Adapting durum wheat to drought and crown rot

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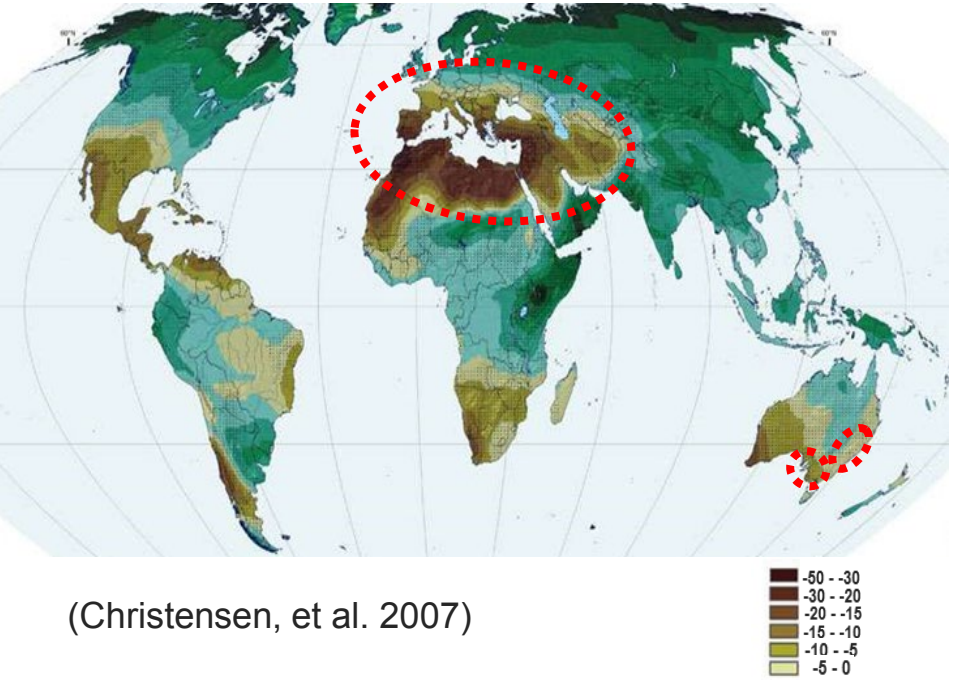
Current and future challenges for durum wheat production

↑ Drought

Future drought hotspots coincide with durum regions



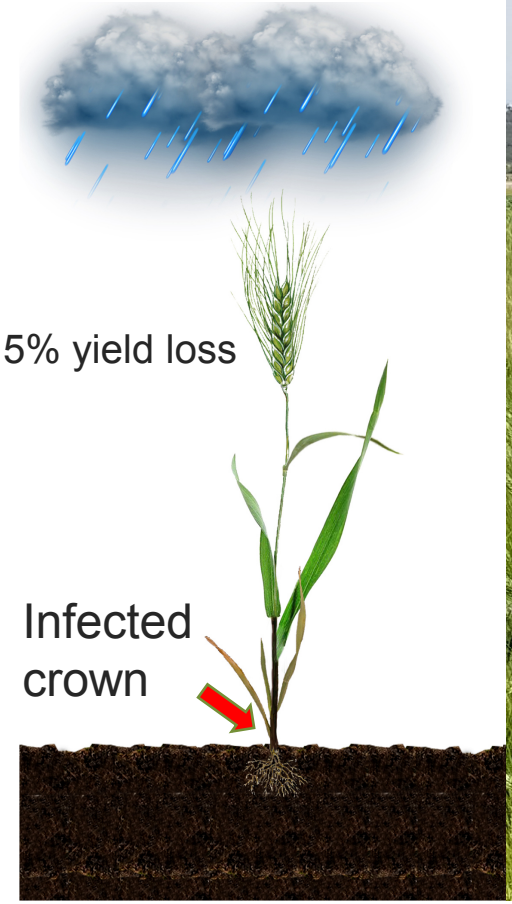
(Christensen, et al. 2007)

↑ Crown rot

Stubble retention

Crown rot caused by *Fusarium* species

How does crown rot cause yield loss?



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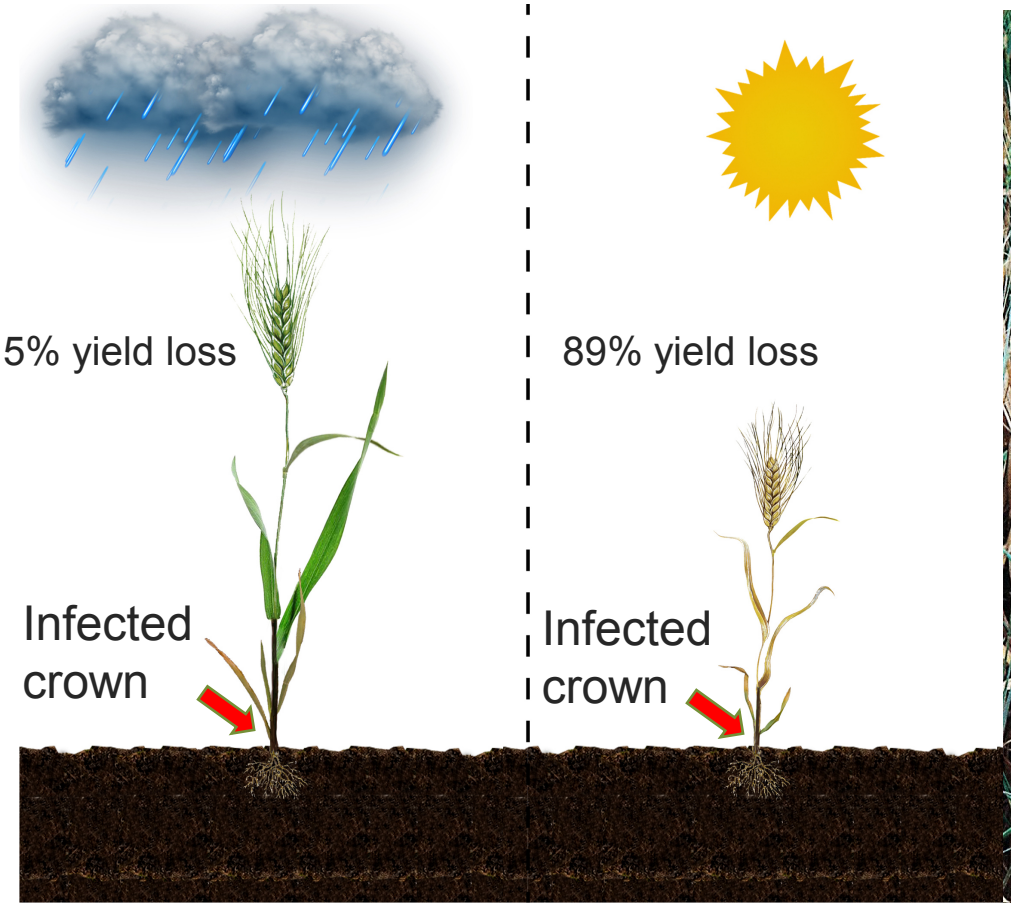

