

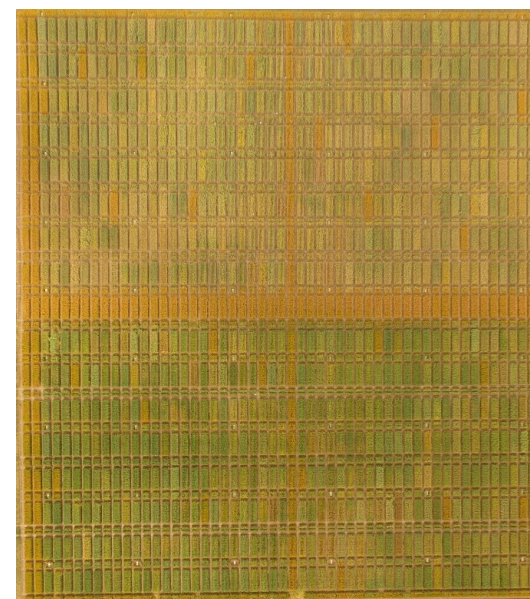
Developing Genetic Strategies for UK Drought Tolerance

WGIN Stakeholders Meeting
3rd March 2021

Clare Lister and Simon Griffiths

Introducing the Paragon x Garcia population

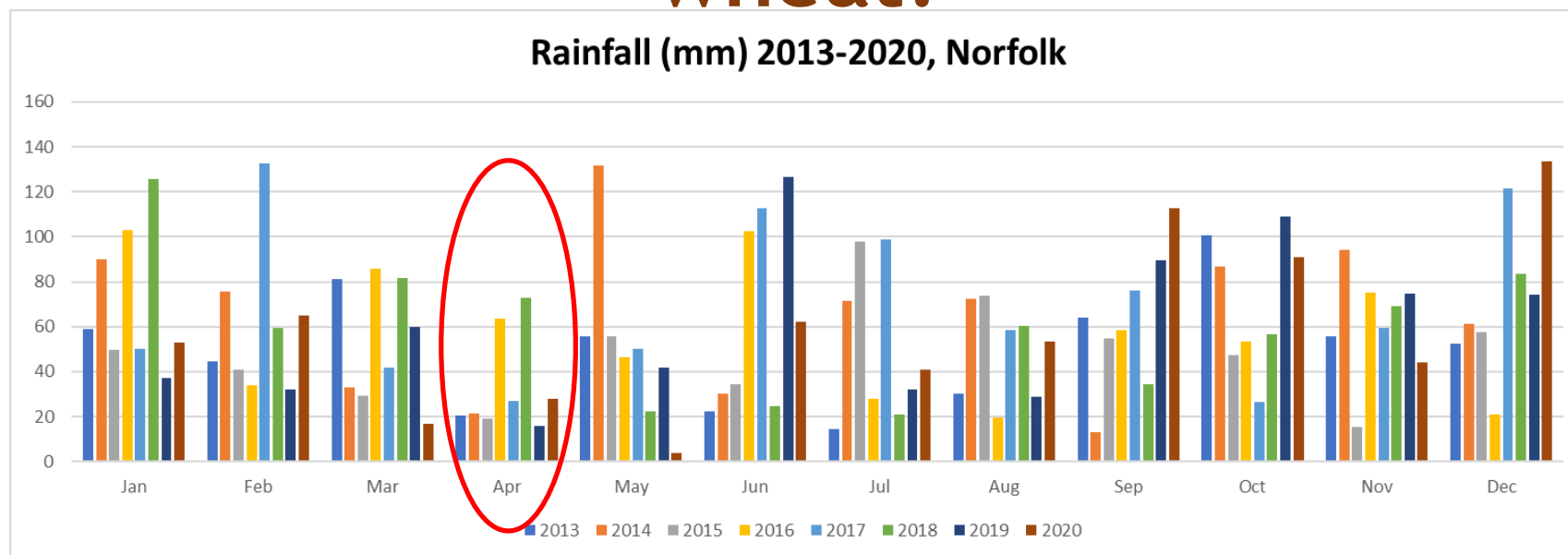
- The **Paragon** x **Garcia** Recombinant Inbred Line (RIL) population produced in WGIN to target UK drought
- **Paragon** - UK spring wheat
- **Garcia** - grown in southern France and northern Spain, adapted to drought stress
- Four years of drought trials in Norfolk.



