This Year and Beyond…!

WGIN Management Meeting 27/11/2020

Clare Lister, Alfie Kidner, David Norris and Simon Griffiths

Wheat Genetic Improvement Network

John Innes Centre

Trial Summary

- **DALP** (Drought, Anchorage and Lodging Panel)
- **RIL subsets** from NAM populations -> Population selection
- **Rht x Winter Paragon** (RhtB1 / RhtD1 /Rht8 x Vrn1A+Vrn1B)
- **Rht x Rht** (RhtB1 x Rht8 / RhtD1 x Rht8 / RhtB1 x RhtD1)
- **4A DTEM** (NILs from Ava x Cad, 4A DTEM QTL),
- **(Slug resistance** – Watkins 788)

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DALP 2019-2020

- CIMMYT lines and SATYN panel
- Elite varieties
- Roth Res and JIC lines
- DFW Breeders TK H17 and H18
- EMS semi-dwarves
- Selected Paragon x Garcia RILs
- Watkins – all founder parents of NAM populations
- Other parents of available populations

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DALP 2019-2020

- All (except one) parents of NAM populations present in DALP
- ~ 230 lines + / - irrigation
- Spaced plants in 6m plots - irrigate with boom
- Usual phenotyping (DTEM / HT / YLD)
- Lodging scores
- Anchorage tests

DALP 2020-2021

- We were going to abandon DALP but…late change of mind!
- 178 lines in 6m plots, 1 randomized rep each + / - spring irrigation
- Usual phenotyping (DTEM / HT / YLD)
- Lodging scores
- Stem stiffness

RIL subsets 2019-2020

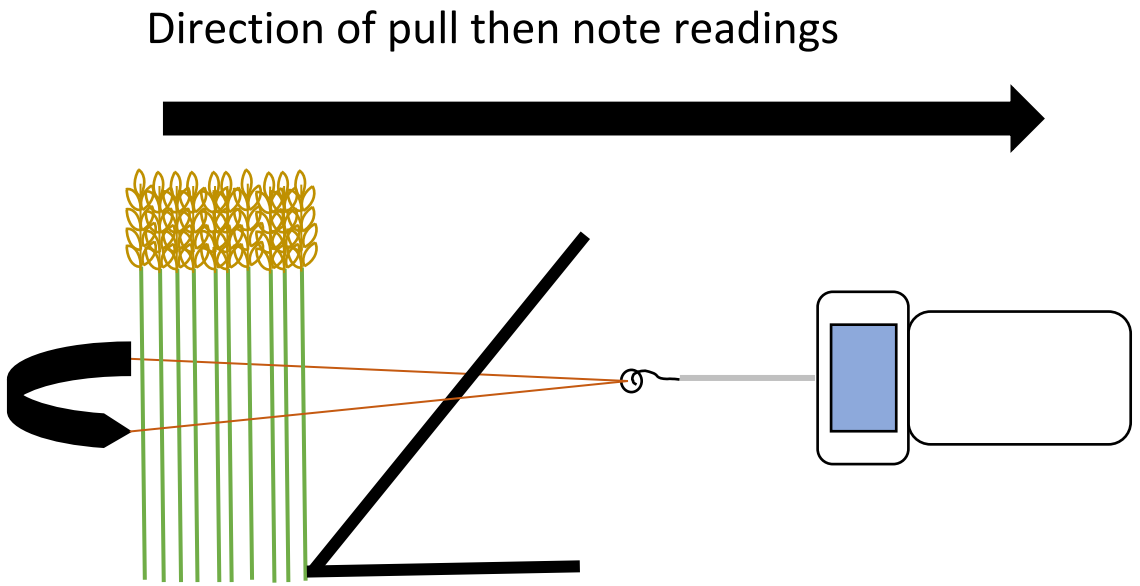
- Selection of RILs similar to Paragon 'benchmark' from NAM populations
- 466 selected from 52 populations
- Drilled in 1 m plots, randomized design, single rep
- Phenotyping:
  - DTEM, HT
  - Lodging – most of it was stem lodging, none observed in Paragon
  - Stem stiffness (concentrated on populations with good standing power) – Alfie Kidner

ed data to select two populations for autumn 2020 trials

AK - Relevance of stem strength

Primary concern is lodging:	Improved nutrient transfer:	Less reliance on roots for strength:
• Stem weakness -> increased susceptibility to weather conditions • High rates of lodging reduces crop yield and quality • Requires greater harvest effort	• Stronger stems more resistant to damage. • Greater transfer efficiency of water, glucose and nutrients throughout plant	• Stem stiffness could compensate for root issues or soil restrictions • Conversely it could exacerbate root lodging?

AK - Testing stem strength in the Field

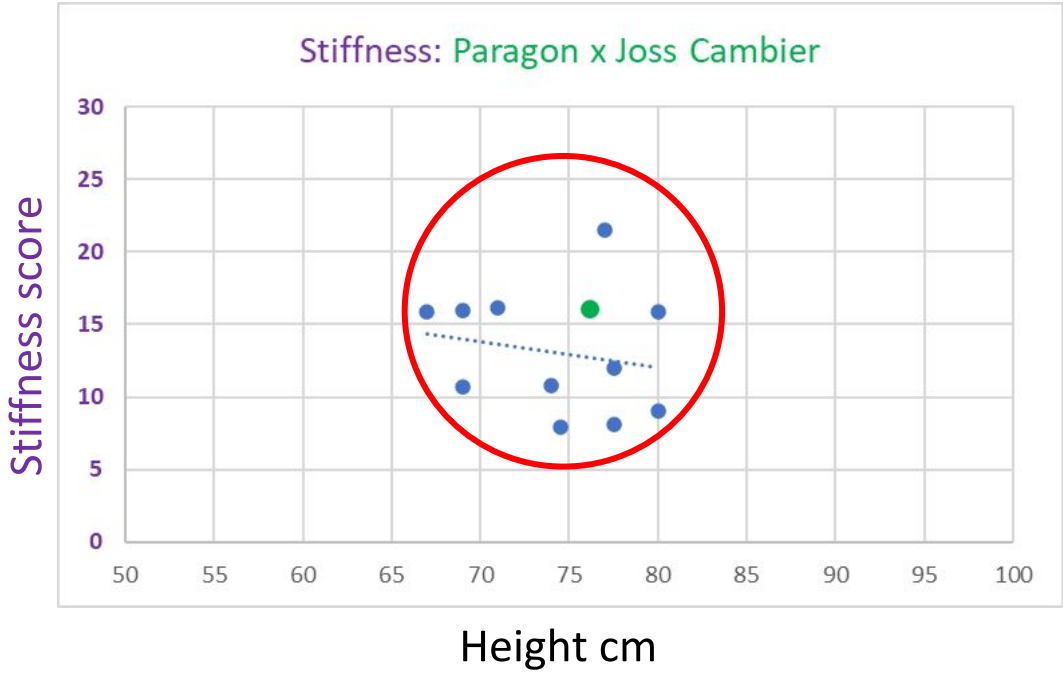


- Kit used:
  - Wooden frame (constructed to 45°)
  - Rubber and twine sling
  - 20N pull-force gauge

- Method:
  - Select a representative plant in plot
  - Place frame at the base (slope facing the plant)
  - Gather 10 stems
  - Place rubber around the stems (at 10 cm from ground) and connect sling to the force gauge
  - Pull gauge until stems are lying on/parallel to slope
  - Record values observed to achieve 45° between stem and ground