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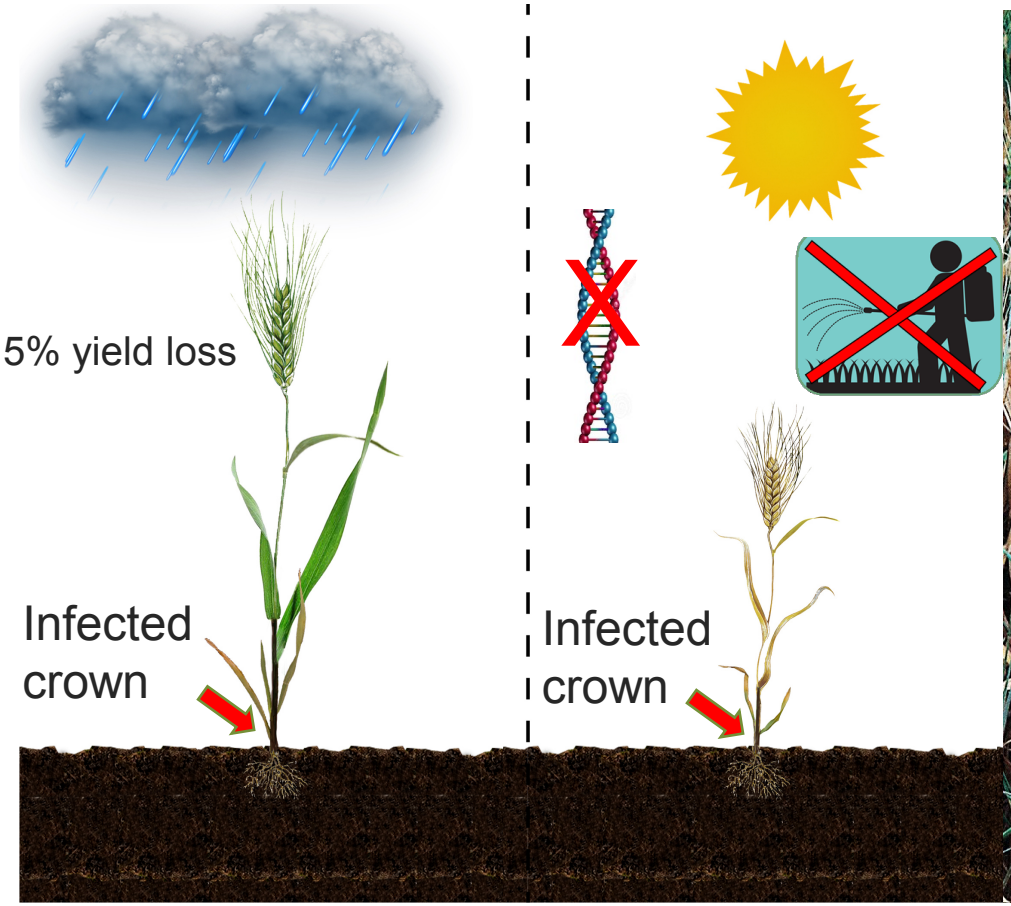
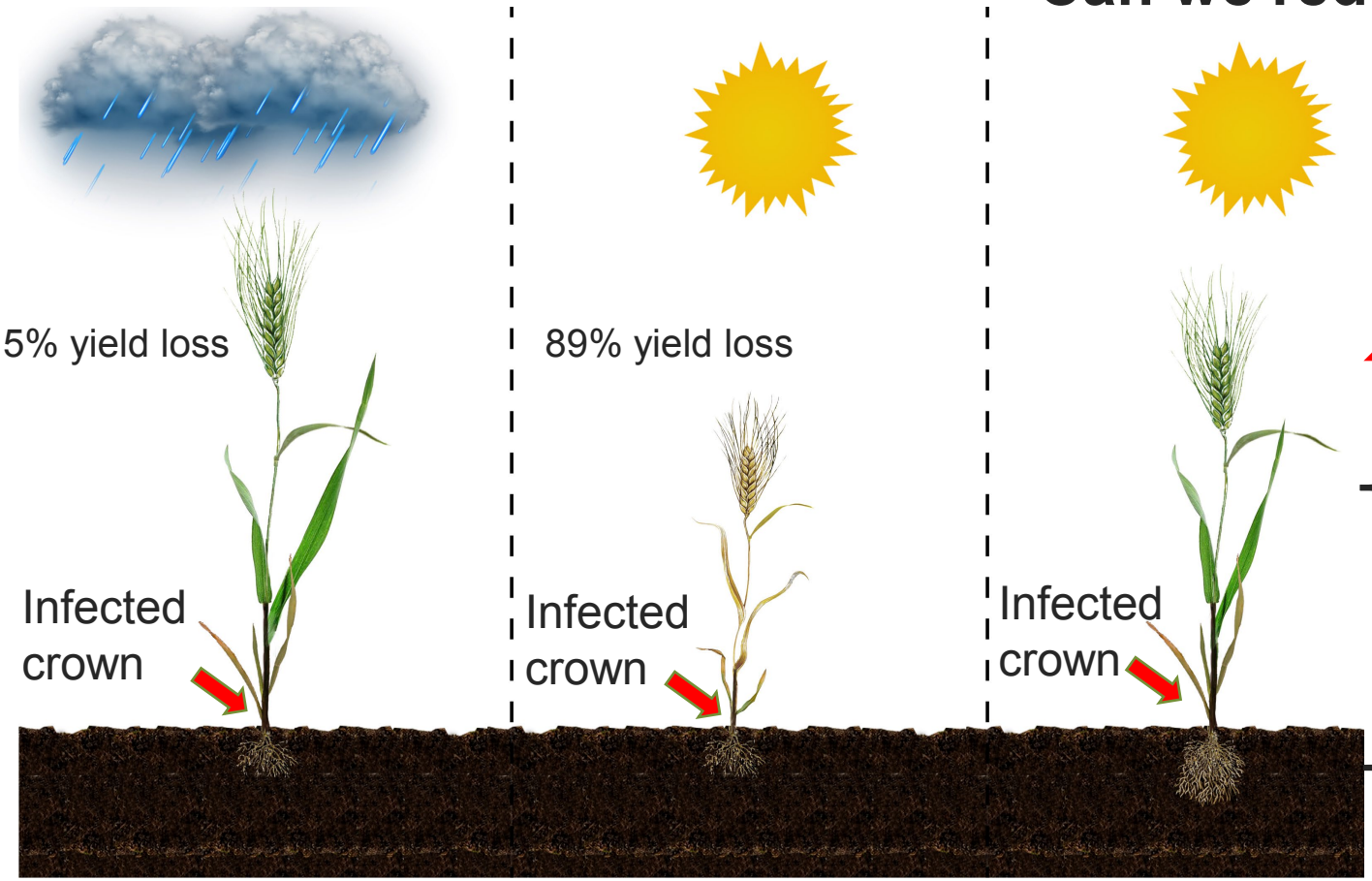


White heads

How does crown rot cause yield loss?



Can we reduce yield loss?

WUE traits

- TE
- Staygreen
- Osmotic adjustment

Improve root system architecture

Can we create populations to investigate WUE traits?

Establishing populations to fuse ICARDA and Australian germplasm

ICARDA founder lines

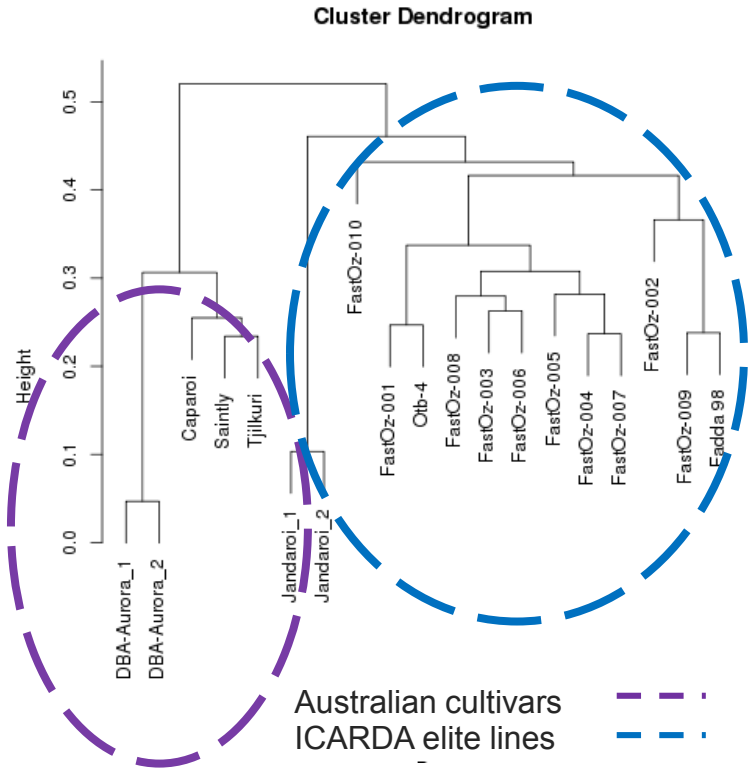
- Adapted to drought and heat
- Tolerance for soil-borne diseases
- Low quality

Australian cultivars

- High quality
- Very susceptible to crown rot

Ideal populations

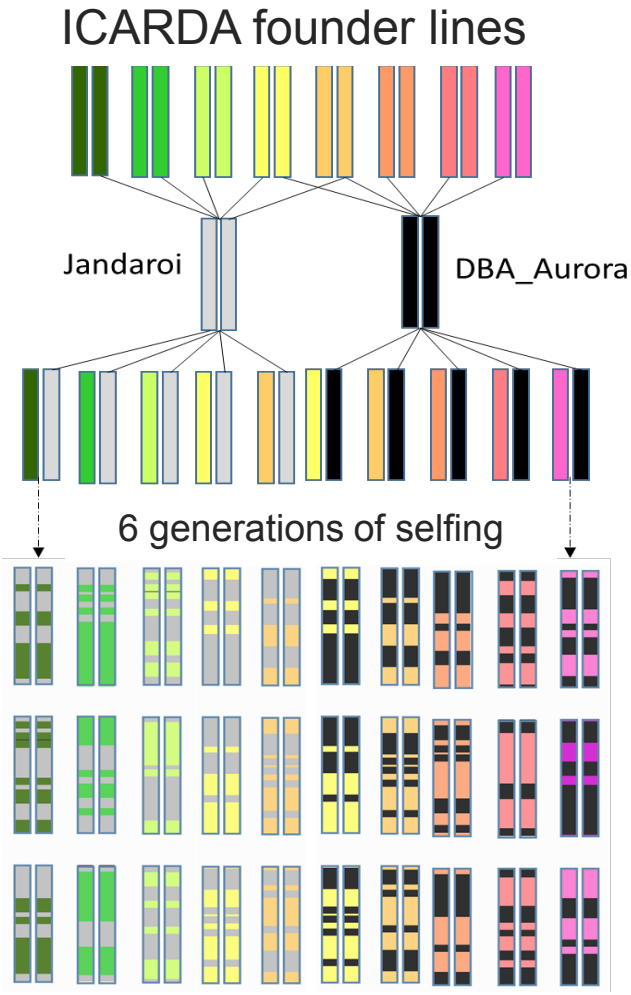
- Combine adaptive traits with quality
- Suitable for genetic studies