NI
(Not
Irrigated)

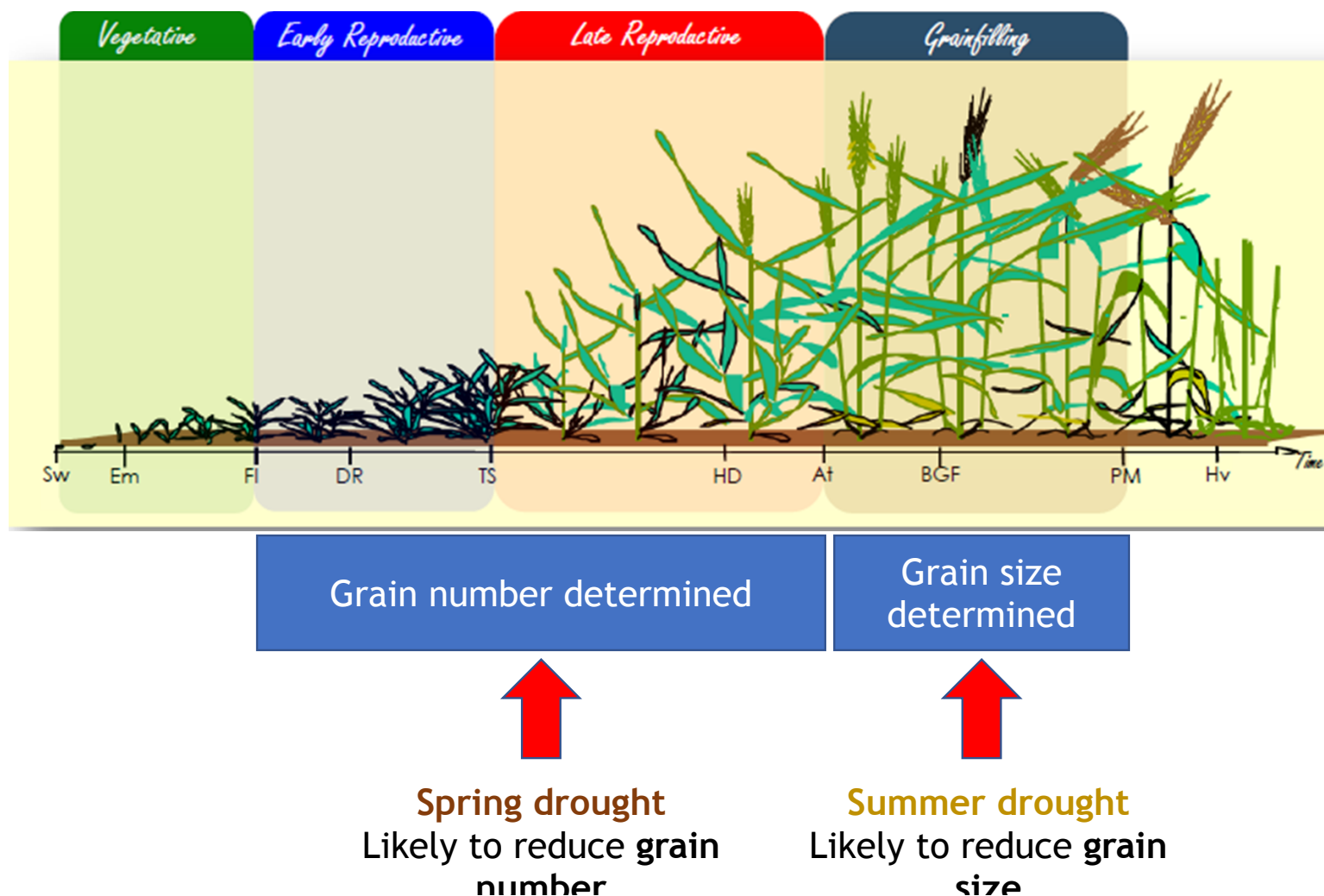
IR
(Irrigated)

When is drought a problem for UK wheat?



- Recent UK trend for low spring rainfall, especially in April
- In all years, except 2016 and 2018, total April rainfall was below 25mm
- April drought usually coincides with early to mid reproductive development

When is drought a problem for wheat?



Wheat coping strategies for UK drought?

Direct protection?