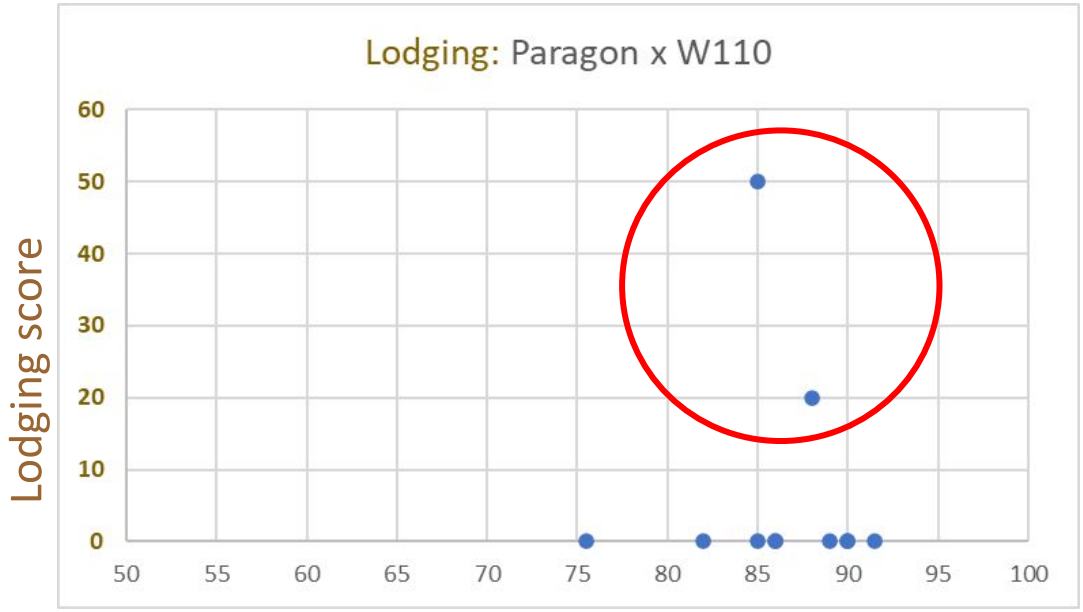
Paragon x Joss Cambier

Joss Cambier - Scottish winter wheat
Straw wall-thickness defined as ‘thin’



Paragon x Watkins 110

Watkins 110 - French winter wheat
Spectacularly tall!



Paragon x Watkins 110

Watkins 110

Approximately 1.4 m tall in summer 2020 (Paragon 80-85 cm)

Very upright with thick stems

Any lodging very close to harvest

Huge seed!

RILs 2020-2021

Paragon x Joss Cambier

- 3 randomized reps, 6m plots
- Early drilling and lots of fertilizer and no PGR to encourage lodging!

Paragon x Watkins 110

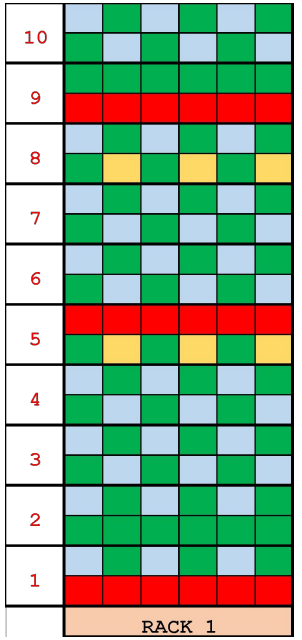
- 3 randomized reps, 1 m plots
- Offset rows but with Paragon between

Phenotyping

DTEM, HT, YLD

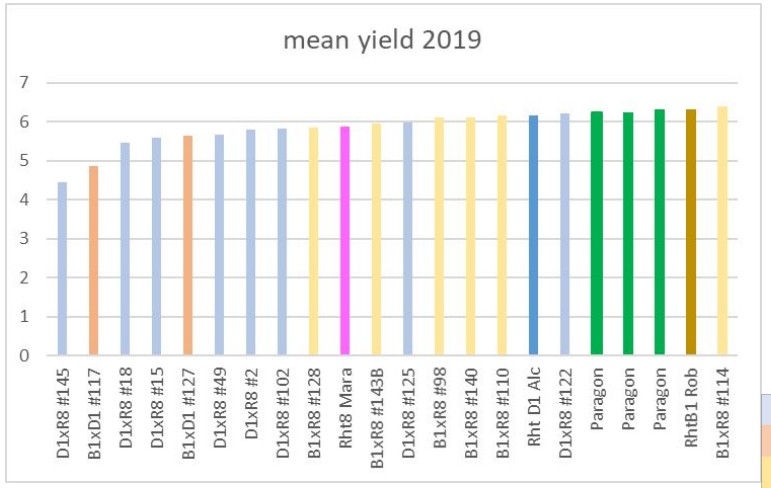
Lodging and Stem stiffness

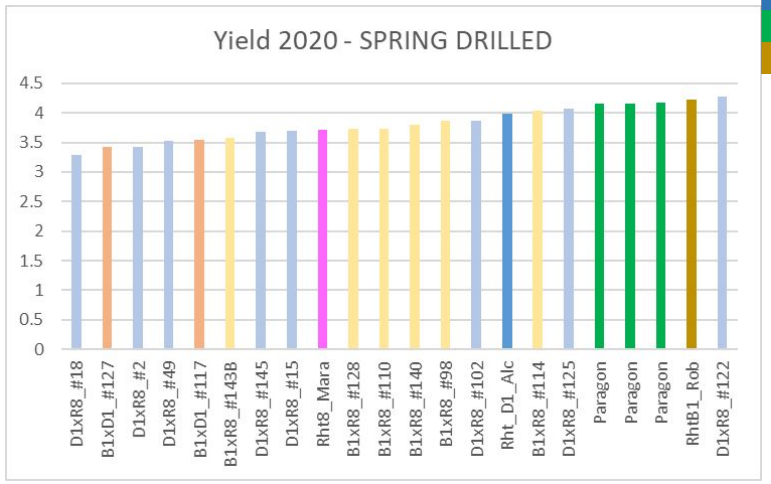
-> QTL mapping

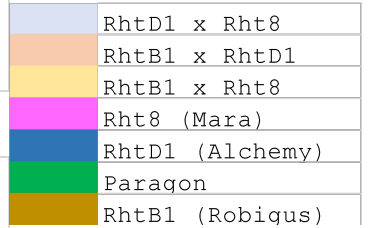


Rht1 x Rht8 2019-2020

- 3rd year of trial
- *Rht8* x *RhtB1* or *RhtD1* in Paragon
- *Rht1* has similar yield to Paragon
- *Rht8* lower yield than *Rht1*
- Addition of *Rht1* reduces yield of *Rht8,* particularly *RhtD1*
- Lower yield in all from spring drilling







