

Four Years of Drought?

Clare Lister and Simon Griffiths

John Innes Centre

WGIN Stakeholders Meeting

14th November, 2019

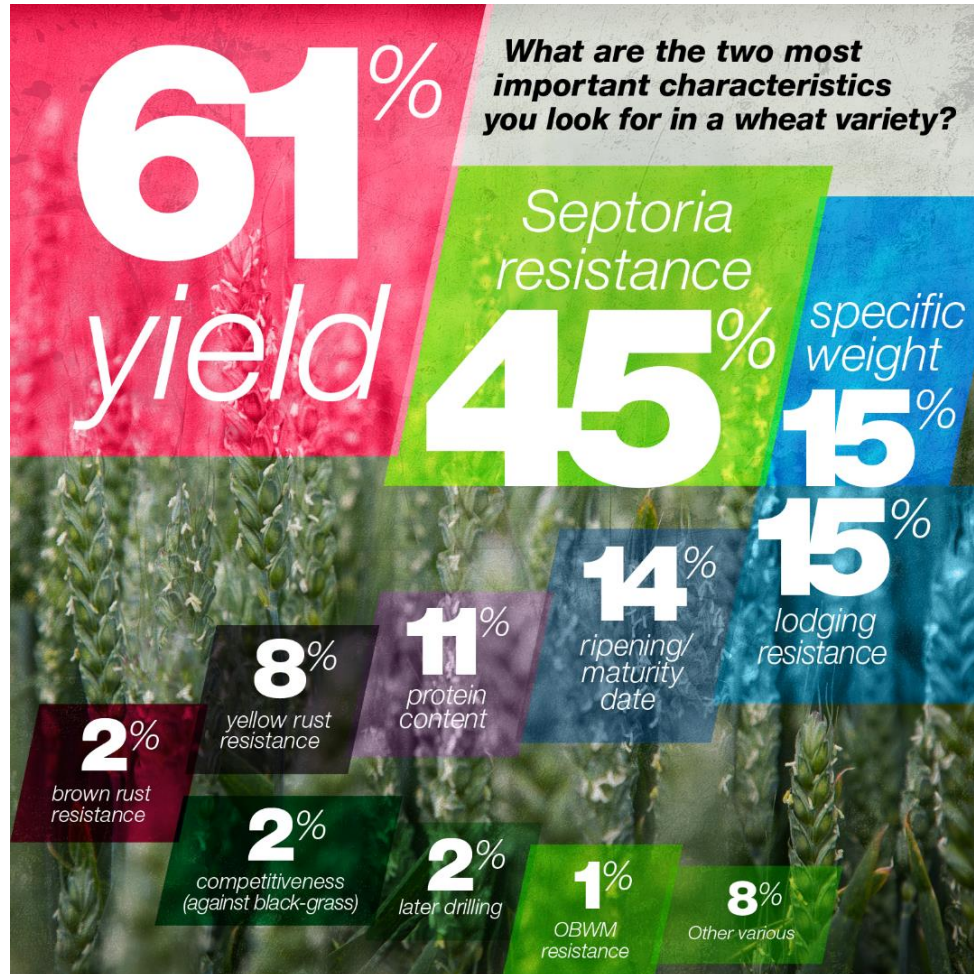
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WGIN Stakeholders Meeting
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Cathy Mumford, Darryl Playford and the JIC Field Experimentation Team
The Griffiths group, especially David Norris, Charlie Philp and Alba Farre
WGIN and DEFRA

It's mostly about Yield (Stability)



Bayer and CPM magazine

- Wheat growing conditions subject to increasing climate volatility in the UK
- Sufficiently high yields, consistent between locations and years, is required
- Improved drought-tolerance could be one route to increased stability
- Genes that are important for adaptation to drought may also positively influence yield

