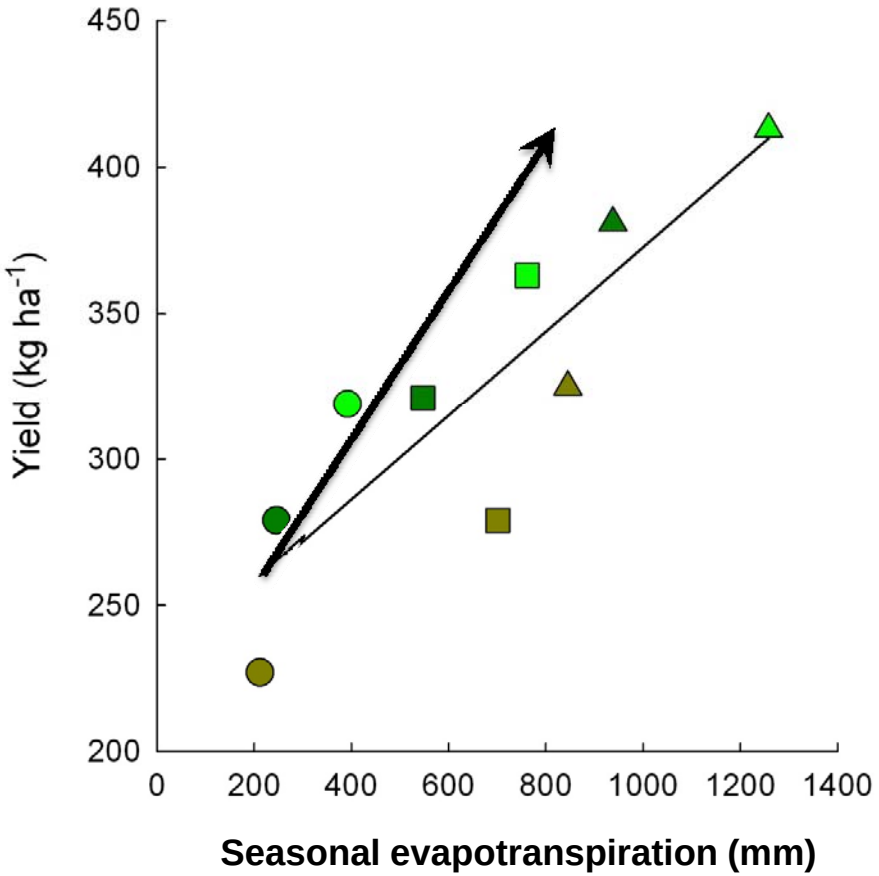
Crop yield is closely related to seasonal water use when water is limiting



Grain yield as a function of seasonal water use, oilseed crops, Eastern India

Yield in water limited environment can be improved by:

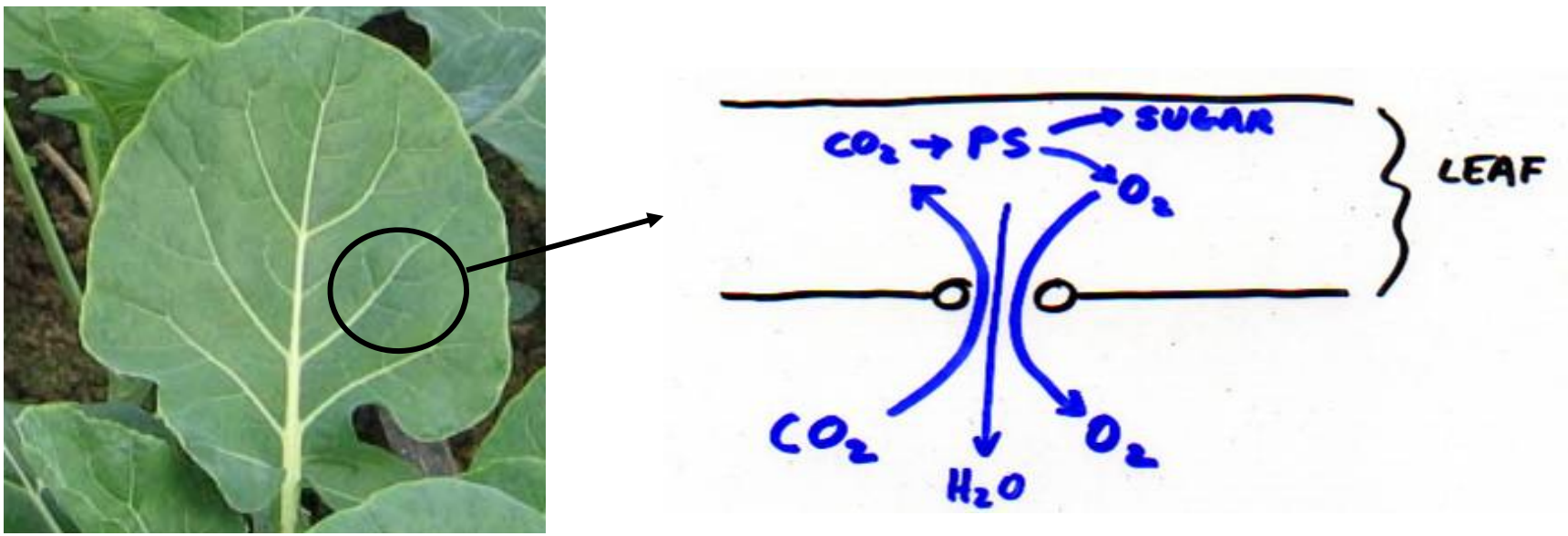
- Increasing the slope of the line - increased water use efficiency (tons per unit volume water)