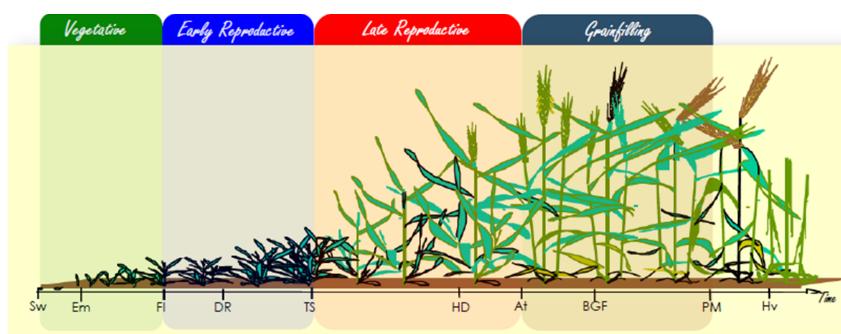
- e.g. reducing floret abortion during late reproductive phase
- e.g. maintaining grain size

Protection at early stage?

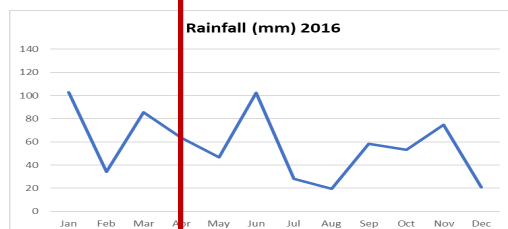
- e.g. increasing tiller number so grains/spike reduction affects yield less

Compensate later?

- e.g. enhanced use of summer rain to increase size of lower number of grains



Paragon x Garcia Experimental Years



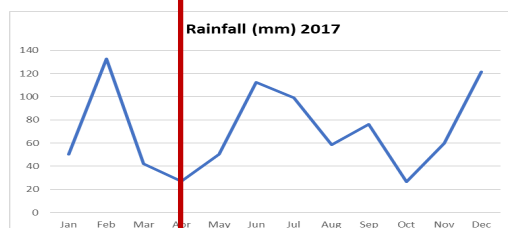
YLDNI_DT2016	YLDIR_DT2016
5.53	5.51
	-0.02

2016

Wet all season

Field 1 - Sandy Loam

No irrigation benefit



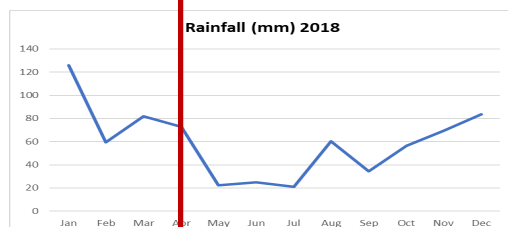
YLDNI_DT2017	YLDIR_DT2017
4.46	5.13
	0.67

2017

Dry April, following wet winter

Lowest yield year Field 2 - Very Sandy

Strongest % irrigation benefit



YLDNI_DT2018	YLDIR_DT2018
5.42	6.24
	0.82

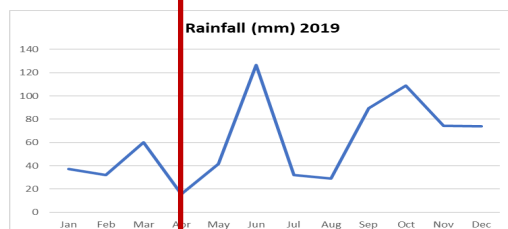
2018

Very wet winter and spring

Very dry summer.