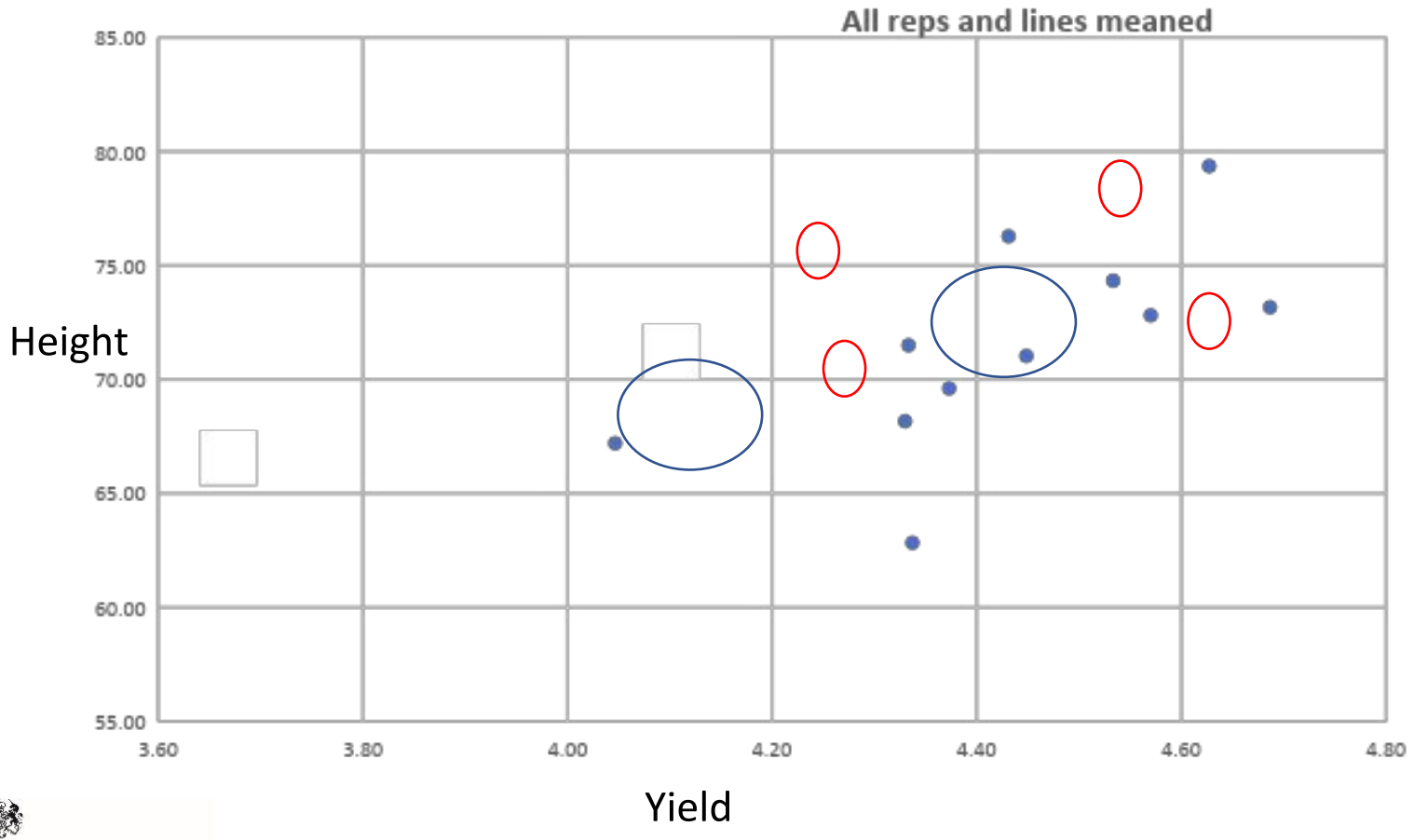
Rht x Vrn 2019-2020

- *RhtB1* and *RhtD1* in Paragon background
- Expected to reduce height ✔ and increase yield **X**

- 'Winter Paragon' produced by crossing in *VrnA1* + *VrnB1* from Malacca
- Increased yield compared to Paragon observed in initial trials
- Subsequently crossed into *Rht8* / *RhtB1* / *RhtD1* to produce winter, semi-dwarf lines

Rht x Vrn 2019-2020

Ist year of trial – Church Farm rather than Morley



	Paragon
	Soisson
	Winter Paragon (Vrn1A + Vrn1B)
	RhtD1 from Alc in Par
	RhtD1 x Winter Par crosses

	RhtB1 from Saitama in Par
	RhtB1 Sait x Winter Par crosses
	RhtB1 from Robigus in Par
	RhtB1 Rob x Winter Par crosses

Slight increase in yield

RhtD + *Vrn* v *RhtD1*

RhtB1 (Rob) + *Vrn* v *RhtB1* (Rob)

Rht x Vrn 2019-2020

Dissecting components of the plants affecting yield differences (AK) in *Rht1* / *Rht* + *Vrn* / control plants

1 m section hand-harvested
Spikes counted
20 random stems

- Ear length in the 20
- Measure all internodes
- Count spikelets
- Thresh ears - weigh grain and chaff separately
- Marvin grain

Same process with remainder of samples

→ Biomass, harvest index, spike index, spikes per m2, grains per m2, grains per ear, grains per spikelet, yield, internode partitioning

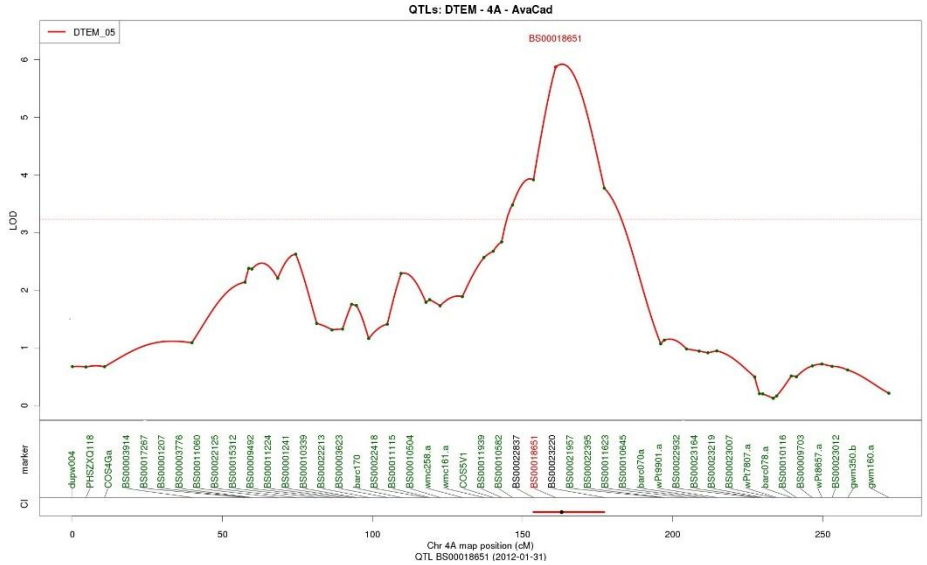
Data still being analysed…

Rht x Vrn 2020-2021

- Repeat, fewer lines, more controls, 5 reps

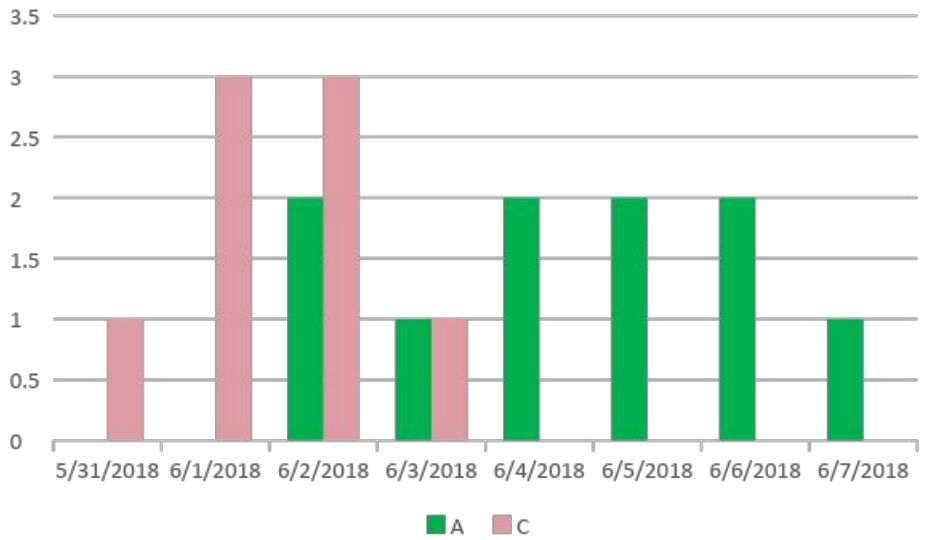
4A DTEM

- QTL on 4A for DTEM in AxC NILs
- Only identified when Axiom mapping data gave better coverage of chromosome 4A
- Possibly *PhyB*