Durum multi-parent NAM

- Oz reference varieties crossed with ICARDA founders
- 6 selfing generations
- Speed breeding to accelerate population development
- F6 lines genotyped with DArTseq platform

Speed breeding facility, University of Queensland



F6 leaves sampled for genotyping

NAM population structure

Reference parents

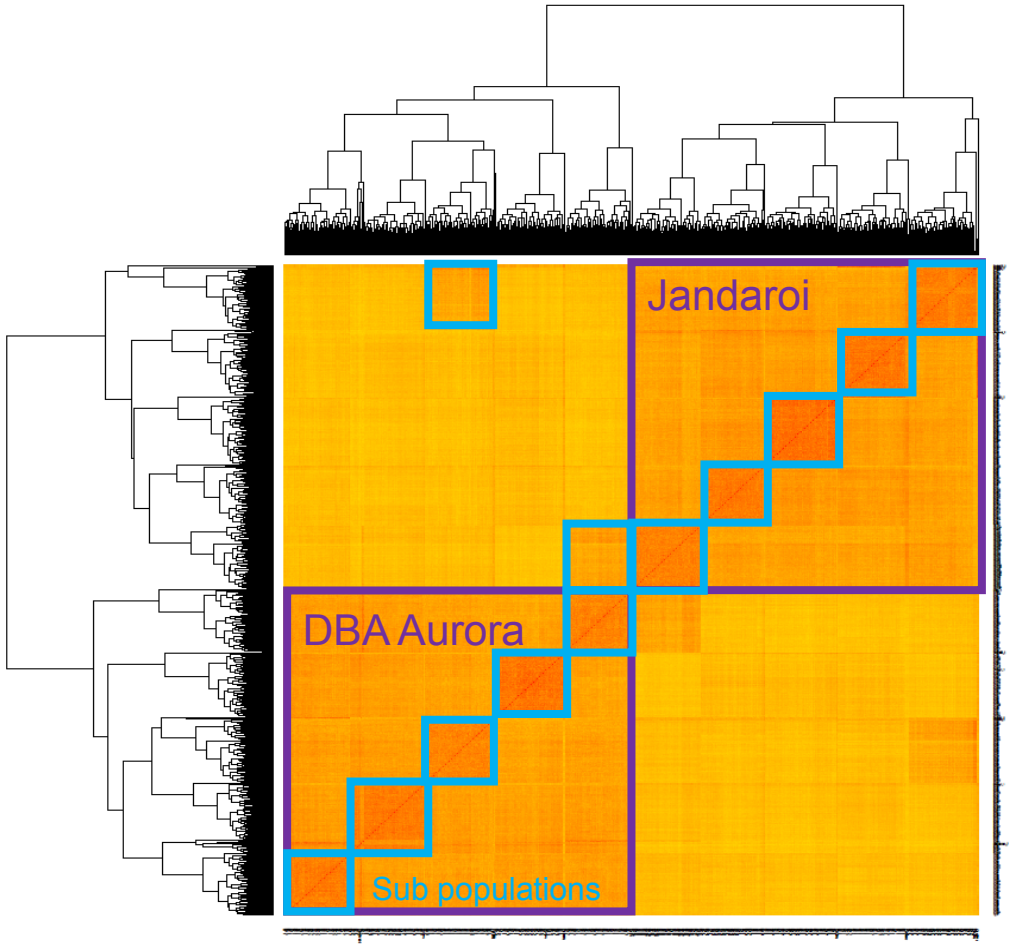
DBA Aurora and Jandaroi

Founder parents

Fastoz2, Fastoz6,Fastoz10, Kunmiki, Outrob4,Fastoz3, IC-078, Fadda98

Common founders

Kunmiki and Outrob4



Can we phenotype root architecture?

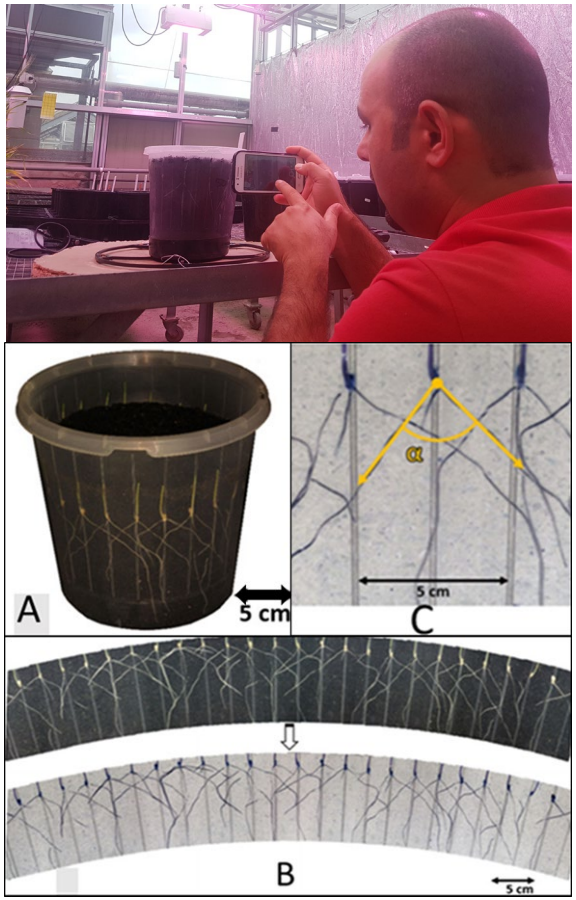
Phenotyping root angle

Root angle variation

- **Glasshouse**: 48.3 - 112 (°)
- **Field:** 51.7 - 85.8 (°)