Biggest yield benefit

Field 3 - Very Sandy



YLDNI_DT2019	YLDIR_DT2019
5.18	5.21
	0.03

2019

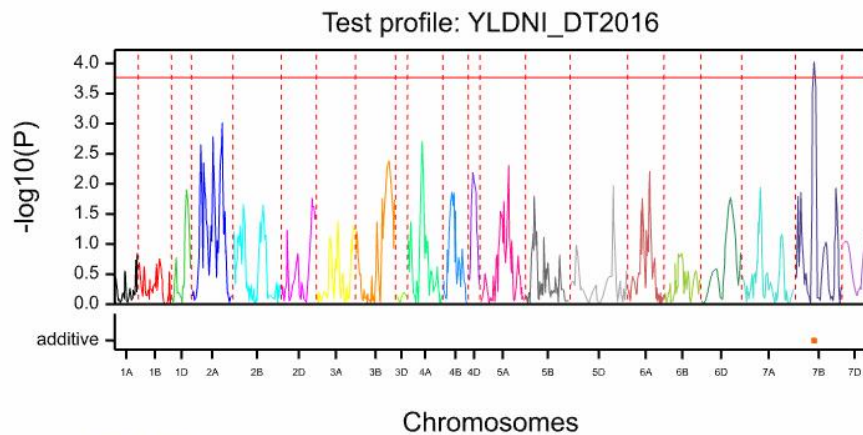
Dry winter and April, wet summer

No irrigation benefit

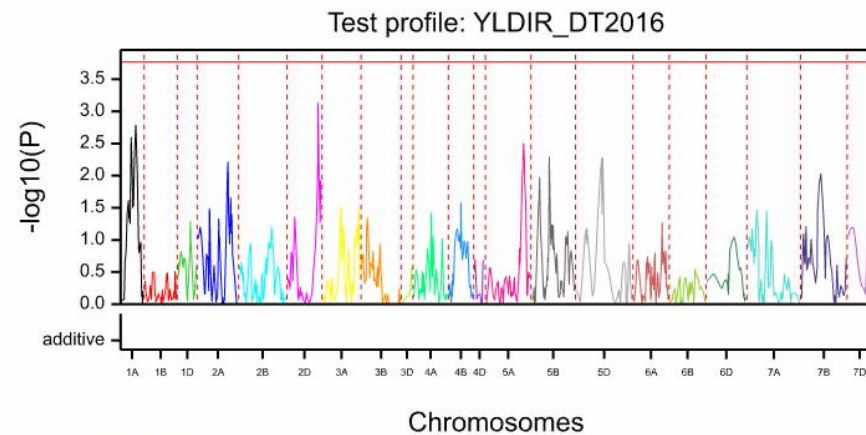
Field 1 - Sandy Loam

Yield QTL identified on 2B in Paragon x Garcia population

But not in 2016...



QTL effects:
additive (blue=Parent 1 ; yellow-red=Parent 2)



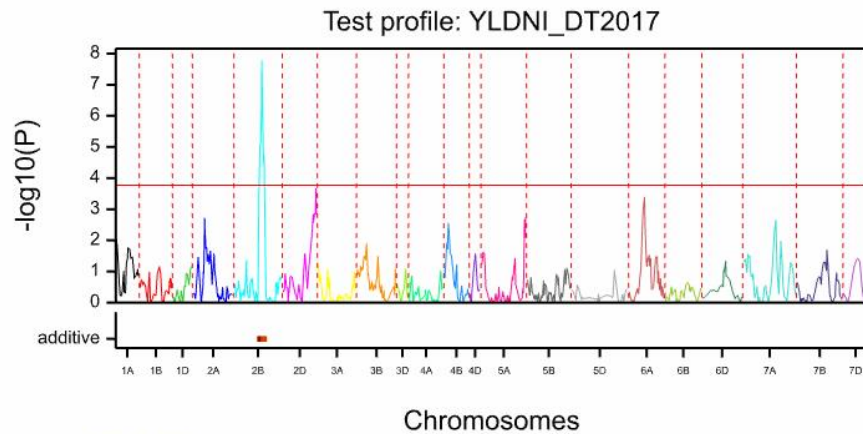
QTL effects:
additive (blue=Parent 1 ; yellow-red=Parent 2)

NOT IRRIGATED (NI)

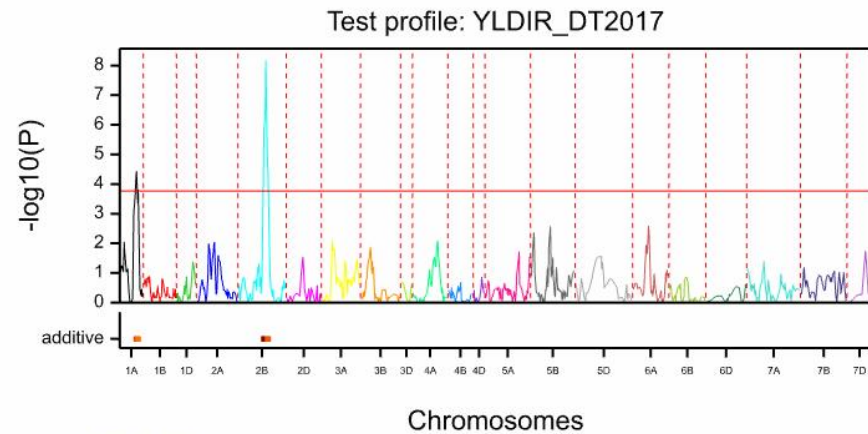
IRRIGATED (IR)