- Lines homozygous for the QTL region in an Avalon or Cadenza background have been identified

4A DTEM



4A DTEM 2020-2021

- 3RD Year of yield trial

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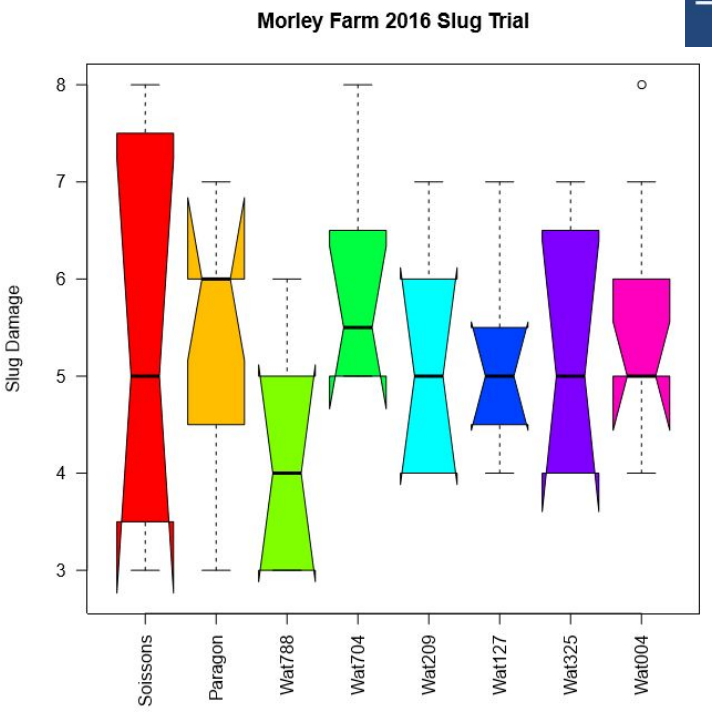
Slugs

- Work by Griffiths group and JIC Insectary showed that Watkins 788 has high slug resistance

- Great interest from farmer Tom Allen-Stevens! (of Crop Production Magazine)

- Runs **BOFIN** (British On-Farm Innovation Network) http://bofin.org.uk/



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Slugs

Current projects

If you'd like to be involved in any of these projects, please contact tom@bofin.orguk

Sept 2020 – BOFIN is working with John Innes Centre and Rothamsted Research to find farmers interested in growing wheat that may be naturally resistant to slugs. The wheat is a landrace variety, of little commercial value other than this potential trait that's been identified through lab trials as part of the BBSRC-funded Designing Future Wheat pre-breeding programme. Around six participating farmers would grow a 0.4ha plot of wheat in a field known to be prone to slugs in 2021/22 season as part of a FarmInn project. The aim of the project would be to assess to what extent the wheat resists slug-foraging activity.

- However we need to bulk up to **50 kg for farm-scale tests**!!! (from about 1 kg of stock…) 🤣
- **2020-2021** – 4 X 6m plots for bulking, but will require another round in 2021-2022…

Summary

TRIAL	2020-2021	2021-2022	2022- harvest 2023 ?
DALP (+/- IRR)	1ST YEAR	2ND YEAR	3rd YEAR
Par x Joss Cambier	1ST YEAR	2ND YEAR	3rd YEAR
Par x Watkins 110	1ST YEAR (1m)	1ST YEAR (6m)	2ND YEAR
Rht1 / Rht8 x Winter Paragon	2ND YEAR	3rd YEAR	
4A DTEM	3rd YEAR		
RIL subsets (+/- IRR)?		?	?

Height genes on chromosome 2D

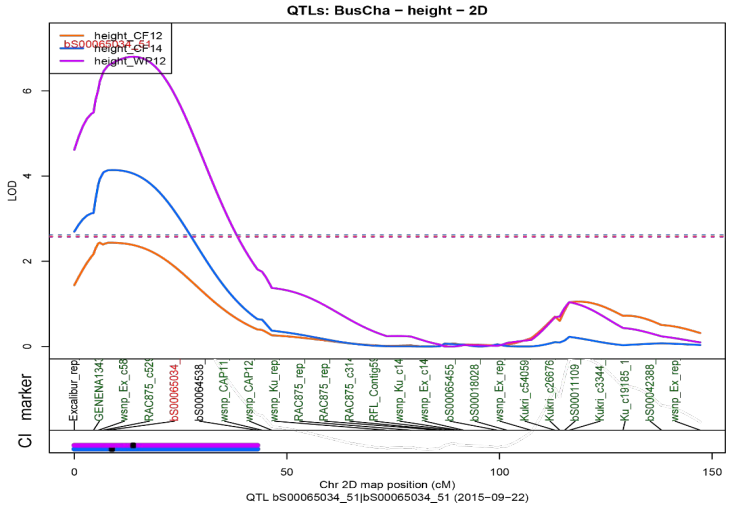
JIC WGIN management update

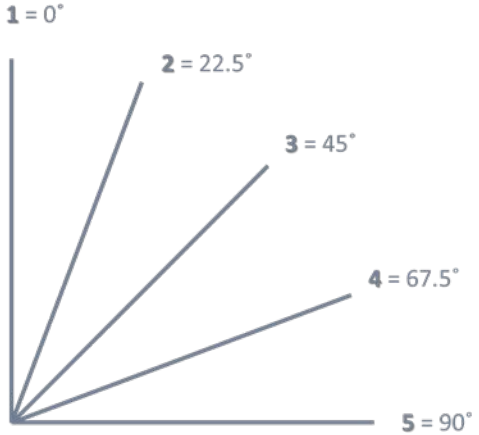
26th Nov 2020

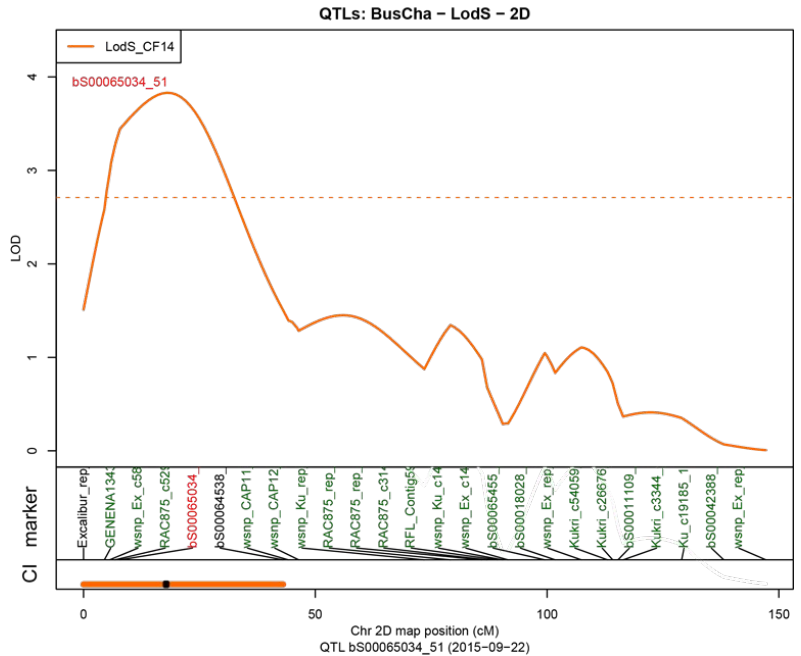
Why do height QTL matter?