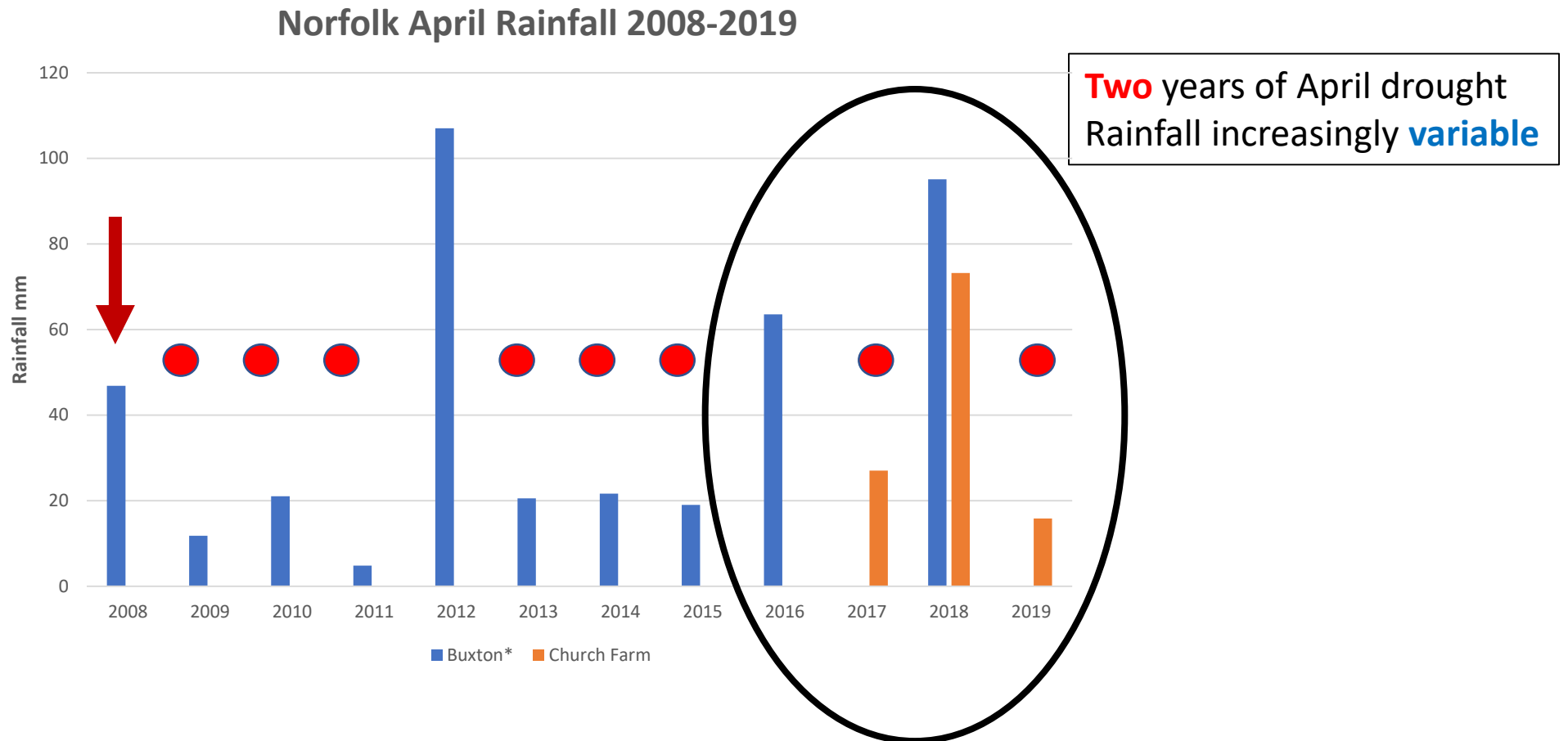
The Problem of Spring Drought

- In the UK April drought coincides with the start of stem elongation and spikelet formation (**G31 onwards**).
- Grain number is determined here so drought decreases yield due to reduced spikelet number



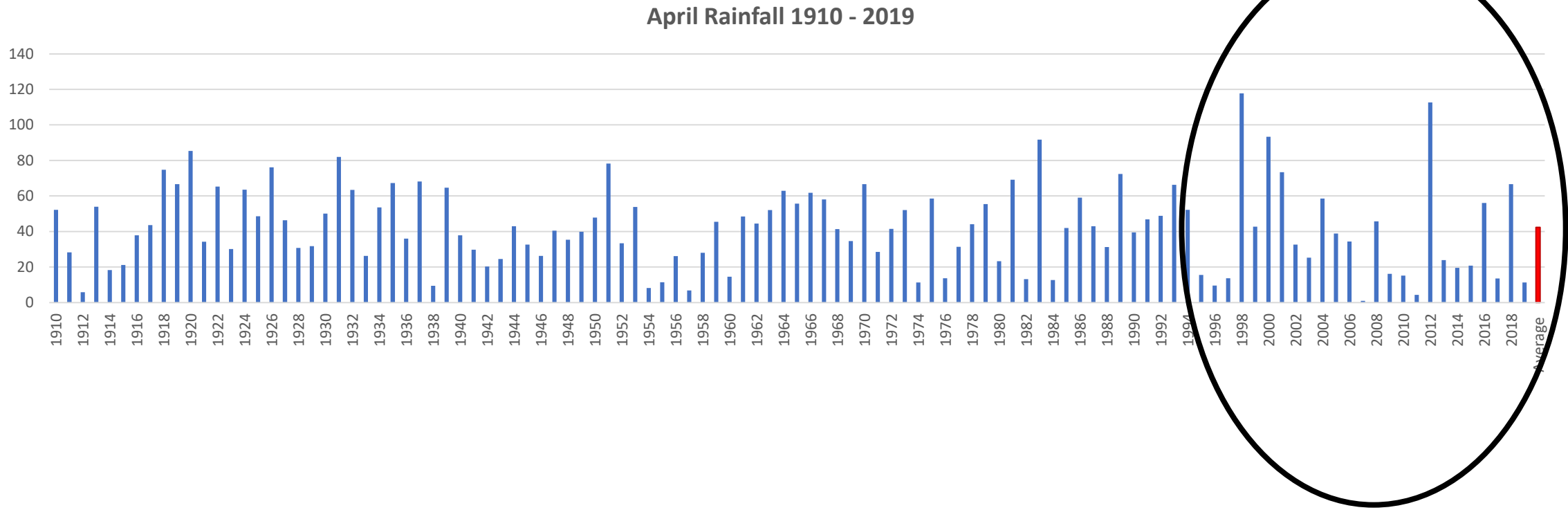
The Problem of Spring Drought

- April drought occurs frequently in Norfolk!