Yield QTL identified on 2B in Paragon x Garcia population

2017 - 2B yield QTL in NI and IR
Garcia alleles increased yield



QTL effects:
additive (blue=Parent 1 ; yellow-red=Parent 2)



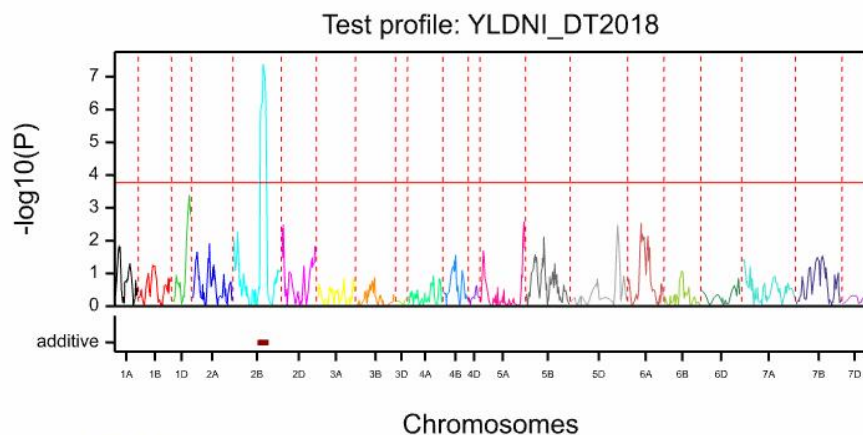
QTL effects:
additive (blue=Parent 1 ; yellow-red=Parent 2)

NOT IRRIGATED (NI)

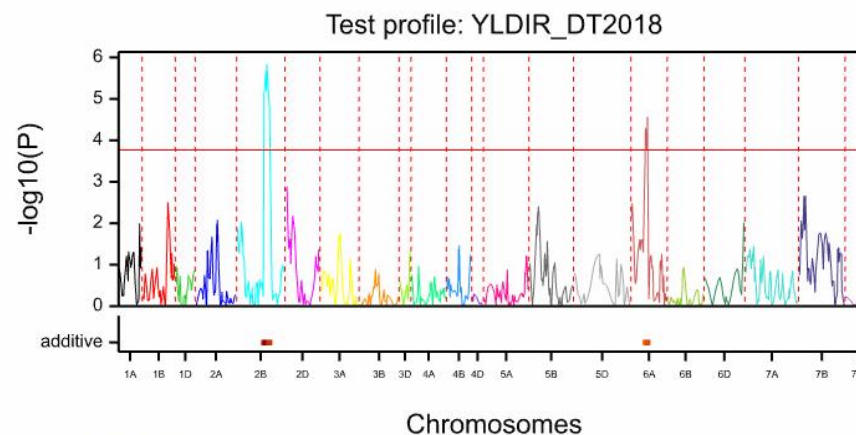
IRRIGATED (IR)

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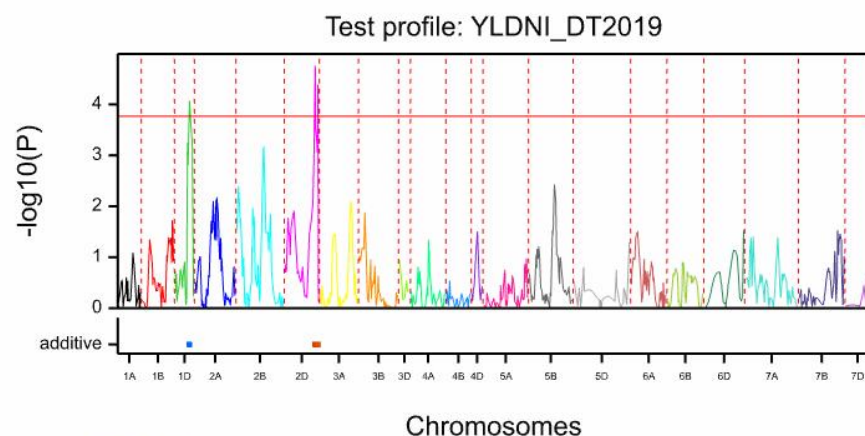
QTL effects:
additive (blue=Parent 1 ; yellow-red=Parent 2)