1. Because they are there! Why haven't breeders selected hard against eg some height increasing alleles.
2. Increased height causes lodging.
3. Increased height is linked to beneficial traits.
4. There might be potential for the use of alternative (to Rht1) semi dwarfing alleles in UK breeding.
5. Today, focussing on 2D height effects.

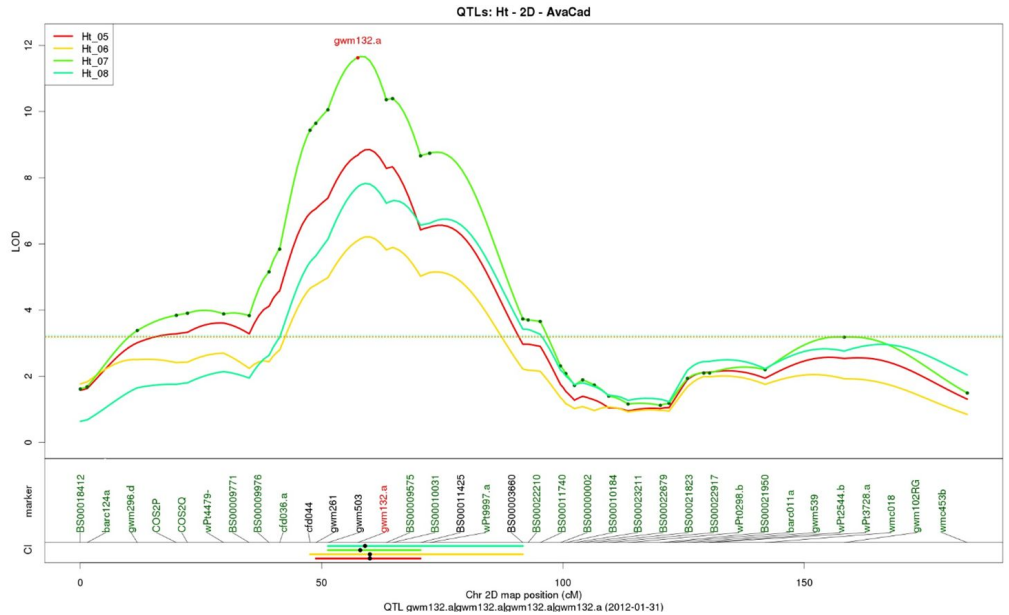
The lodging link – Buster x Charger

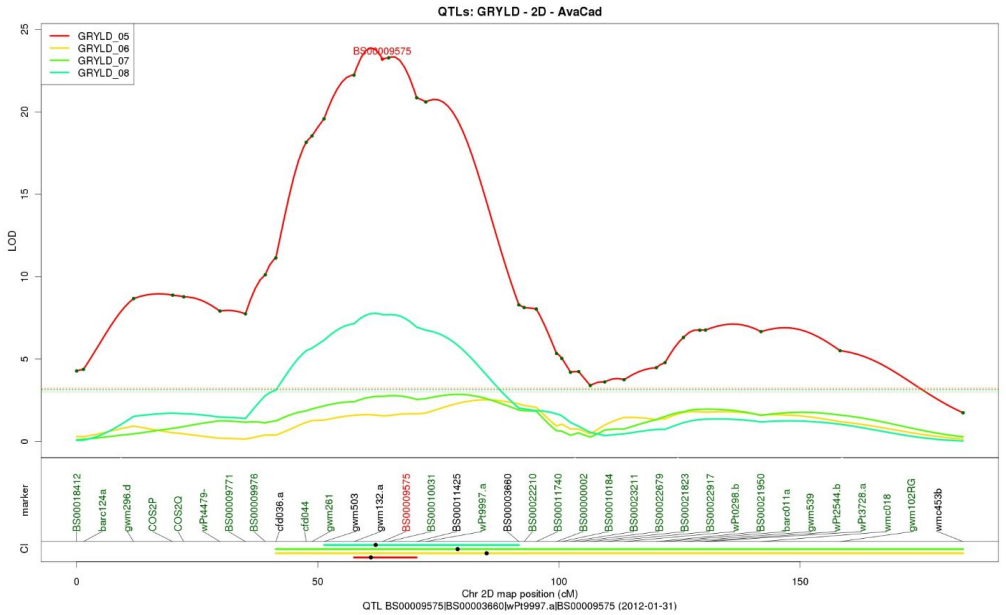






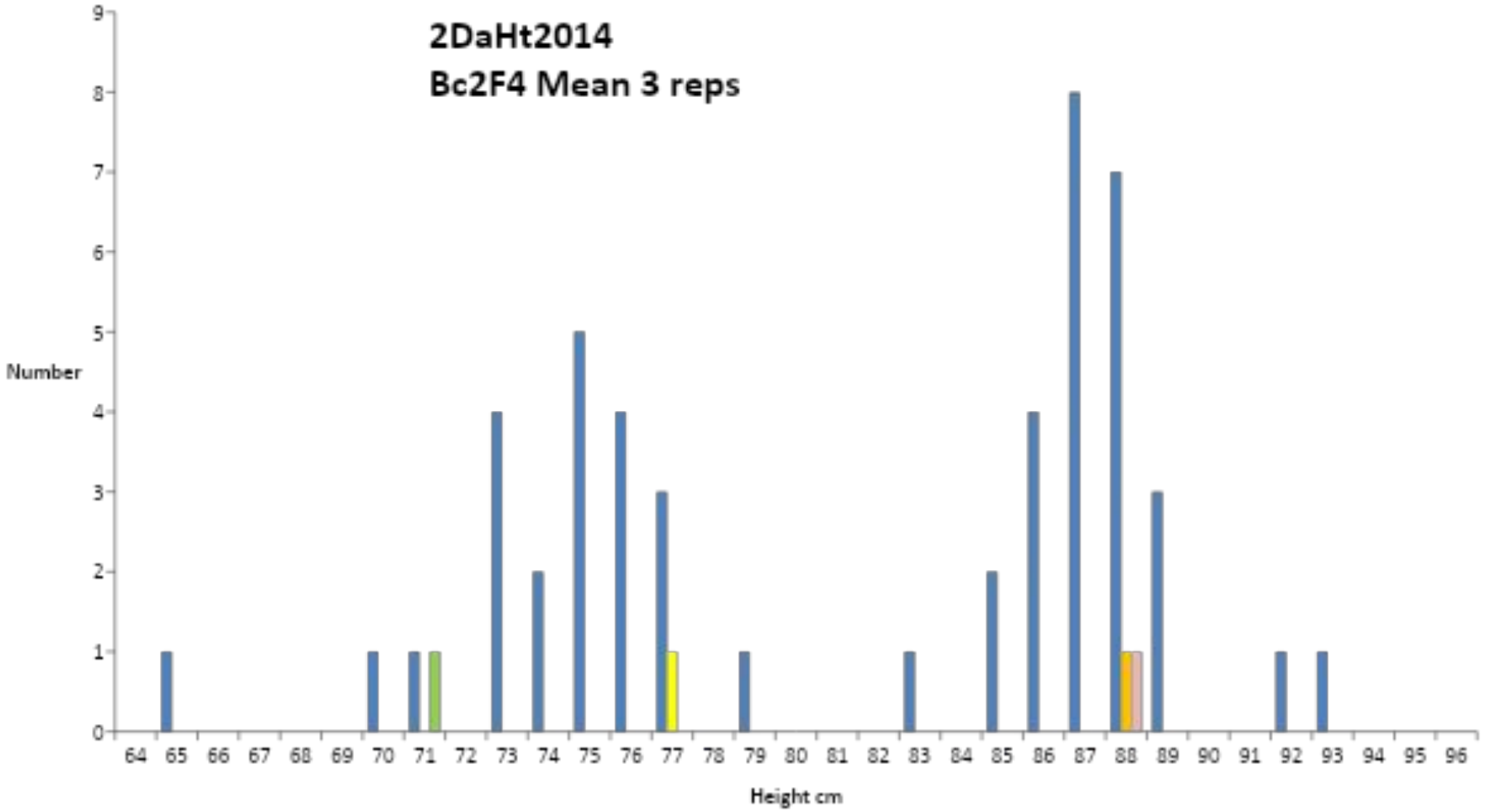
Yield and height- Avalon x Cadenza example