From: Kar et al 2007 Ag. Wat. Manag. 87:73-82

Water use efficiency (WUE)

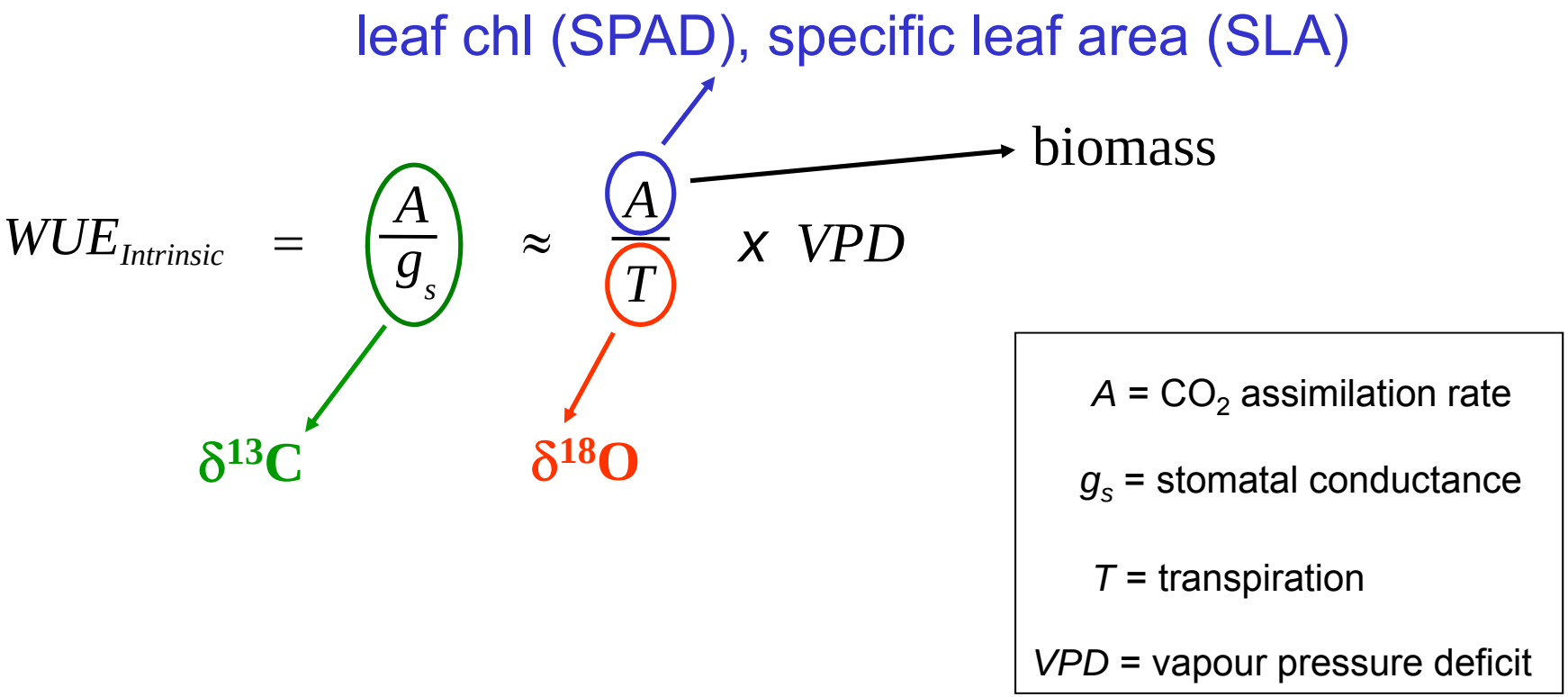
Can be studied at different scales: crop—plant—leaf