NOT IRRIGATED (NI)

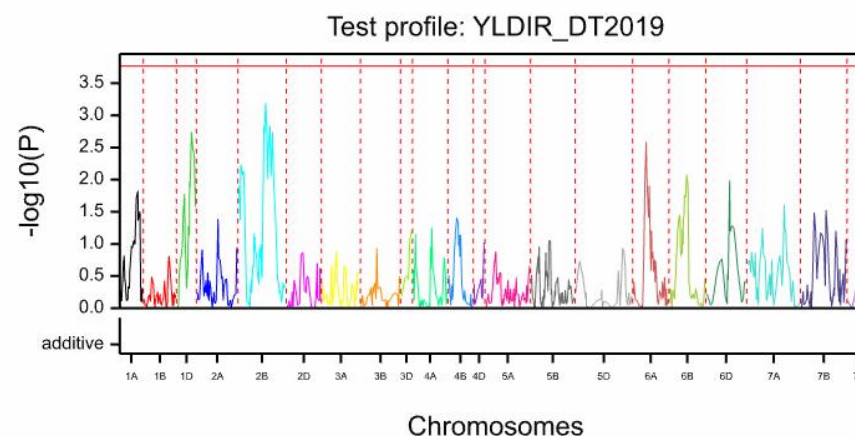
IRRIGATED (IR)

Yield QTL identified on 2B in Paragon x Garcia population

... or in 2019



QTL effects:
additive (blue=Parent 1 ; yellow-red=Parent 2)



QTL effects:
additive (blue=Parent 1 ; yellow-red=Parent 2)

NOT IRRIGATED (NI)

IRRIGATED (IR)

Is the 2B QTL particularly useful for UK drought tolerance?

YLDNI_DT20 17	Locus #	Locus Name	Linkage group	Position (cM)	$-\log_{10}(P)$	
	173	wsnp_JD_c47318_32176833	2B	142.1	7.175	633 Mb
					High value allele	
					Garcia	

YLDNI_DT20 18	Locus #	Locus Name	Linkage group	Position (cM)	$-\log_{10}(P)$	
	176	Excalibur_rep_c108662_13 2	2B	154.26	6.85	682 Mb
					High value allele	
					Garcia	

- The 2B QTL was particularly strong in irrigated seasons.
- However, the QTL was not NI specific in those seasons.
- Maybe this QTL is involved in temperature response (+/- irrigation)?
- Major effect - high LOD scores
- Potentially a good target for marker assisted selection in breeding.

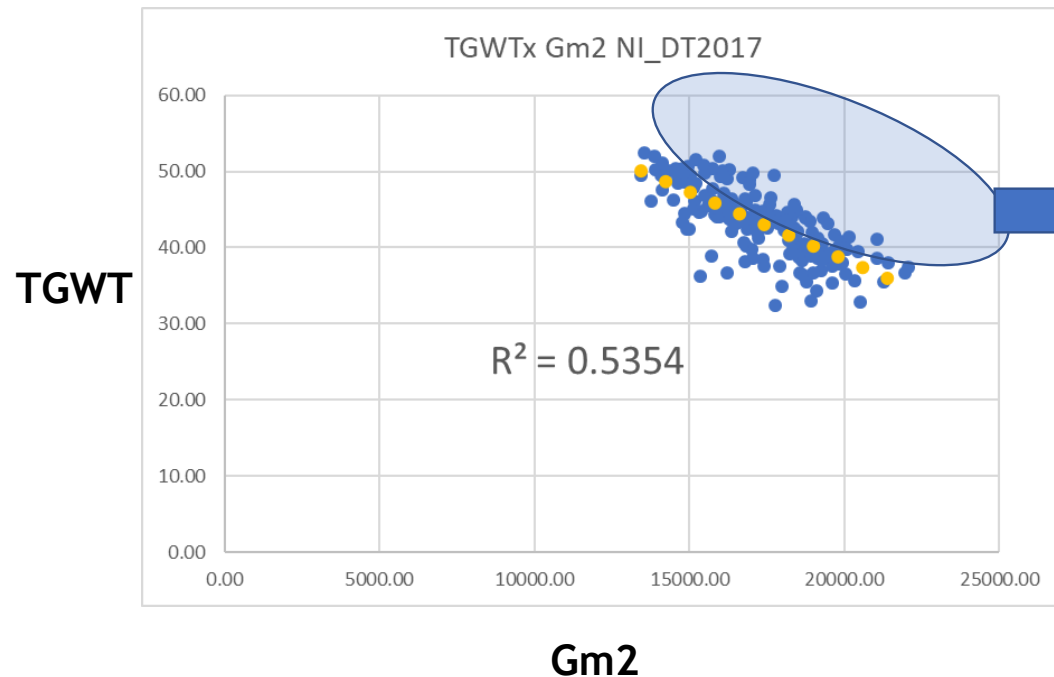
Which yield components are effected by the 2B QTL?