Richard et al. (2015) Plant Methods

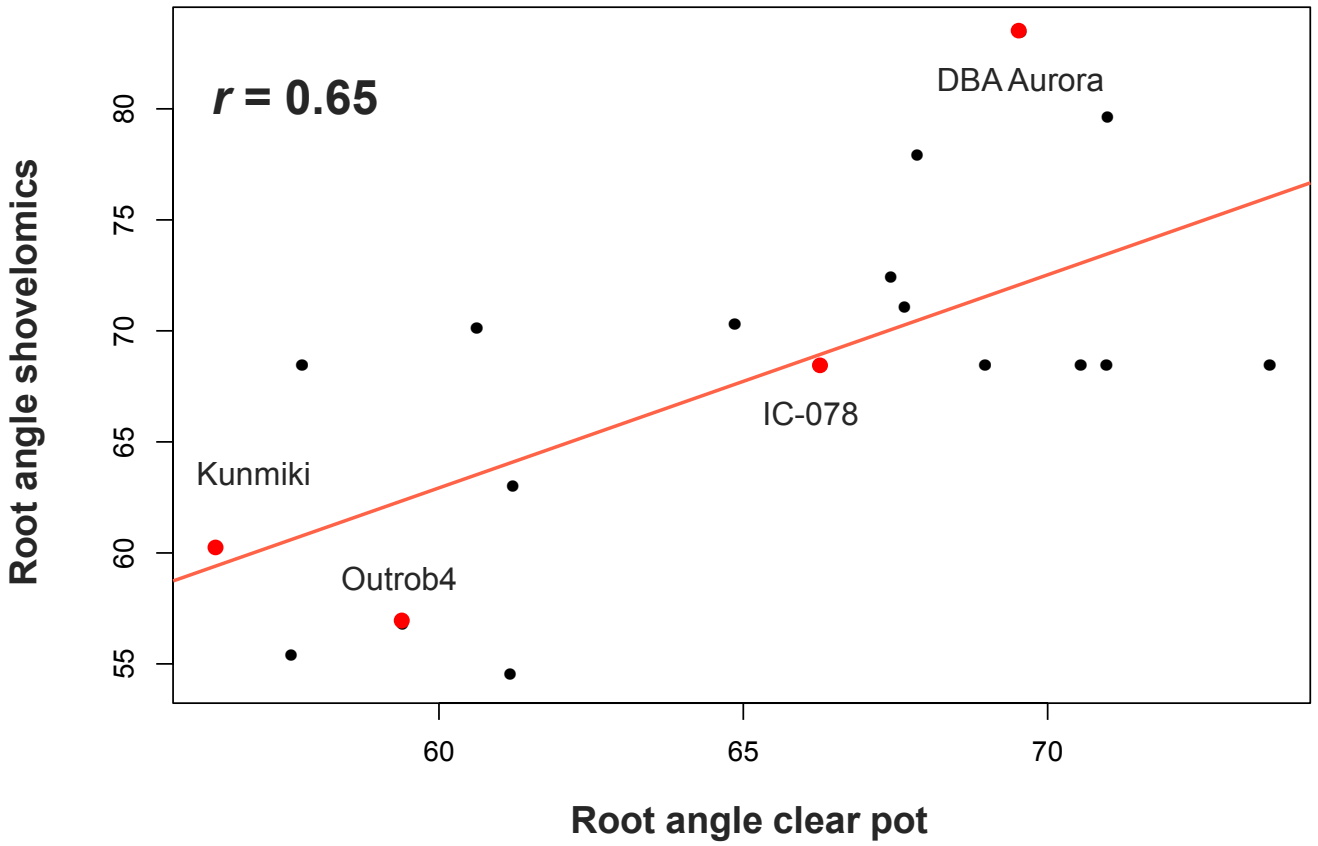
Clear pot



'Shovelomics'

Clear pot vs shovelomics

Good correlation between glasshouse and field



What are the genomic regions controlling root architecture?

GWAS for root angle

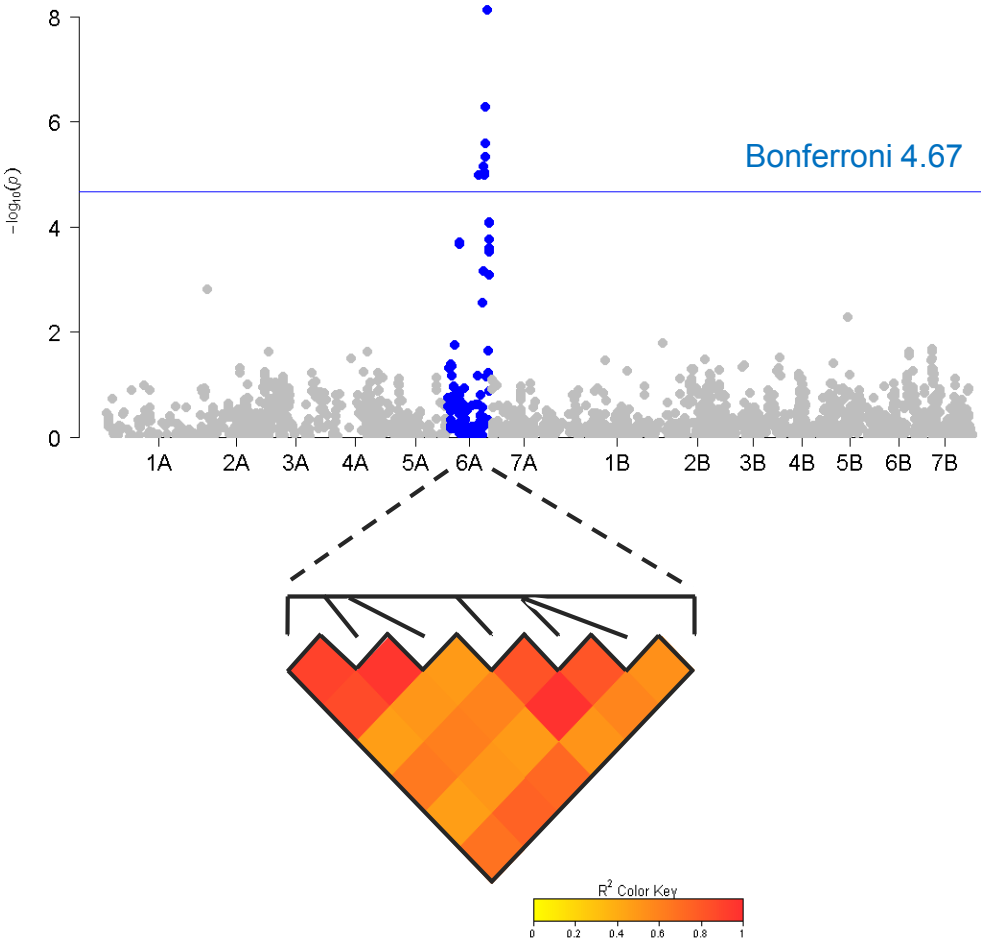
Methods

- Subset of 393 NAM lines
- 2,541 high quality DArTseq SNPs
- GenABEL R package

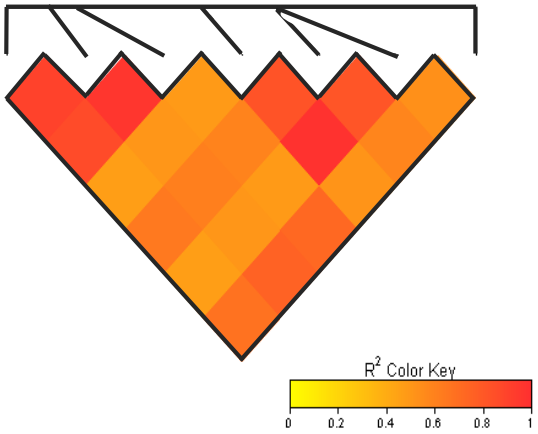
Results

- Major root angle QTL on 6A
- Associated markers in high LD

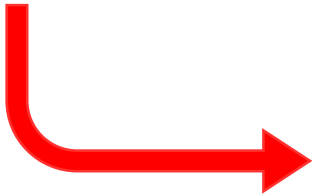
(r^2 = 0.46 - 0.99)