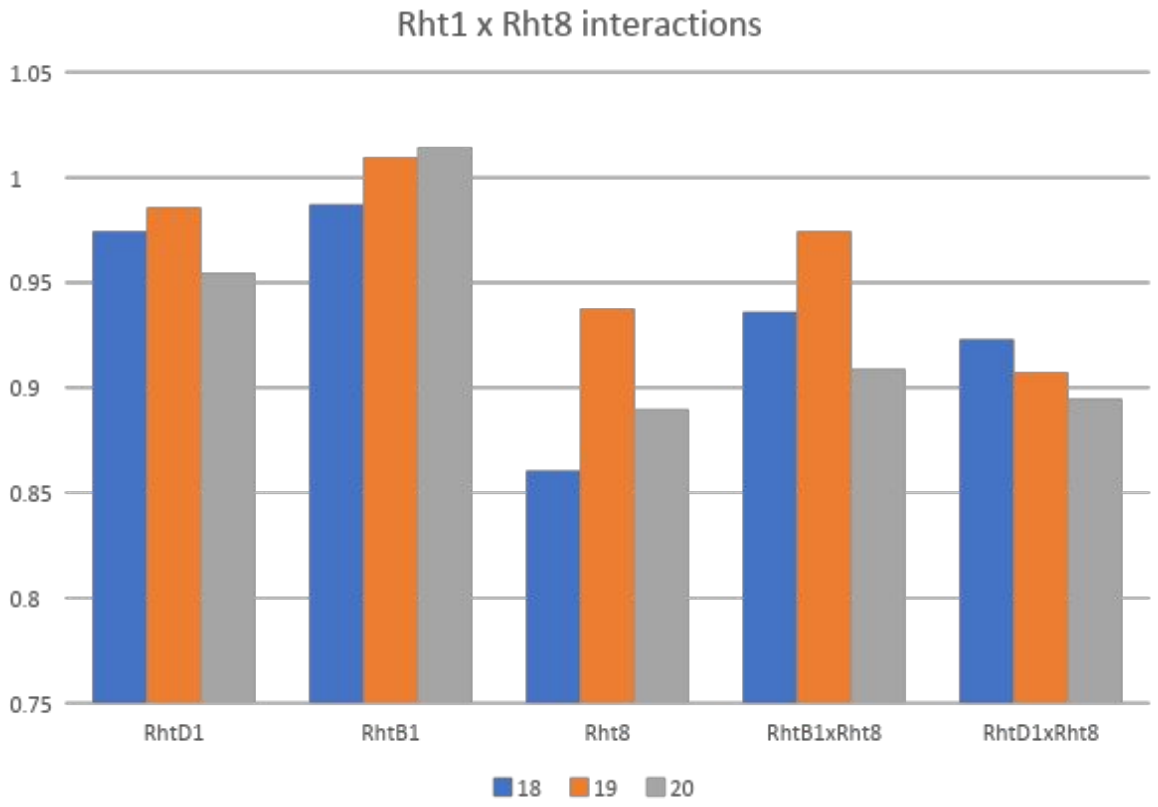


Linkage or pleiotropy?

Fine mapping of Avalon x Cadenza 2D height



Not a promising start for sesqui-dwarfs in the UK



ELSEVIER

Field Crops Research

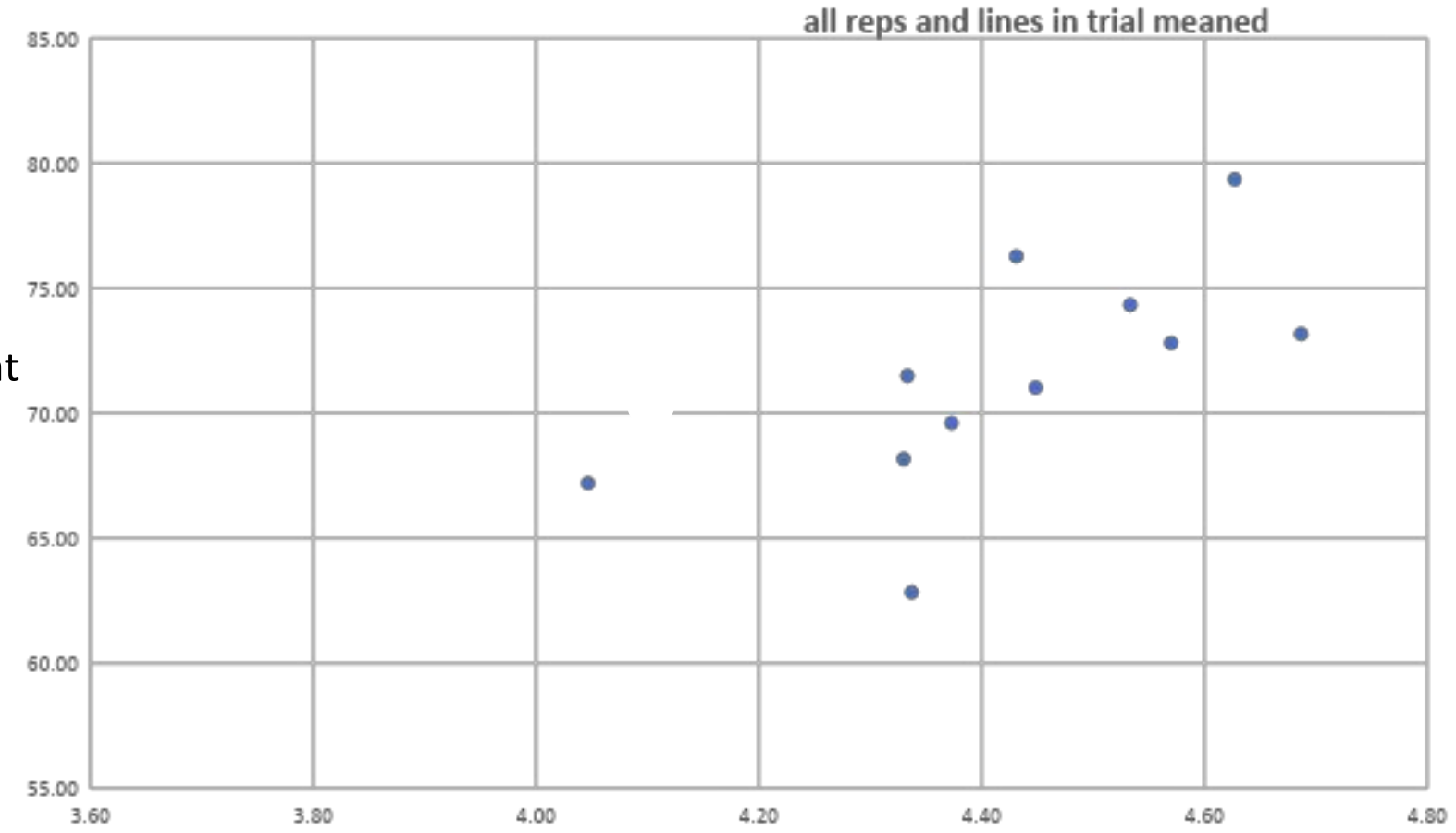
Volume 127, 27 February 2012, Pages 17-25