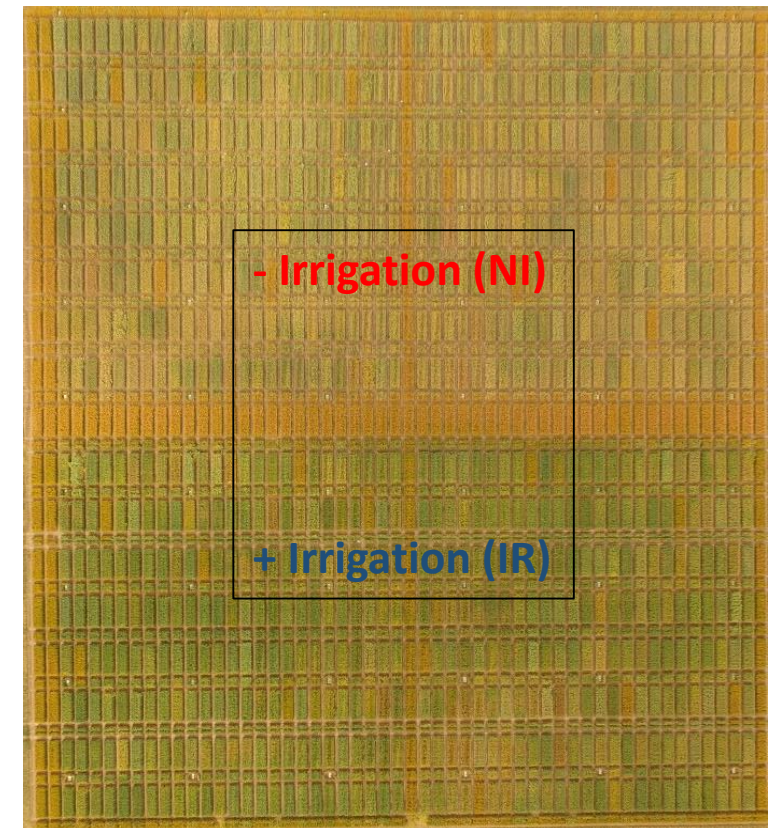
The Problem of Spring Drought

- April drought more frequent in Norfolk in the last 25 years!
- Rainfall also more variable and extreme



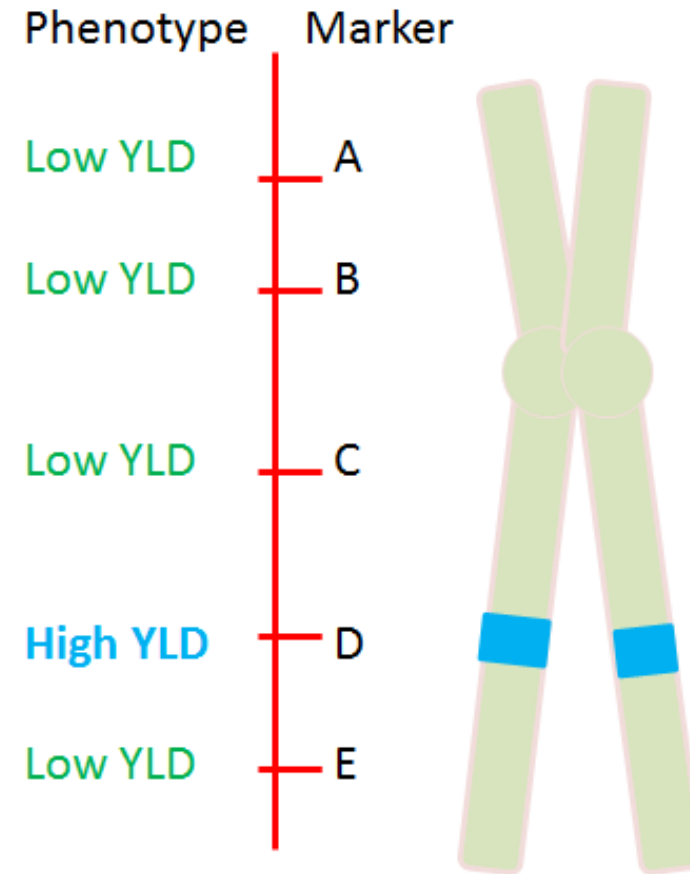
Look for useful genes in drought-adapted wheat

- For example **southern Europe** for which variety **Garcia** was developed.
- The Paragon x **Garcia** RIL population was generated within WGIN to study drought tolerance (DT)
- 177 RILs used in 4 years of trials (2016-2019)
- Phenotype and yield data analysed
- Comparison of IR and NI plots



Look for useful genes in drought-adapted wheat

- Phenotype and yield data
+ marker data from this population allows identification of specific chromosome regions from Garcia carrying DT genes (= *QTL mapping*)
- Results discussed below...

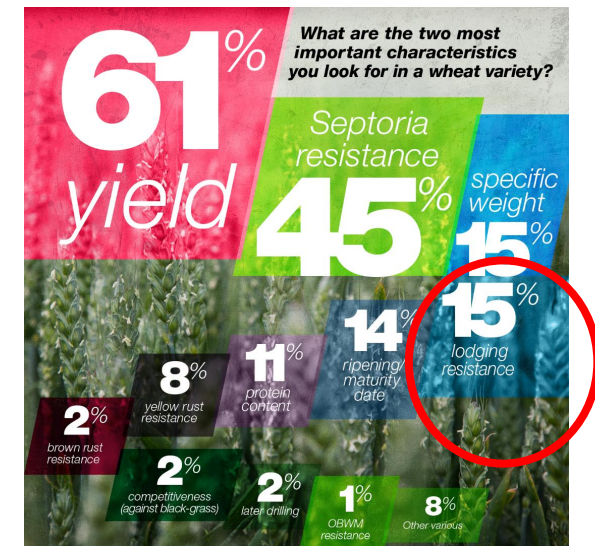


The DALP Panel

- Now exploring Drought tolerance, plus Anchorage strength and Lodging-resistance in a Panel of about 200 lines (**DALP**) including:
 - *Rht* and EMS semi-dwarfs in Paragon
 - Selected Paragon x Garcia RILS
 - The DFW Breeders' Toolkit, from 2017 and 2018
 - Elite varieties
 - Parents of crosses with Paragon, generated in WGIN
 - Watkins lines
 - CIMMYT and SATYN lines
 - WGIN Diversity Panel

Screening of DALP

- Drilled spaced plants (Nov 2019)
- Single rep each for + / - irrigation
- Developed anchorage strength test in 2018
- Will test plants for anchorage post-anthesis and + / - irrigation
- Will also assess lodging