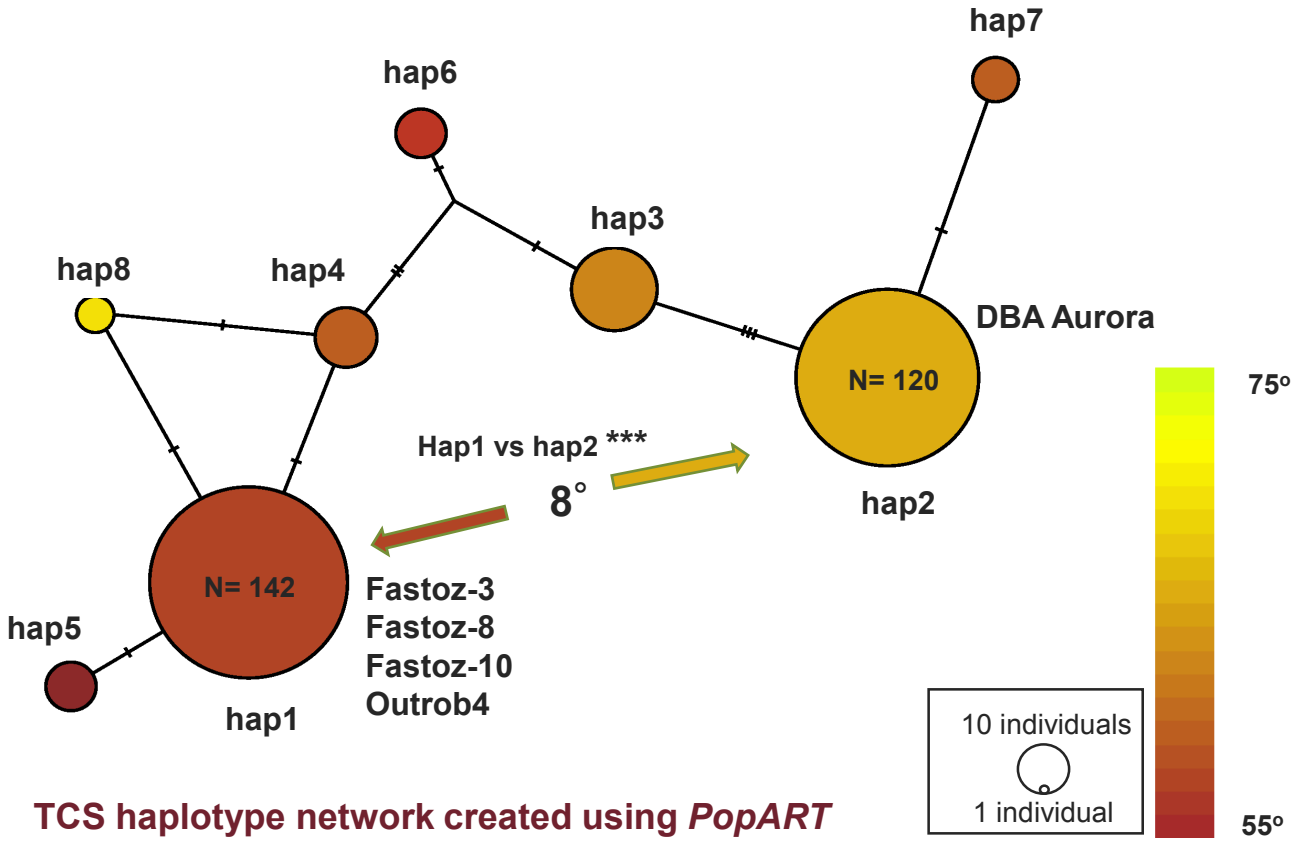


Haplotype analysis for 6A root angle QTL

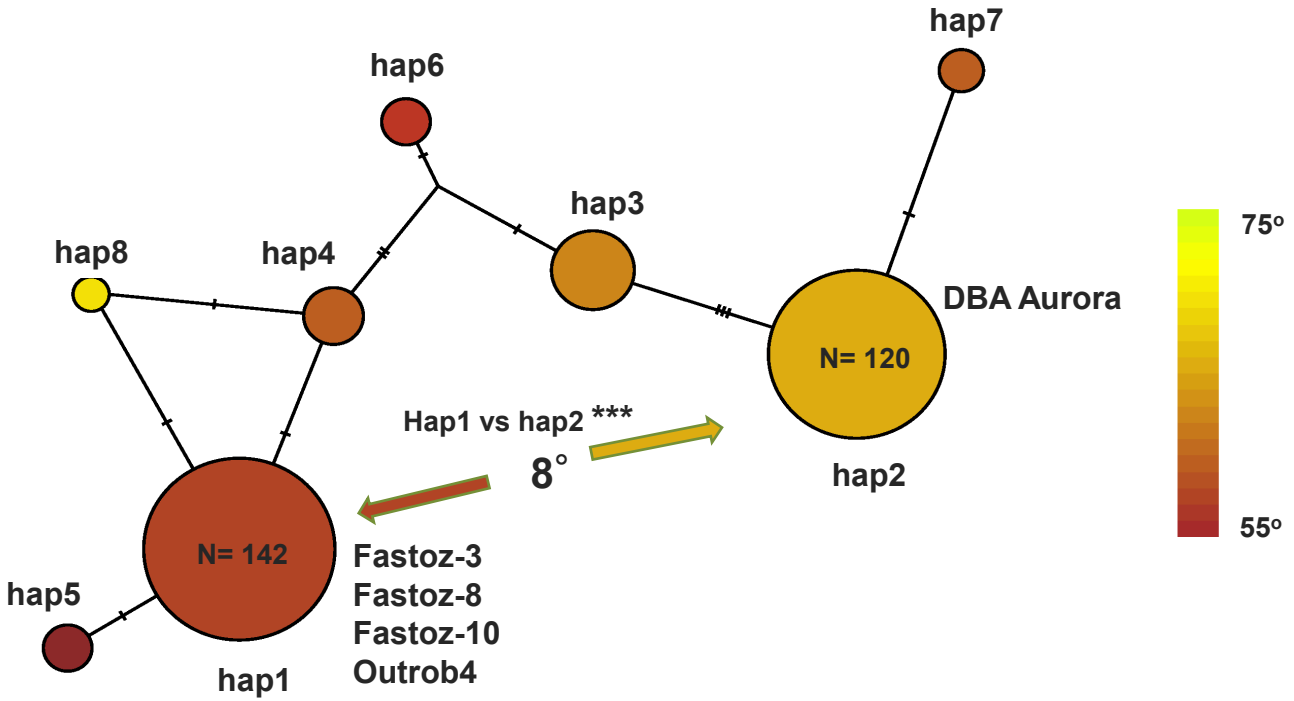


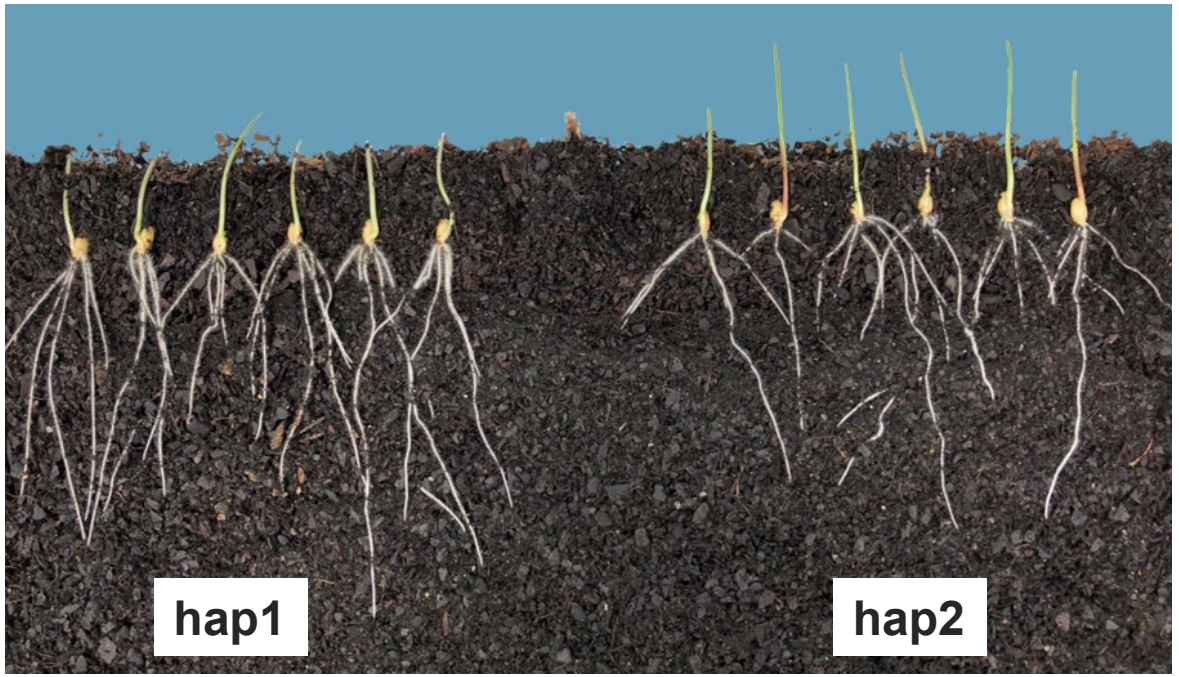
Markers used to construct haplotype network





TCS haplotype network created using *PopART*


hap7
hap6
hap3
hap8
hap4
DBA Aurora
N= 120
75°
55°
Hap1 vs hap2 ***
8°
hap2
N= 142
Fastoz-3
Fastoz-8
Fastoz-10
Outrob4
hap5
hap1


hap1
hap2

Does root architecture influence field performance?

Field evaluation under drought conditions

- Hermitage drought station, Warwick, QLD
- Subset of 168 NAM lines
- Data collection: weekly NDVI measurements, flowering time, plant height, yield

Hermitage research station

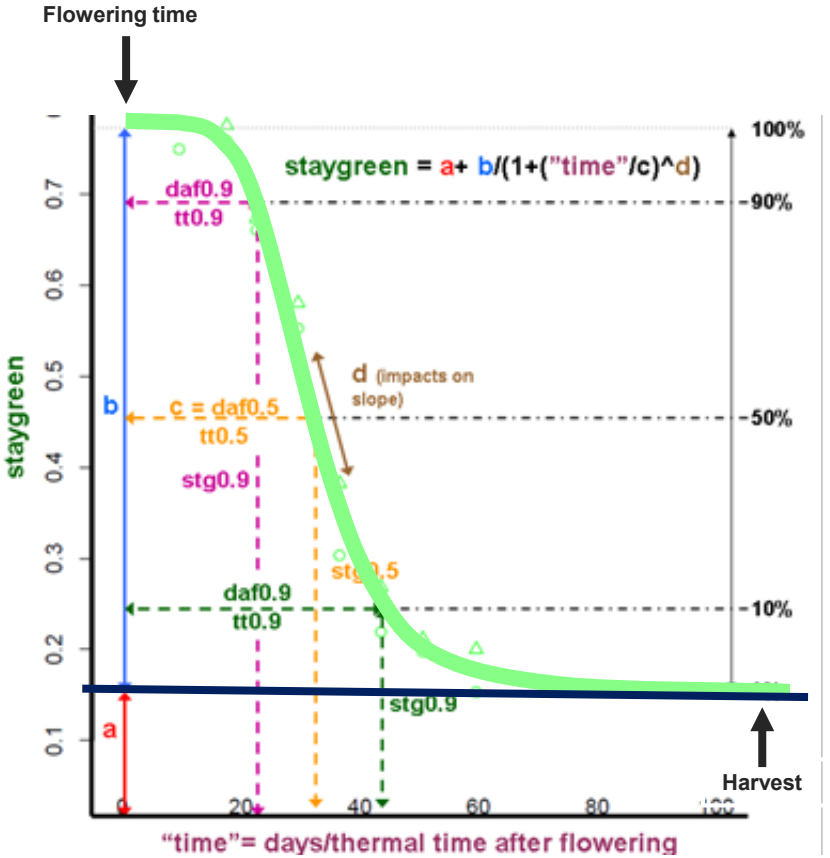
Measuring plant height

Counting storms on harvest day!