Combining gibberellic acid-sensitive and insensitive dwarfing genes in breeding of higher-yielding, sesqui-dwarf wheats

G.J. Rebetzke, D.G. Bonnett [1], M.H. Ellis [1]

Show more

Is it a spring wheat problem?



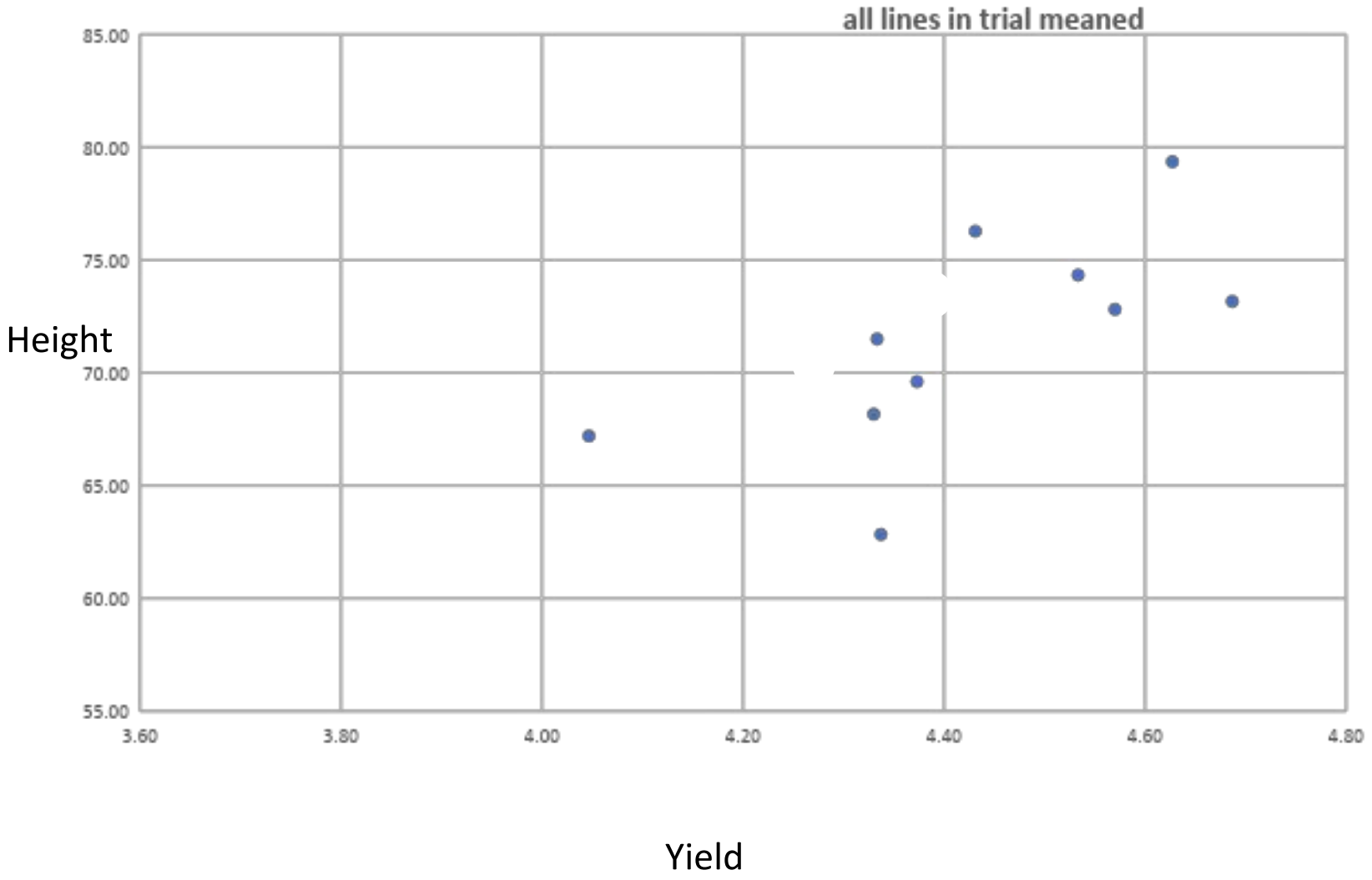
Height

Yield

	Paragon
	Soisson
	Winter Paragon (Vrn1A + Vrn1B)
	RhtD1 from Alc in Par
	RhtD1 x Winter Par crosses

	RhtB1 from Saitama in Par
	RhtB1 Sait x Winter Par crosses
	RhtB1 from Robigus in Par
	RhtB1 Rob x Winter Par crosses