- This is important in understanding the mechanism of yield increase.
- But no significant QTL detected for grain size (TGWT) or number (Gm2)
- Maybe because both traits are increasing in Garcia?
- ... and individually they are relatively weak effects?

- Comparing the allelic phenotypic means at the 2B YLD QTL peak

Allelic marker	YLDNI_DT2017	YLDIR_DT2017	TGWTNI_DT2017	TGWTIR_DT2017	Gm2NI_D2017	Gm2IR_D2017
Paragon	4.31	4.93	42.94	41.45	16902.75	20037.01
Garcia	4.56	5.28	43.81	43.20	17464.78	20544.69
Effect	0.25 kg	0.34 kg	0.87g	1.74g	562.03	507.68

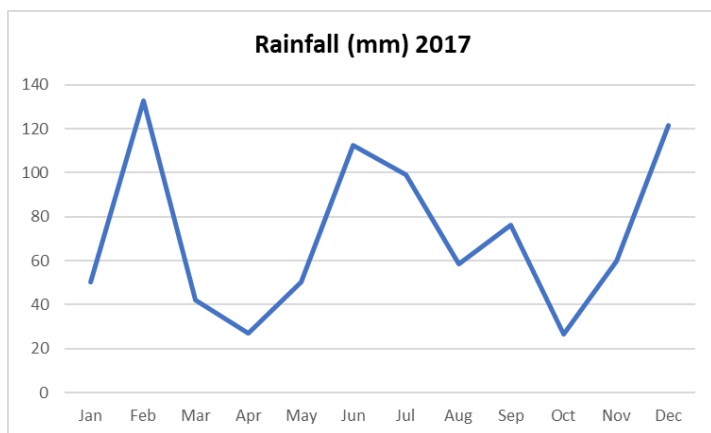
Unexpected effect of Garcia 2B YLD QTL



These lines have relatively high grain number *and* grain size

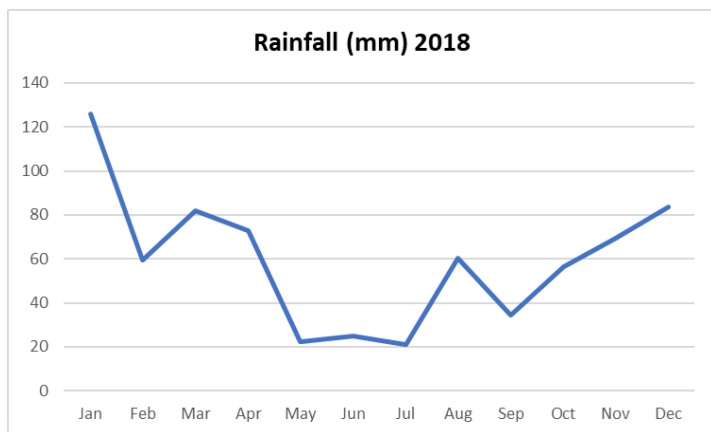
The Garcia 2B YLD effect therefore defies the usual *negative* correlation between grain size and number

Why would this **2B Garcia** QTL increase yield in 2017 and 2018?