Phenotyping rate of senescence

- NDVI measurements collected
- Logistic curve
- Staygreen is a consequence of saving water early in the season

Modelling rate of senescence

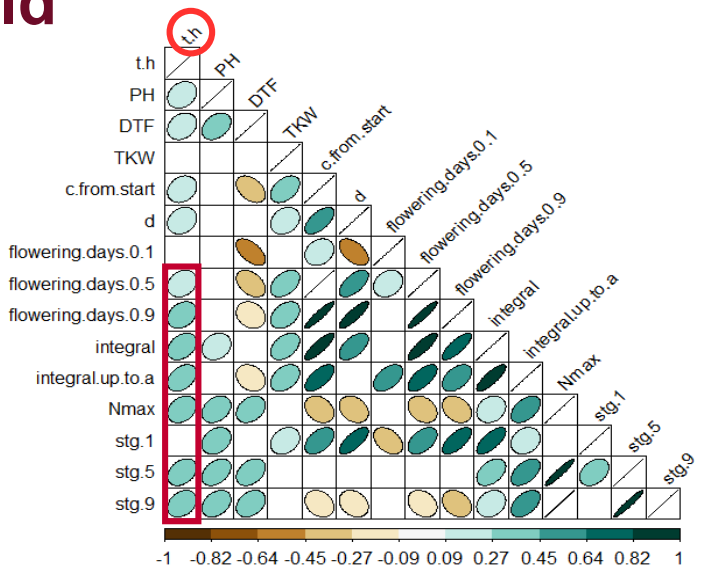


Senescent type Staygreen type

Christopher et al. (2016)

Correlation between staygreen and yield

- Staygreen traits were significantly correlated with yield



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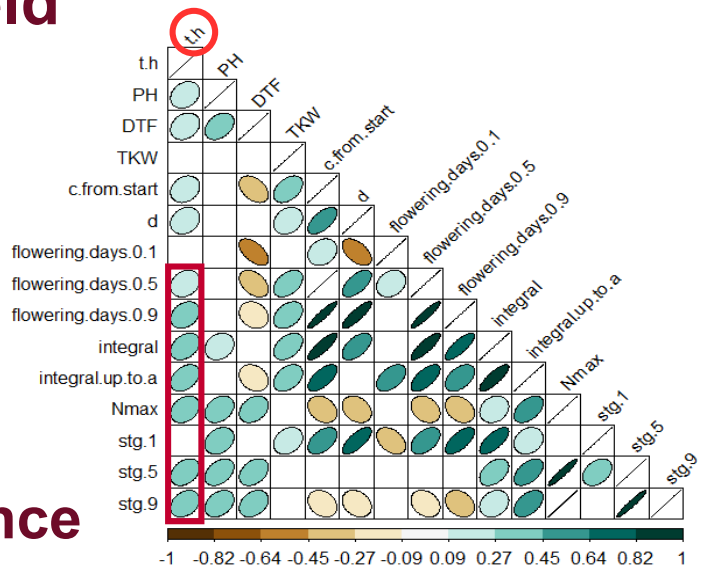
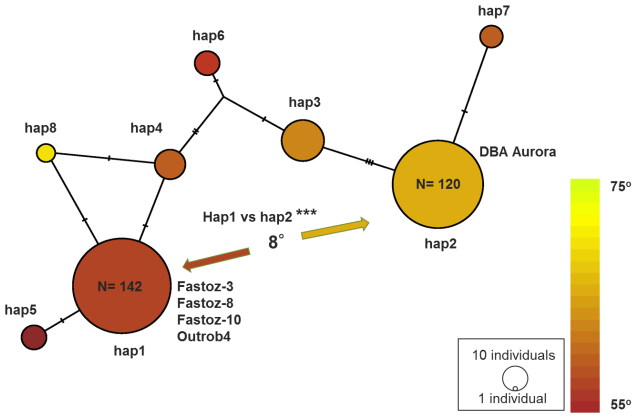
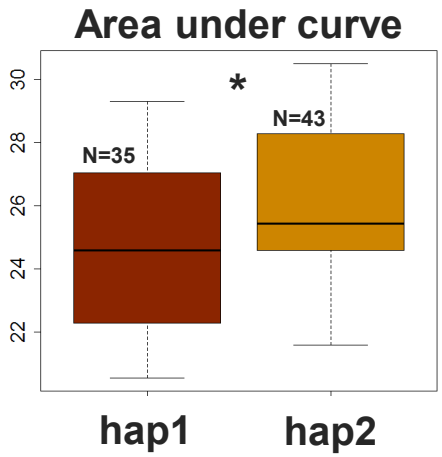
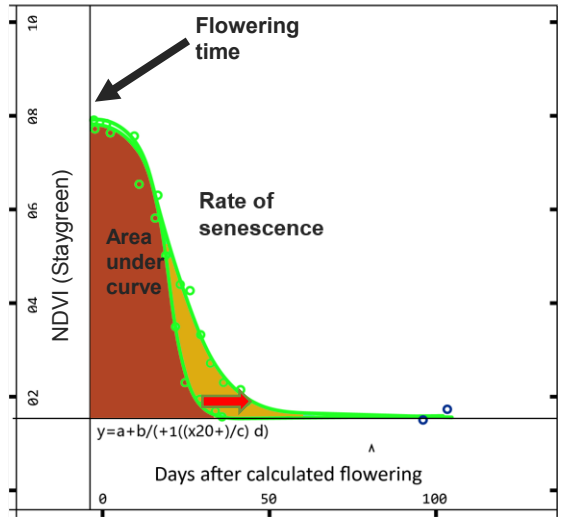


Root angle QTL effects on yield performance







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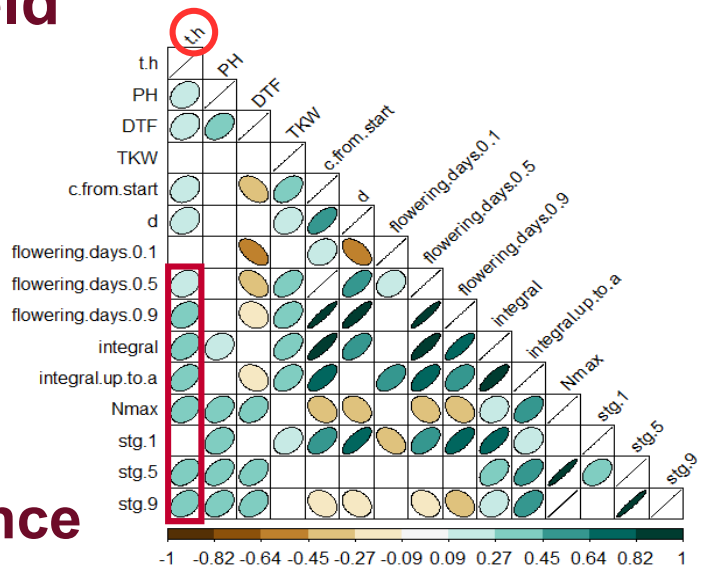