- Crop: tons/ha/mm (yield/seasonal evapotranspiration)
- Single pot plant: biomass gain/transpiration (WUE_p)
- Leaf: CO_2 assimilation rate/stomatal conductance = A/g_s
  (intrinsic WUE, measured by IRGA, $\delta^{13}C$)

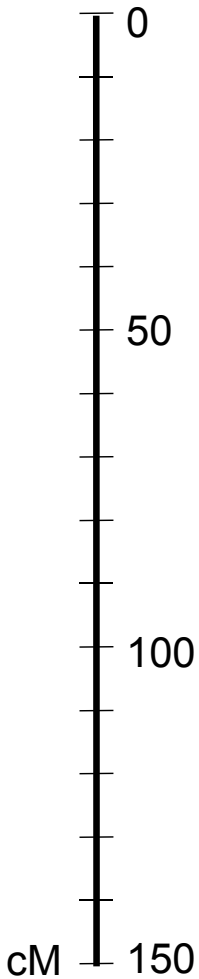


Trait assays to asses both WUE and indicators of yield potential

- WUE is a ratio, selection on this alone could drive g_s down too far, leading to loss of yield (very low g_s will limit A)
- Other trait data is needed to assess components of the ratio

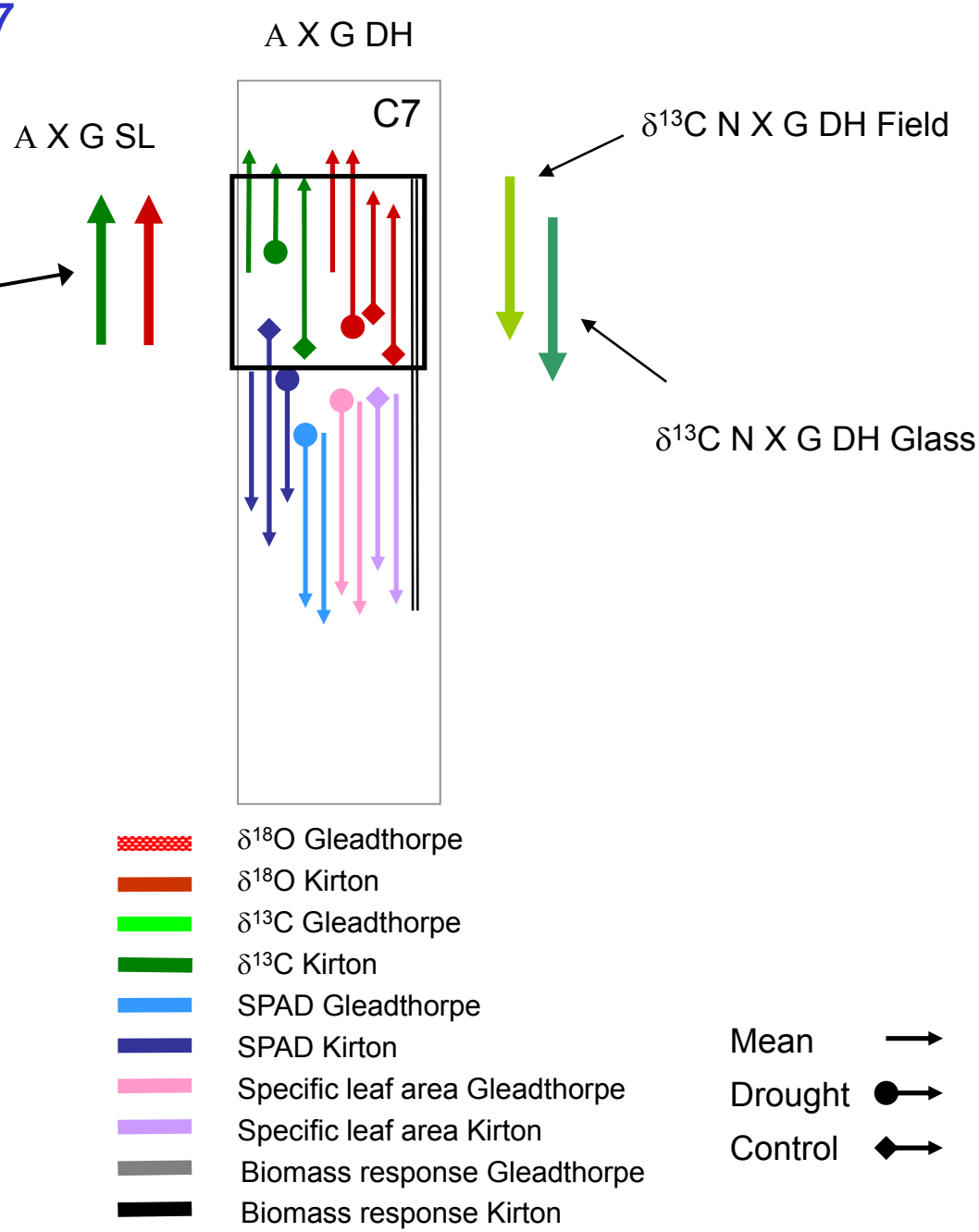


Evidence for WUE QTL on C7

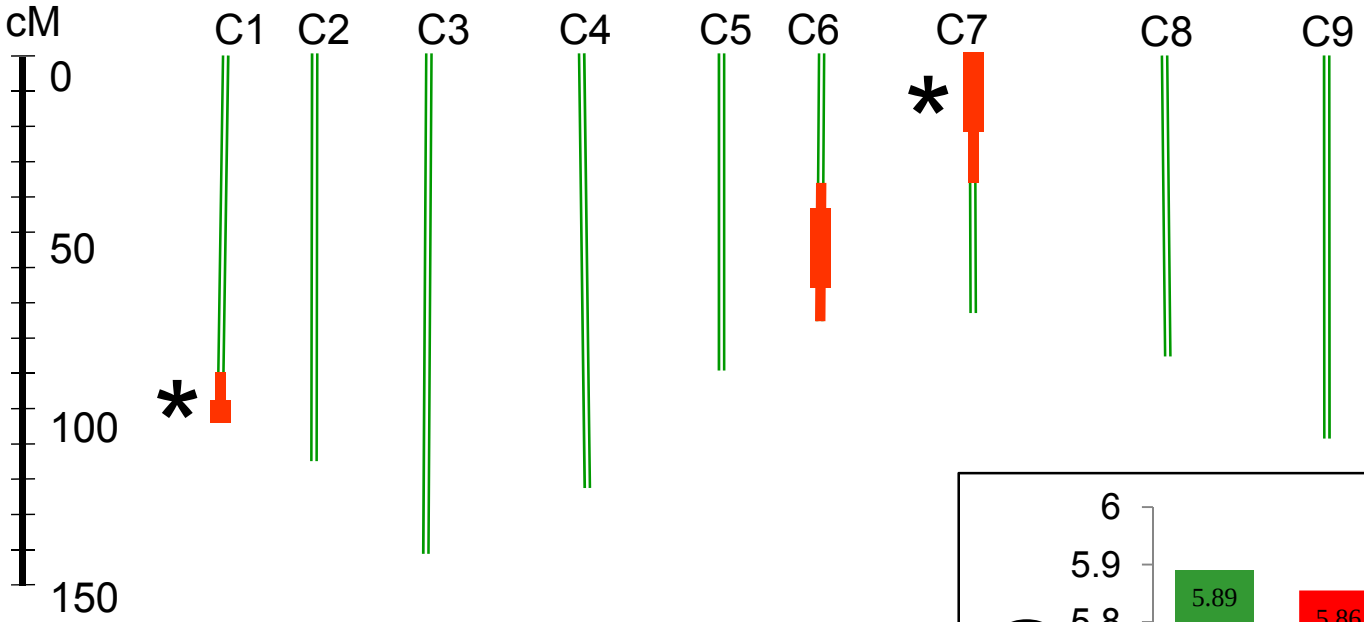


- Evidence for QTL from substitution line SL118 from the same A x G cross

- A12 parent provides:
- high WUE_i
- low transpiration (high $\delta^{18}O$).
- no effect on leaf traits or biomass detected