Dry Spring versus Dry Summer

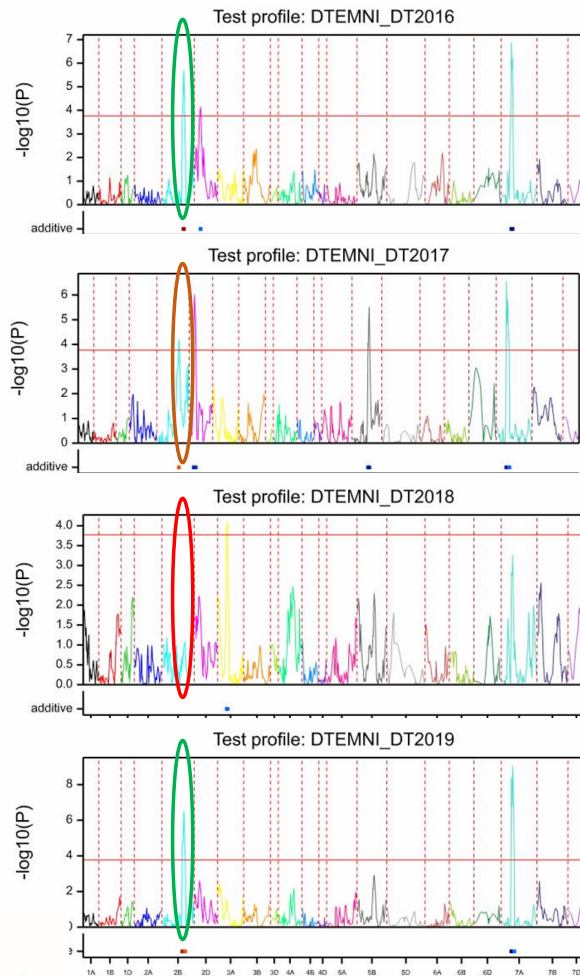
2017
Increases grain number in spring drought
then
Increases grain size in the summer rain



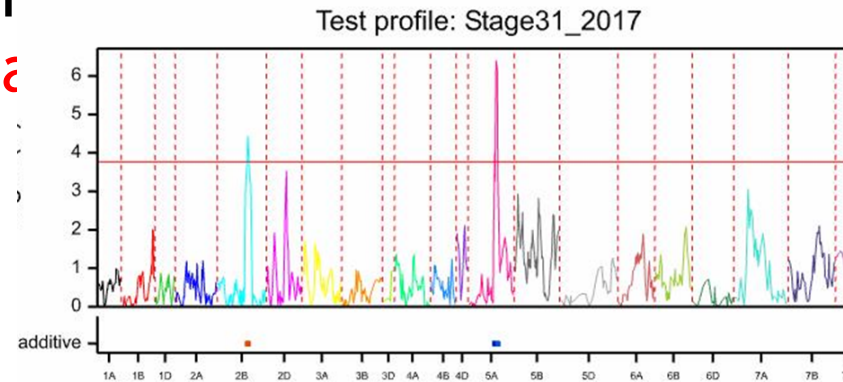
2018
Wet spring does not limit grain number
Maintains/increases grain size in dry summer

- Dual effect of the **2B Garcia** allele is beneficial
in both scenarios; dry spring *and* dry

What else maps to this 2B locus?



- Growth Stage 31 is onset of stem extension
- 2B QTL detected at GS31
- Heading date QTL at same location as yield QTL
- Garcia carries the late heading allele
- In the years that the yield QTL is detected, 2017 and 2018 heading date QTL is weak or **or**



So what is the 2B Garcia QTL doing?

- Could the early slowing of development in April reduce drought impact?
- How could these developmental changes influence subsequent grain size?
- Maybe grain filling can be prolonged due to later flowering?
- Heading date QTL - genetically linked but could be physiologically distinct from the yield effect.

We suggest that Garcia increases yield in drought conditions by adjusting the timing of spike development

What next?

- **2B Garcia** allele was nominated for the DFW Breeders Toolkit
- Lines identified with **Garcia** or **Paragon** at locus
- NILs in 1 m² plots for seed bulking
- Yield trial autumn 2021 - which will have the higher yield?
- Will there be a phenology effects: GS31, booting, heading, grain fill?
- Will selection for **2B Garcia** alleles increase drought resilience of UK wheat??

Collaboration with RothRes

- Four years of thermal measurements of drought trials at JIC
- PxG RILs from drought trial currently under Scanalyzer

Acknowledgments

Griffiths Group

Simon Griffiths

Simon Orford

Monika Chhetry

Luzie Wingen

JIC Field Experimentation

Cathy Mumford

Chris Allen

Rich Samworth

Kevin Crane

Stephen Johnson

Luke Dewing

Becca Lee

Darryl Playford

Rothamsted Research

Malcolm Hawkesford

Andrew Riche

March Castle

Nicolas Virlet

Pouria Sadeghi-Tehran

Adam Michalski (Poland)

THANK YOU!

Past members