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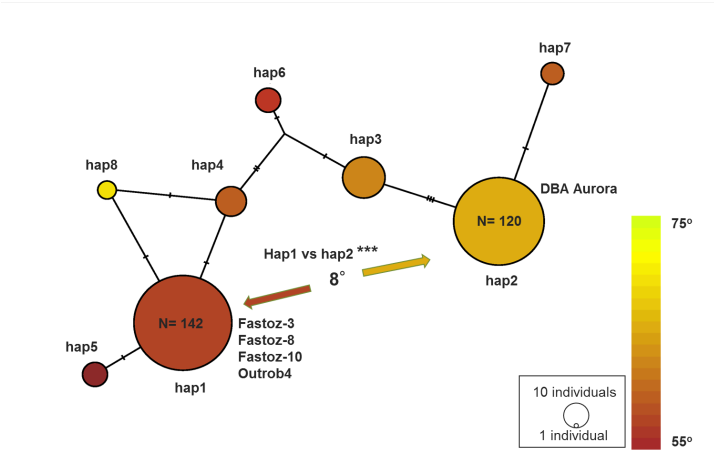
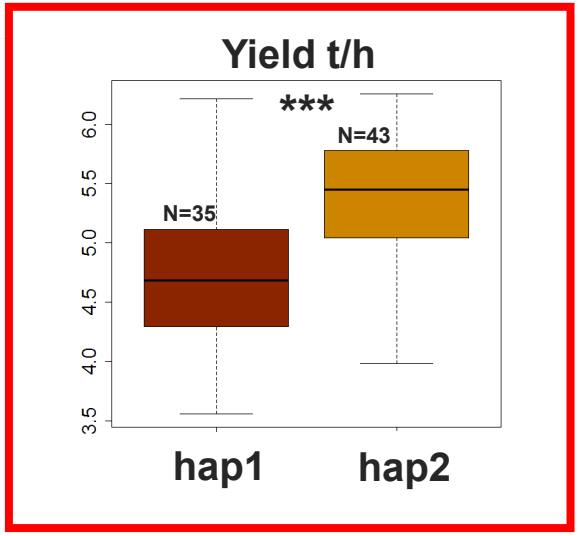
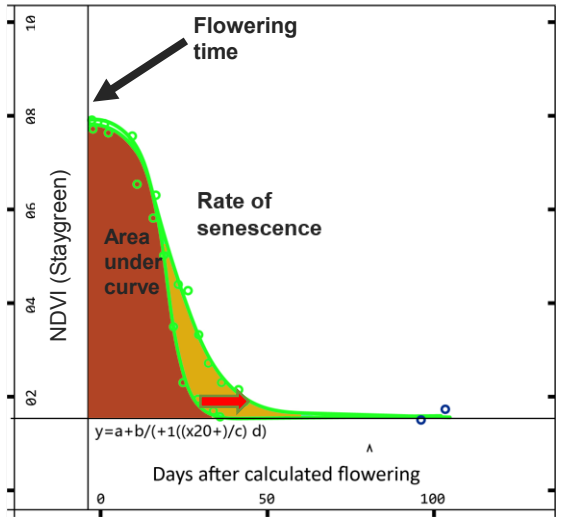






Can WUE traits minimise yield loss under crown rot?

Crown rot experiment

- Similar trial, but **high crown rot pressure**
- Data collection: flowering time, plant height, yield and **crown rot**
- Crown rot assessed as a **severity index:**
  - White heads % 1st assessment
  - White heads % 2nd assessment
  - Stem browning

Sown on infected stubble

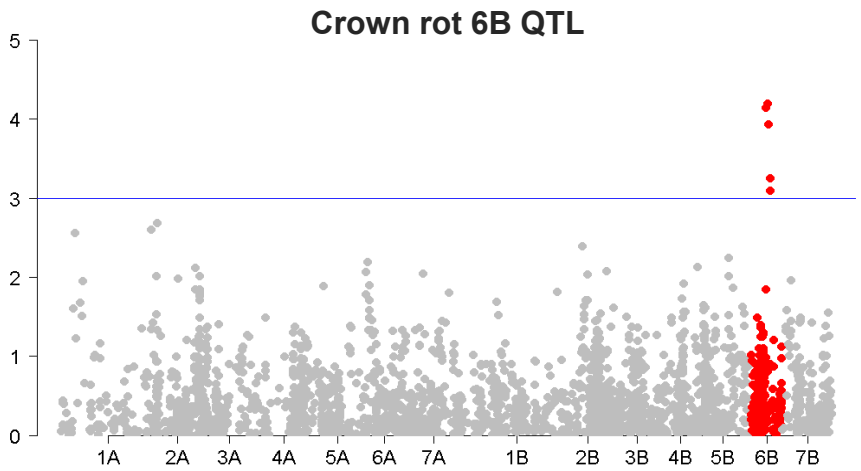
Stem scoring

5% white heads

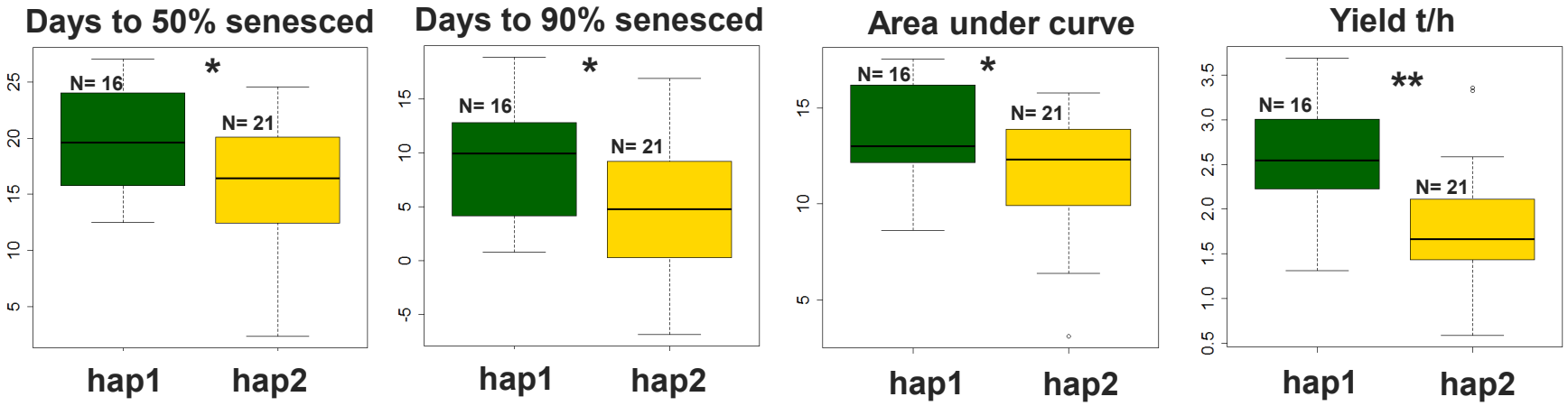
95% white heads

GWAS for crown rot

- QTL on 6B
- Performed haplotype analysis
- The region is also associated with staygreen traits!



Tolerance to crown rot achieved by modulating canopy development



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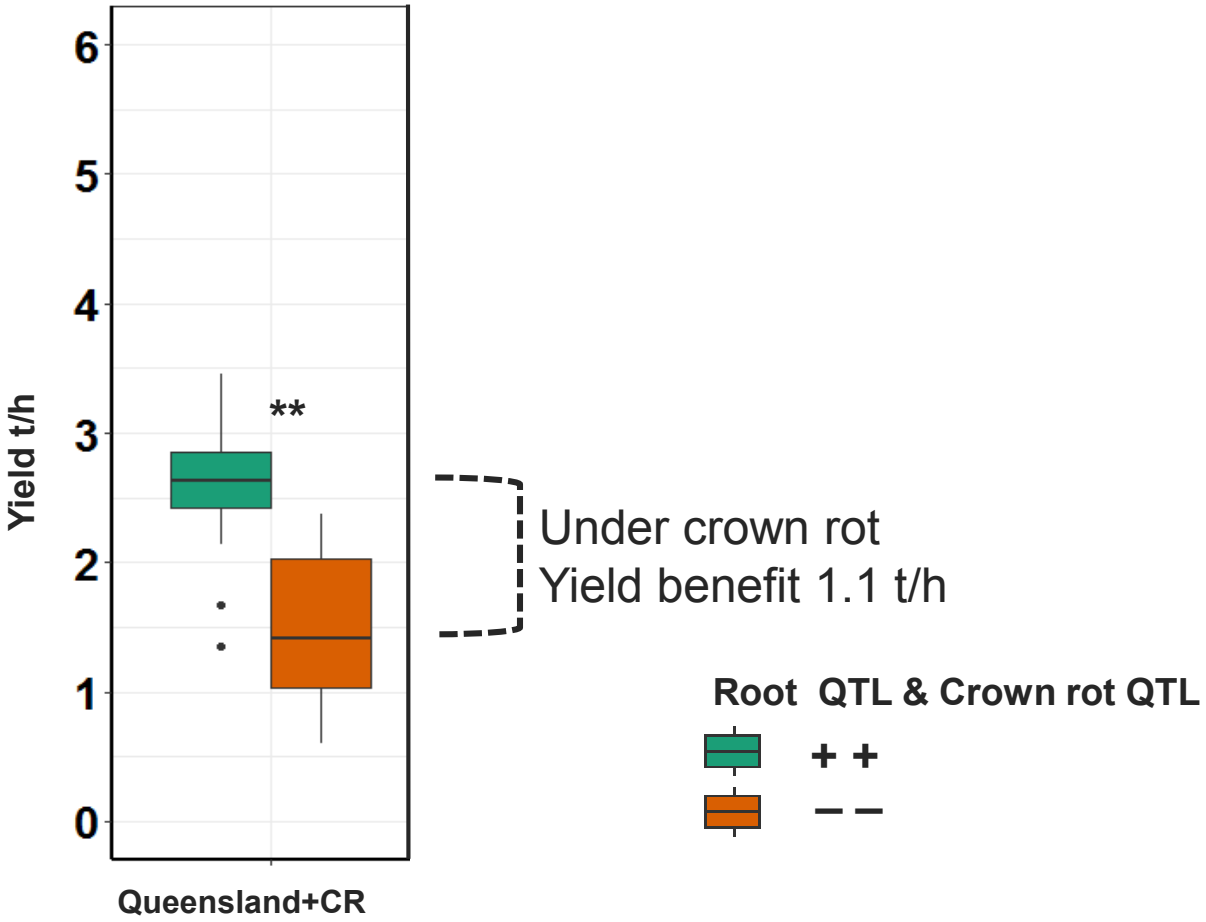
Can we combine root and crown rot QTL?