Screening of populations derived from DALP

- Assessing lodging traits in Paragon NAM (Nested Association Mapping) populations
- Over 80 populations from crosses between Paragon and many varieties in DALP, including the Watkins collection
- Results will help choice of populations for 2020 lodging trials



Most robust QTLs from P x G Drought Trials



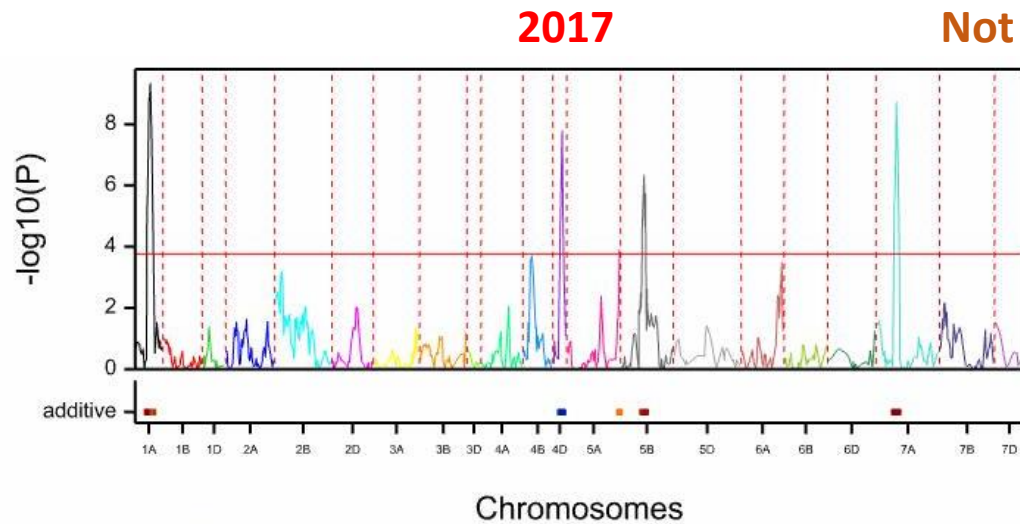
Trial years	Spring	Summer	Field	Soil Type
2015-16	Spring rain	Little summer drought	Opposite Drier	Sandy Loam
2016-17	Spring drought	Some summer drought	Riverside	Very sandy
2017-18	Spring rain	Severe summer drought	Football	Very sandy
2018-19	Spring drought	Some summer drought	Opposite Drier	Sandy Loam

Trial location can affect results

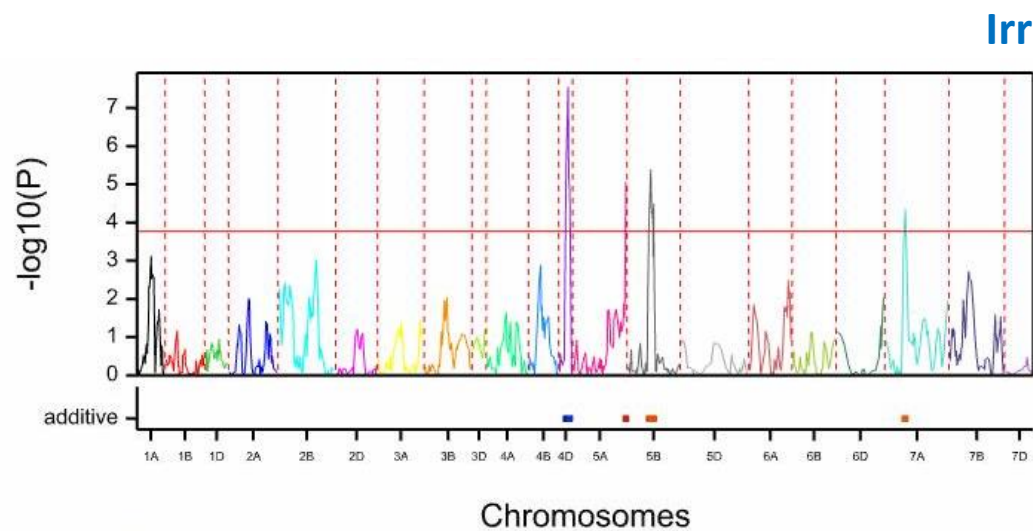
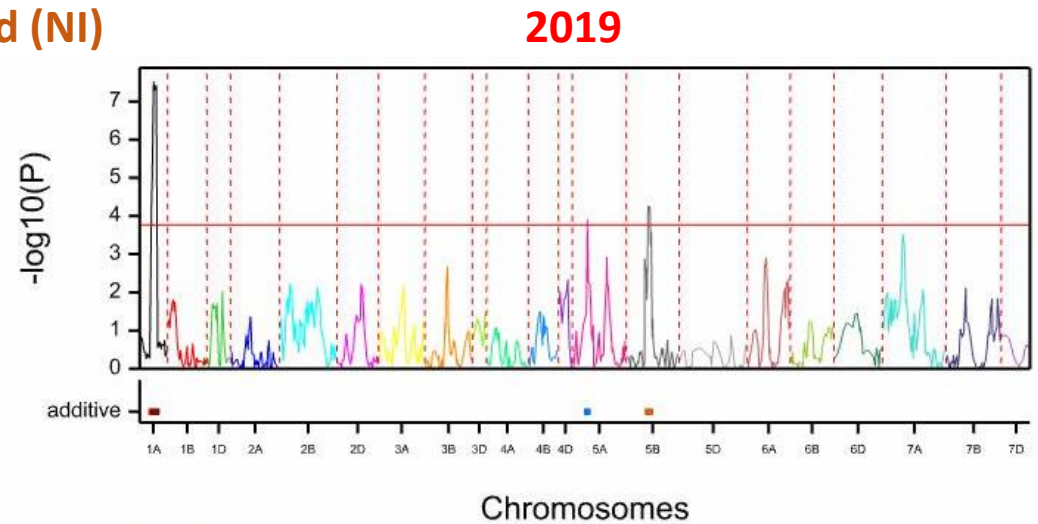
QTLs on Chromosomes