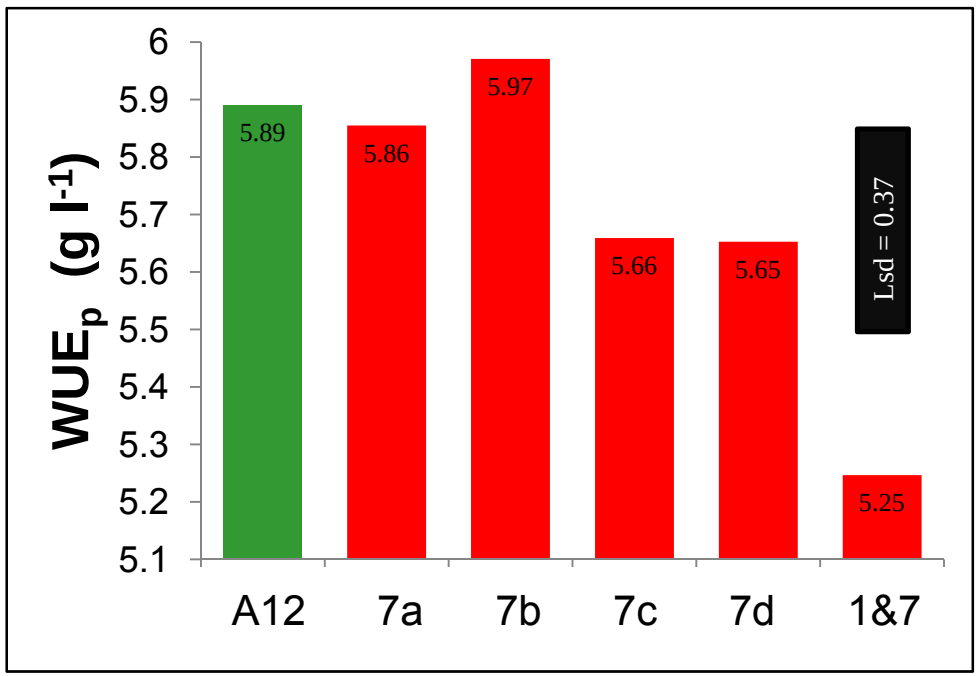


Investigation of top of C7 with substitution line SL118



SL118: introgressions of GD33 DNA (red) in an A12 background (green)

Regions on C1 and C7 epistatic? ⟶



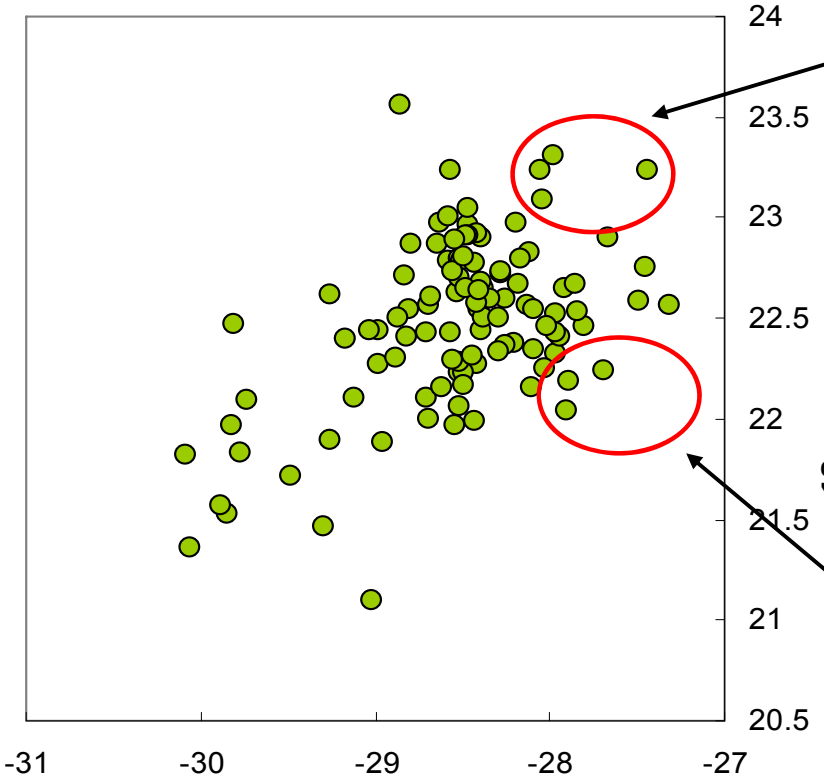
Association mapping in *B. oleracea* diversity sets