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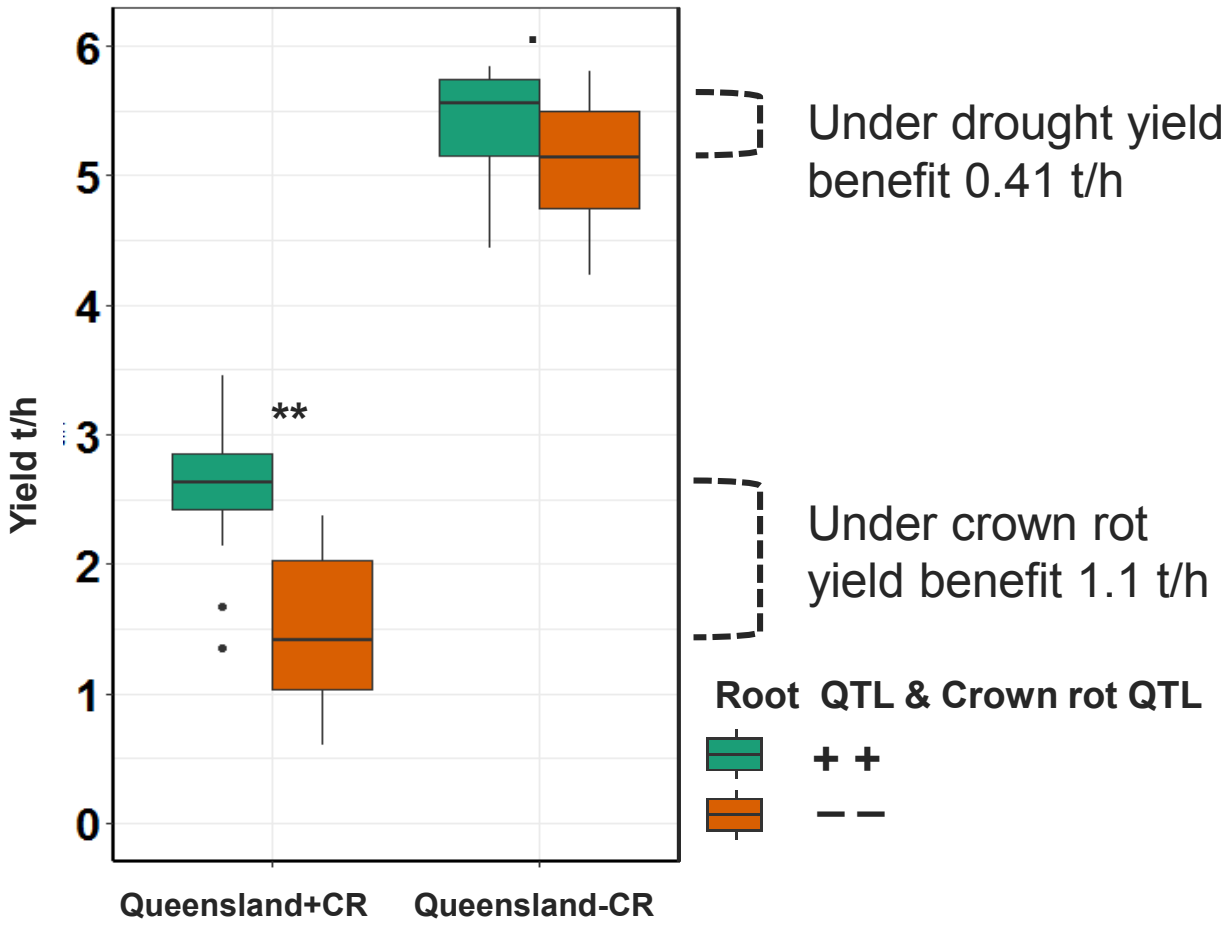

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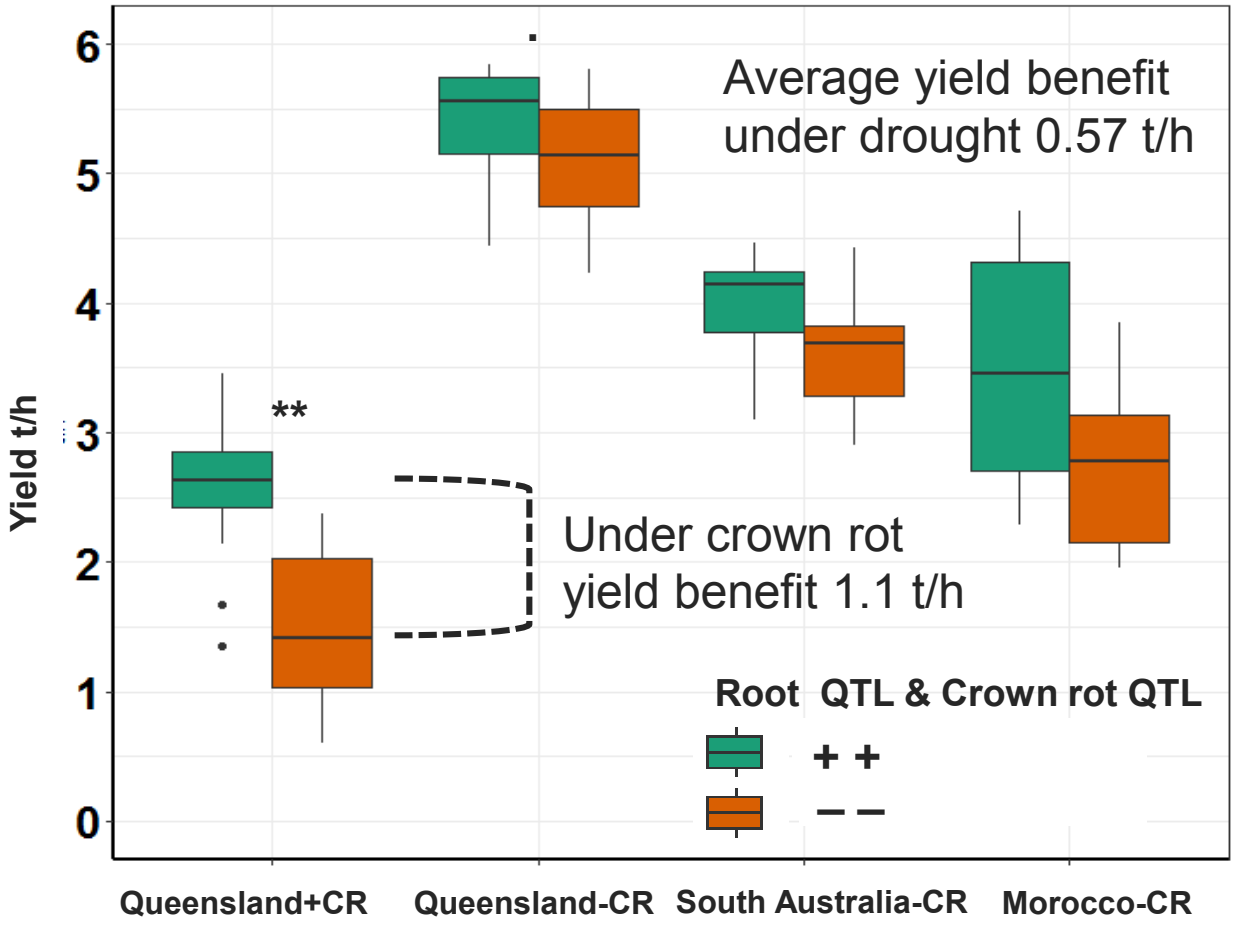

Take home messages

- Powerful NAM population for studying WUE traits
- Major QTL for root architecture on 6A & crown rot on 6B
  - Opportunity to optimise WUE traits to enhance yield under drought and crown rot

What's next?

- Validate trait combinations in a more diverse environmental context
- Combine favourable alleles using a genomic selection strategy

Acknowledgments

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University of Queensland Research Scholarship (UQRS)

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