Trait	2017		2019	
	NI	IR	NI	IR
DTEM	2B-2		2B-2	
Ht	1A-1	1A-1	1A-1	1A-1
YLD	2B-1	1A-2, 2B-1		
SW		1A-2, 2B-1		
TGWT	1A-1 5B-2 7A	5B-2 7A	1A-1 5B-2	5B-1
Grains / m ²				

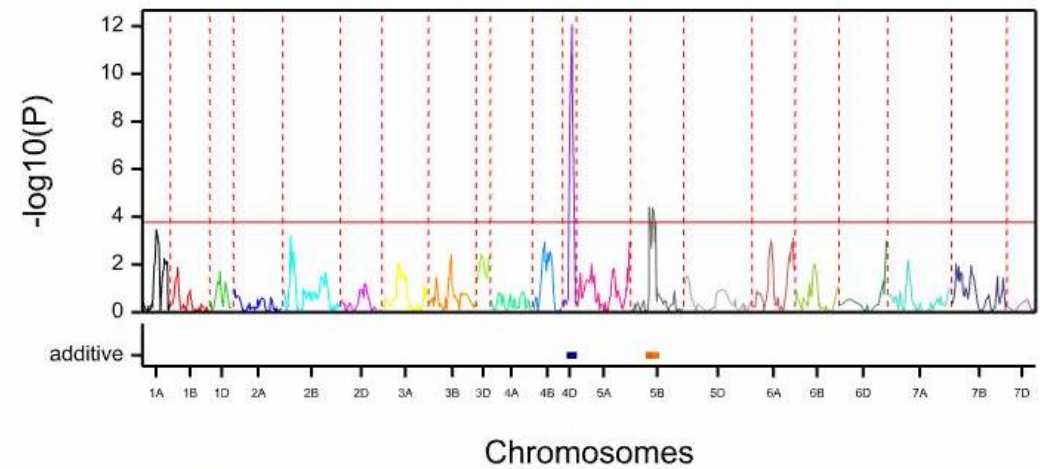
i.e. TGWT QTL* from 2017 and 2019



Not Irrigated (NI)



Irrigated (IR)



	2017		2019	
TGWT	1A-1	5B-2 7A	1A-1 5B-2	5B-1

What next with the QTLs?

- Generate NILs from selected lines
- -> NIL production already initiated for 1A-1 and 2B-1 QTLs
- Field trials + / - irrigation of NILs, phenotyping
- Fine mapping of QTLs
- Identify markers for Breeders
- Could give some markers now
- Physiological comparison of NILs with Paragon or Garcia at QTL
- Examination of genome sequence for possible gene candidates
- Comparison between Paragon and Garcia versions of candidates

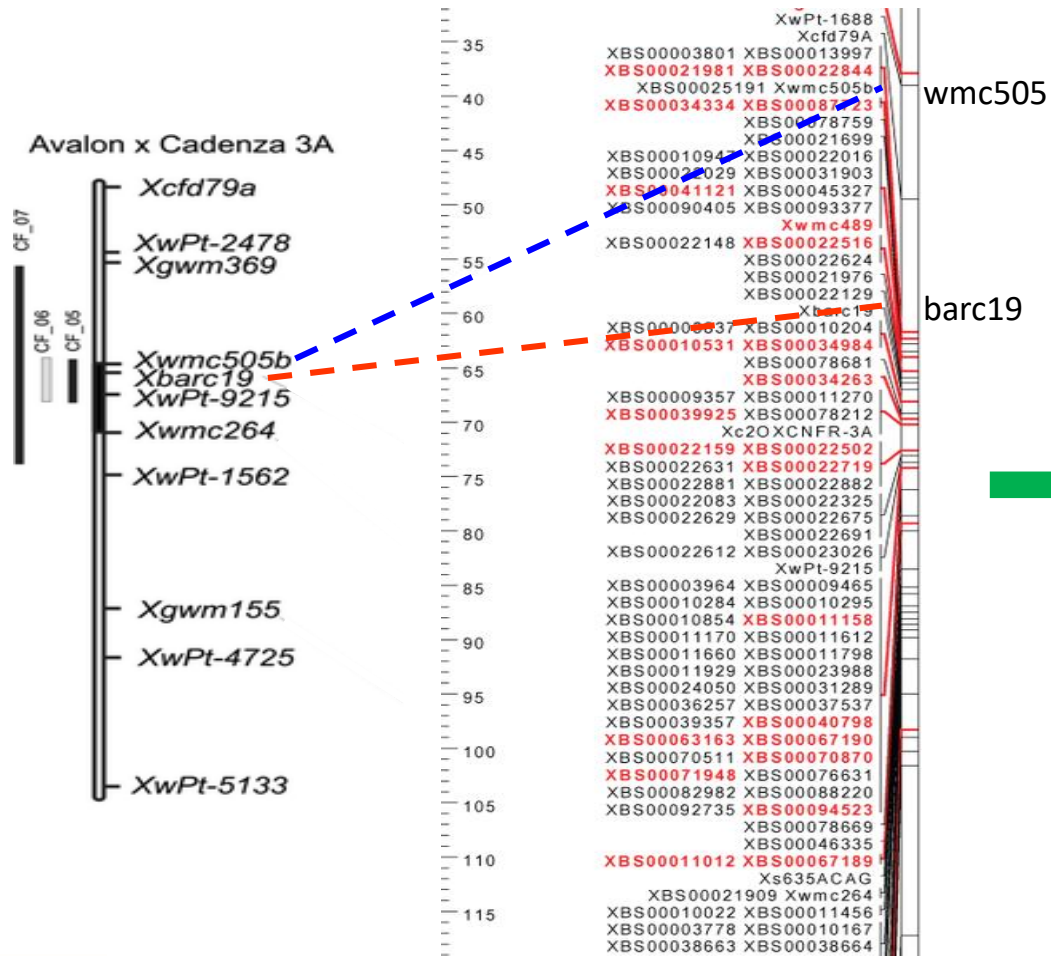
What next with the QTLs?