Diversity sets grown at Kirton
110 lines, two transplantings, 2 irrigation treatments

Data collected for:

- Biomass response to irrigation
- $\delta^{13}C$
- $\delta^{18}O$
- Indicators of photosynthetic capacity (specific leaf area and SPAD)

WUE and biomass in 110 lines of *B. oleracea* foundation diversity set

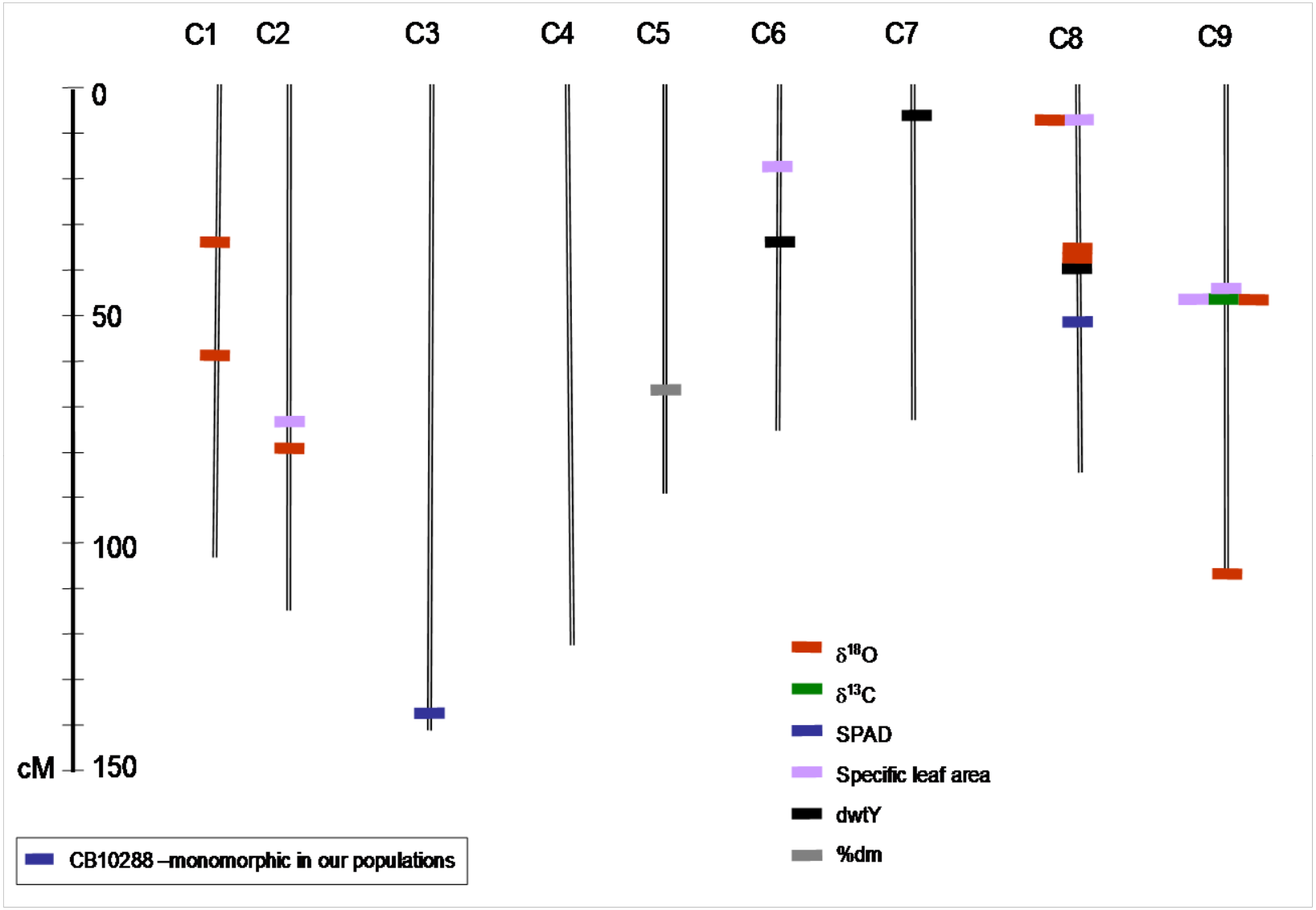


High WUE driven by low stomatal conductance

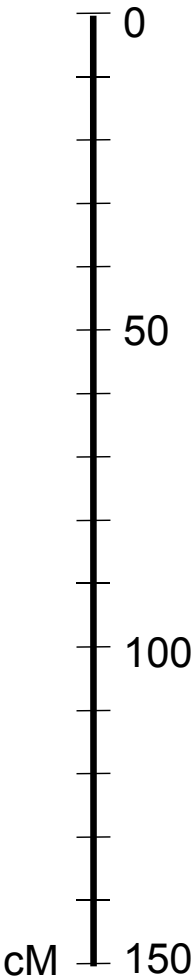
High WUE driven by high rate of photosynthesis

Associated markers – preliminary study

54 markers, 107 lines of diversity set



Comparison of two-parent QTL mapping and allelic association mapping on C9



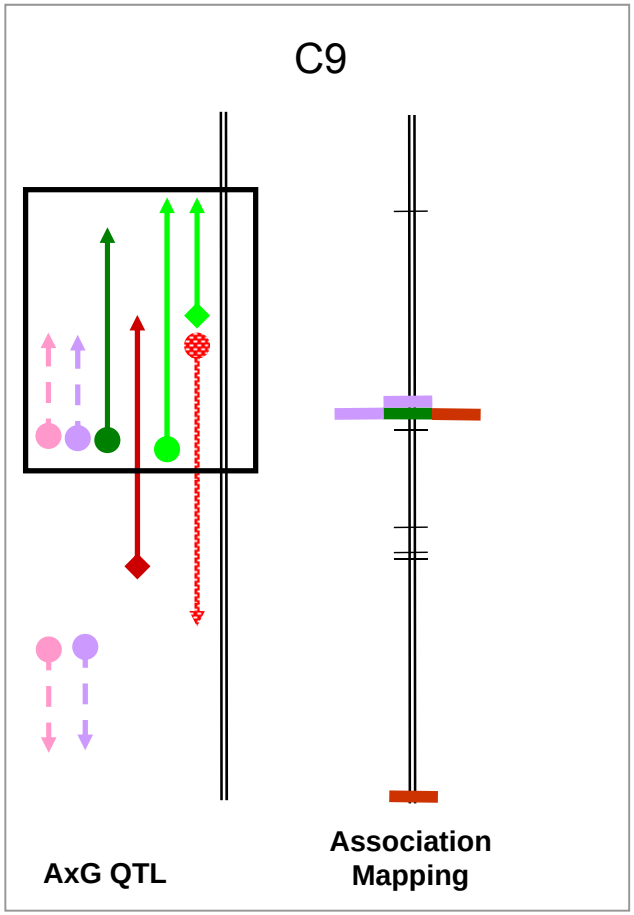
A12 provides:

- High WUE
- High SLA
- Low transpiration (Kirton)

- Allelic association hits correspond to A x G QTL

AxG QTL Key

- $\delta^{18}O$ Gleadthorpe
- $\delta^{18}O$ Kirton
- $\delta^{13}C$ Gleadthorpe
- $\delta^{13}C$ Kirton
- SPAD Gleadthorpe
- SPAD Kirton
- Specific leaf area Gleadthorpe
- Specific leaf area Kirton
- Biomass response Kirton



Drought

Control

2011 *Brassica oleracea* diversity set field trial for association mapping:

2 x phosphorus levels, 4 x reps, 9 plants per plot, 97 x genotypes

Phenotype data: leaf mineral content, biomass, SPAD, specific leaf area, $\delta^{13}C$, $\delta^{18}O$

Genotype data: genome wide SNPs plus targeted markers
(Arabidopsis GWAM/B.o. QTL)

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