- Time to go off-piste...
 - Have followed this same process in another WGIN project
 - Three closely linked QTLs on 3A for height (Ht)¹, heading (Hd)² and yield (YLD)³
 - Identified in **Avalon x Cadenza**, Savannah x Rialto and Spark x Rialto
- ¹ Griffiths et al 2012,
 - ² Griffiths et al 2012
 - ³ Ma et al 2015

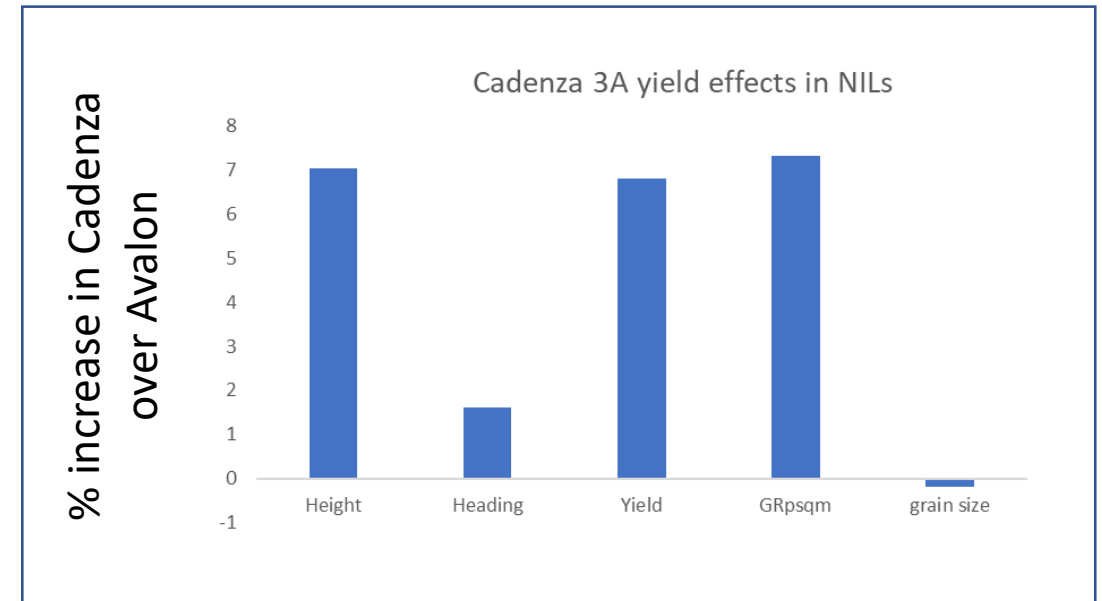


From QTL mapping to NILs

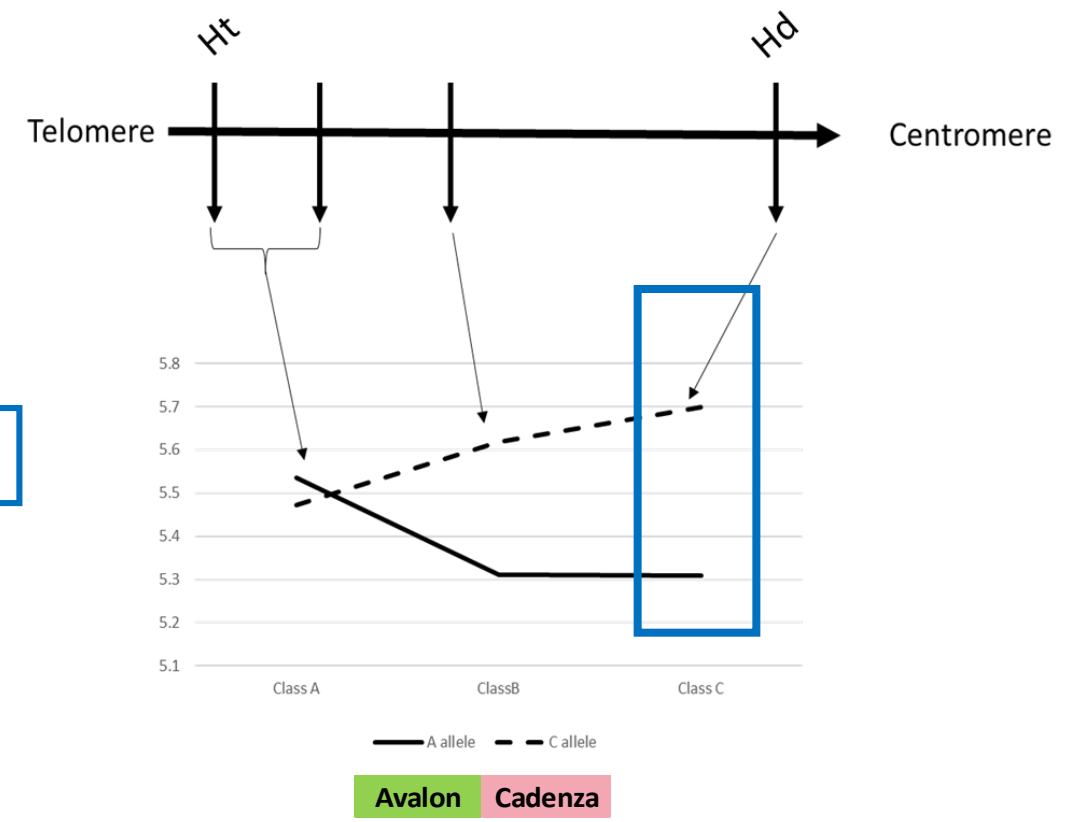
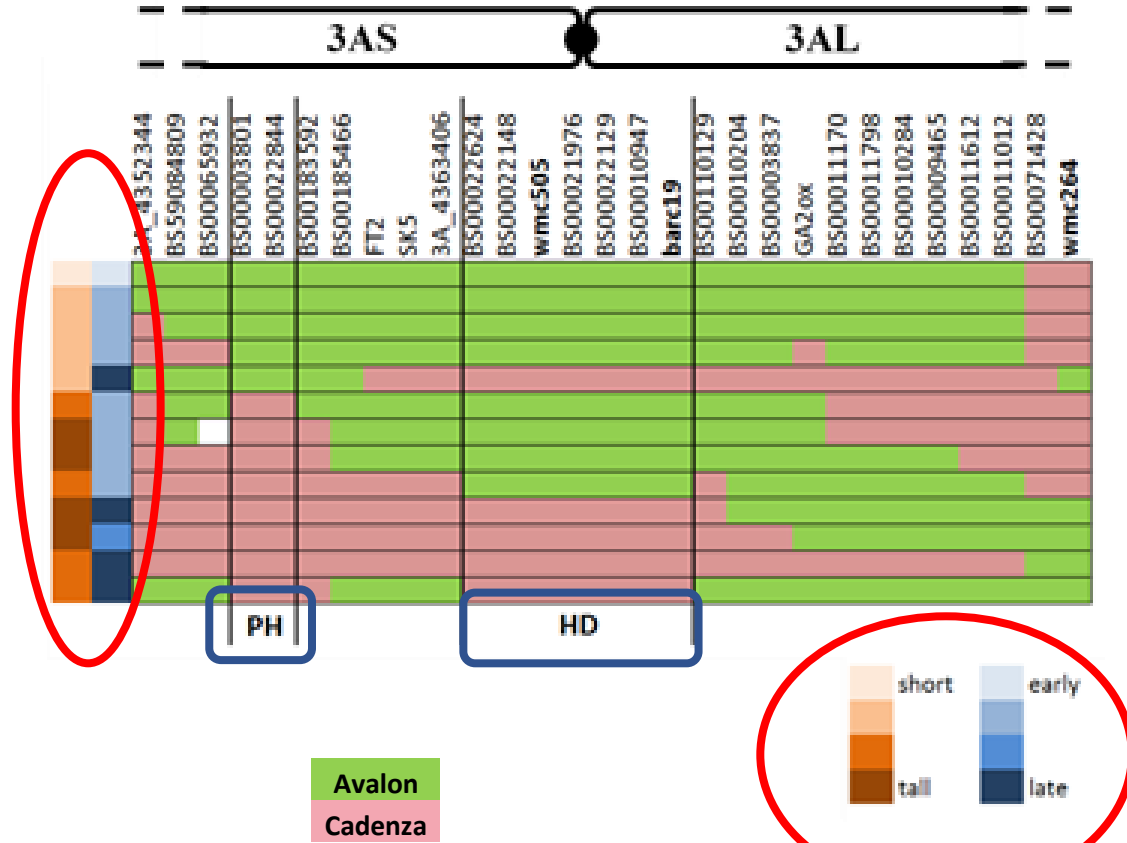
QTL mapping



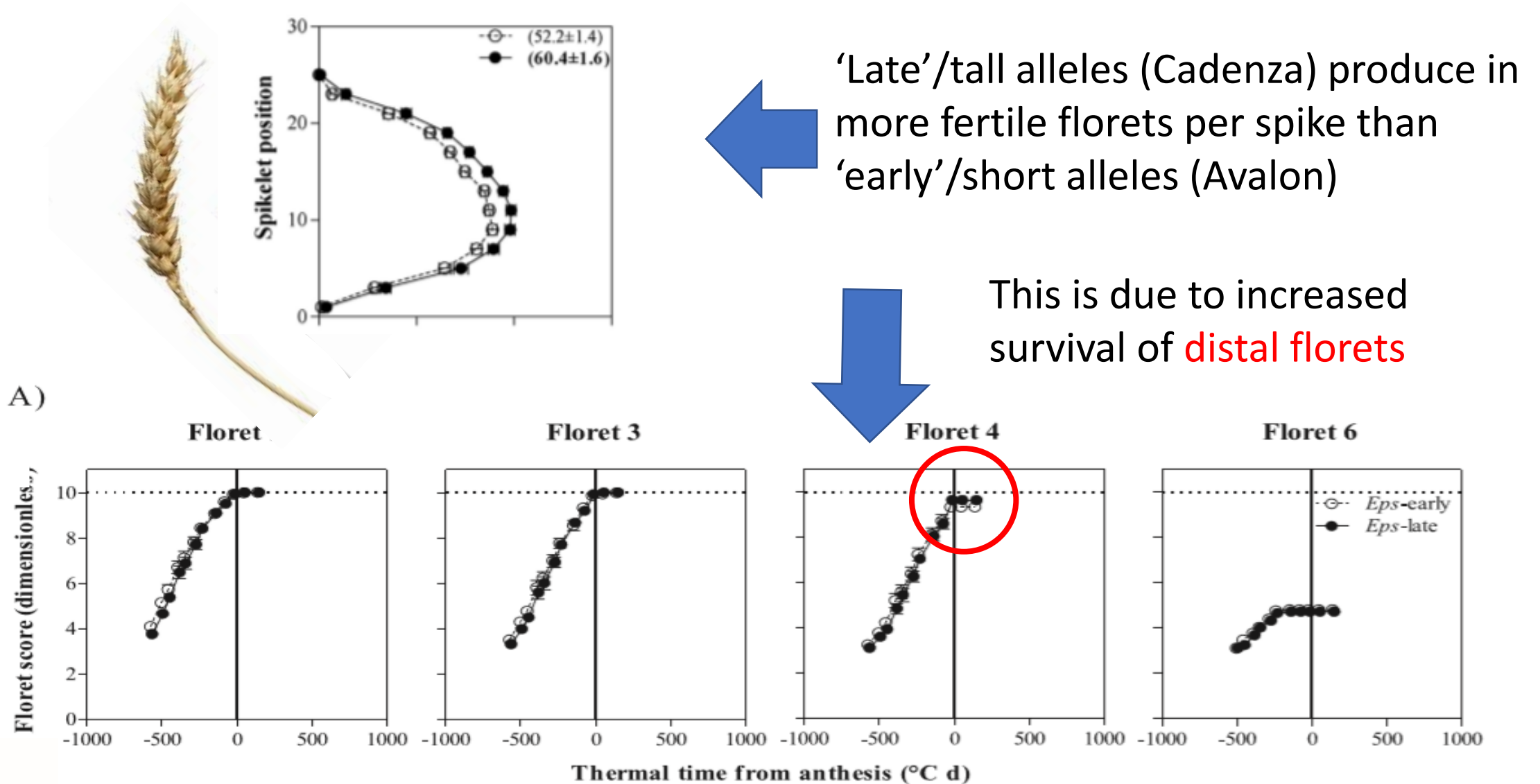
Phenotyping of Near Isogenic Lines



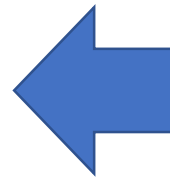
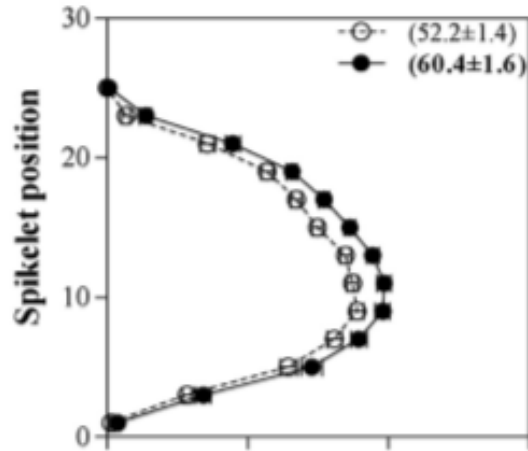
Fine Mapping of Traits



Dissection of Phenotype



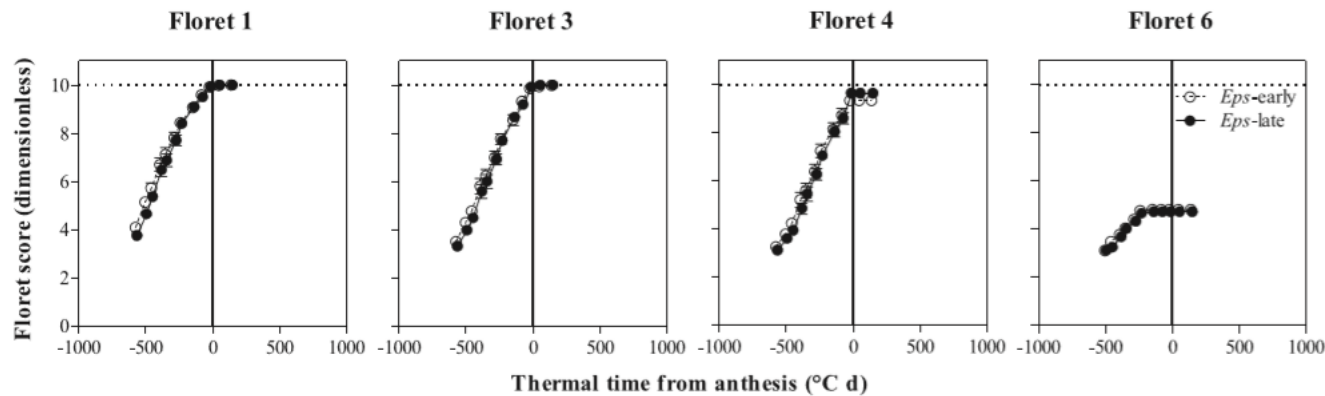
Dissection of Phenotype



'Late'/tall alleles (Cadenza) produce in more fertile florets per spike than 'early'/short alleles (Avalon)

This is due to increased survival of **distal florets**

A)



Identification of 3A QTL gene candidates

- Large region of CS sequence covering the three QTLs analysed (~160 Mb).
- Over 1000 genes are located in region
- Putative gene candidates for all three traits have been identified

Conclusion

- We will follow a similar plan in the analysis of the QTLs in Garcia which could give an advantage in drought conditions
- NIL production has already started for two of these but there are at least another two which should be initiated
- The Paragon x Garcia NILs and marker information are already available to breeders under a WGIN MTA