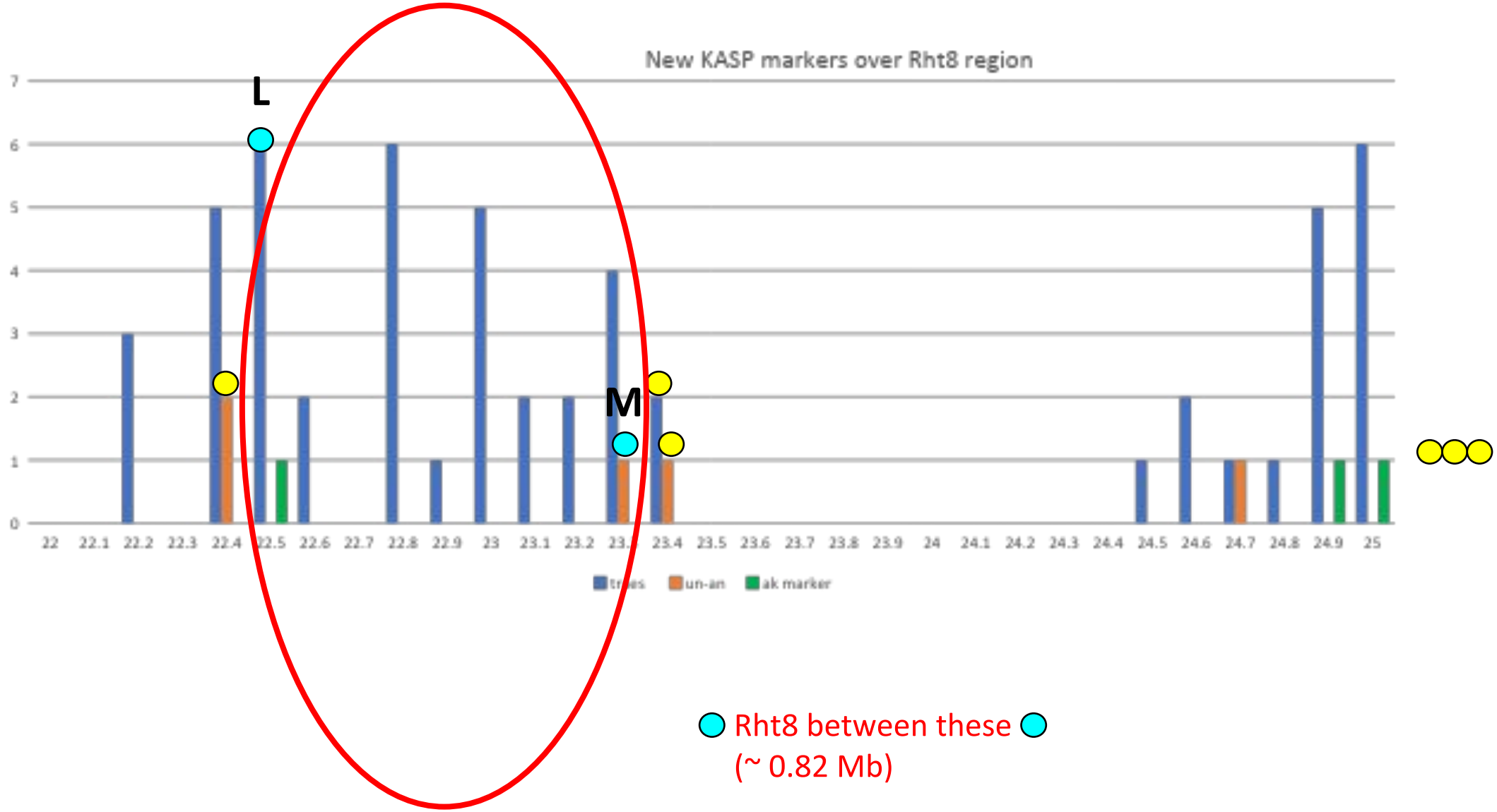
Converting to winter growth habit makes *Rht8* even worse….



	Paragon
	Soisson
	Winter Paragon (Vrn1A + Vrn1B)
	RhtD1 from Alc in Par
	RhtD1 x Winter Par crosses
	RhtB1 from Saitama in Par
	RhtB1 Sait x Winter Par crosses
	RhtB1 from Robigus in Par
	RhtB1 Rob x Winter Par crosses
	Rht8 from Mara in Par
	Rht8 x Winter Par crosses

Repeating this trial in Novi Sad, Lleida, and Zurich

Getting very close to cloning *Rht8*



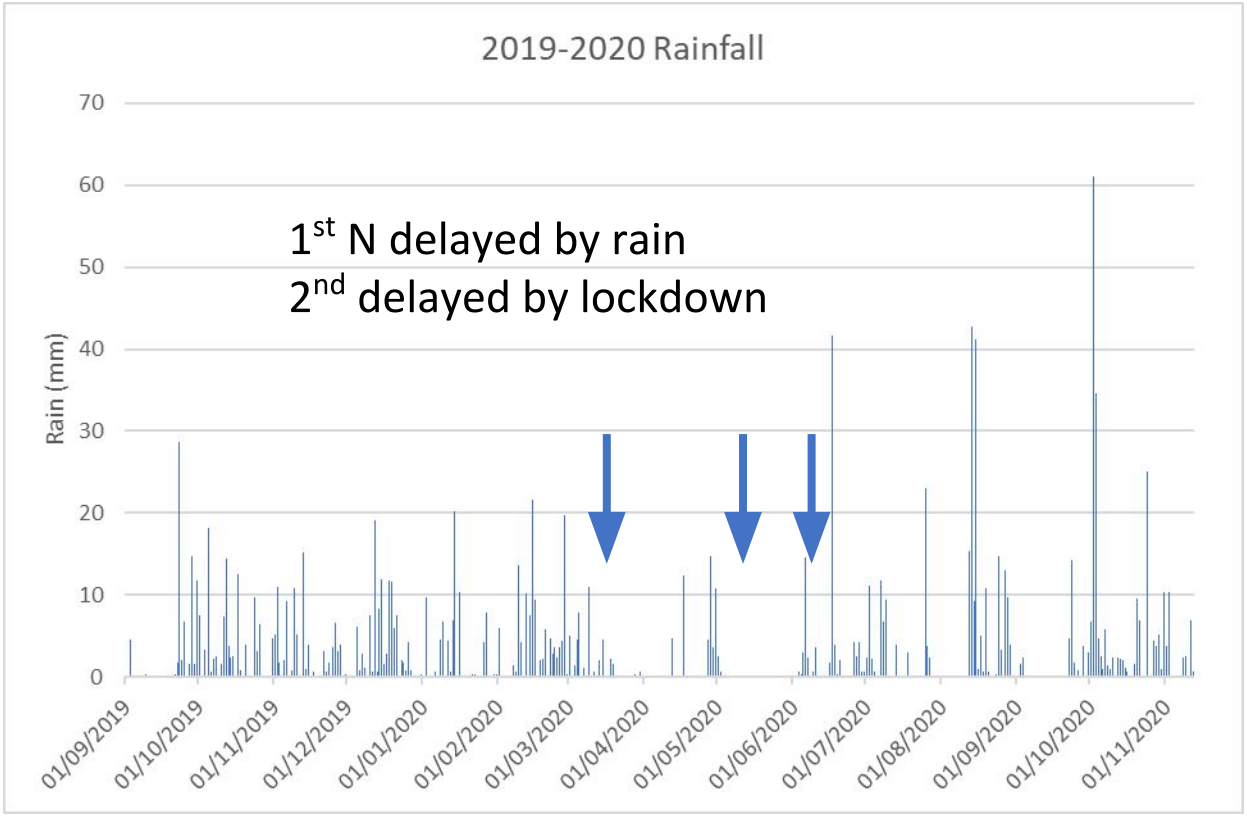
Rht8 between these
(~ 0.82 Mb)


Wheat
Genetic
Improvement
Network
ROTHAMSTED
RESEARCH
WGIN Diversity Update
Andrew Riche
Department
for Environment
Food & Rural Affairs

Operations:

Sown	29-30/10/19			
		SFP	RFP	
Slug Pellets	04/11/19	Y	Y	
Pontos+Firestarter+Velomax	04/11/19	y	y	Herbi
Chlormequat +Modus	15/04/20		y	PGR
Toledo + Optio500 + Chlormequat + Modus	15/04/20	y		Fungi + PGR
Axial Pro + Provalia	04/05/20		y	Herbi
Axial Pro + Provalia + Cello + Claw	04/05/20	y		Herbi + Fungi
Lentyma XE	26/05/20	y		Fungi
Clayton Zorro Pro + Prloine 275 + Toledo	15/06/20	y		Fungis
			Kg/N/ha	
N	16/03/20	N+S	50	
	13/05/20	N	50/100/250	
	09/06/20	N	0/50	
Harvested	22/08/20			

Top 35 wettest days since 1853 – 4 occurred this year

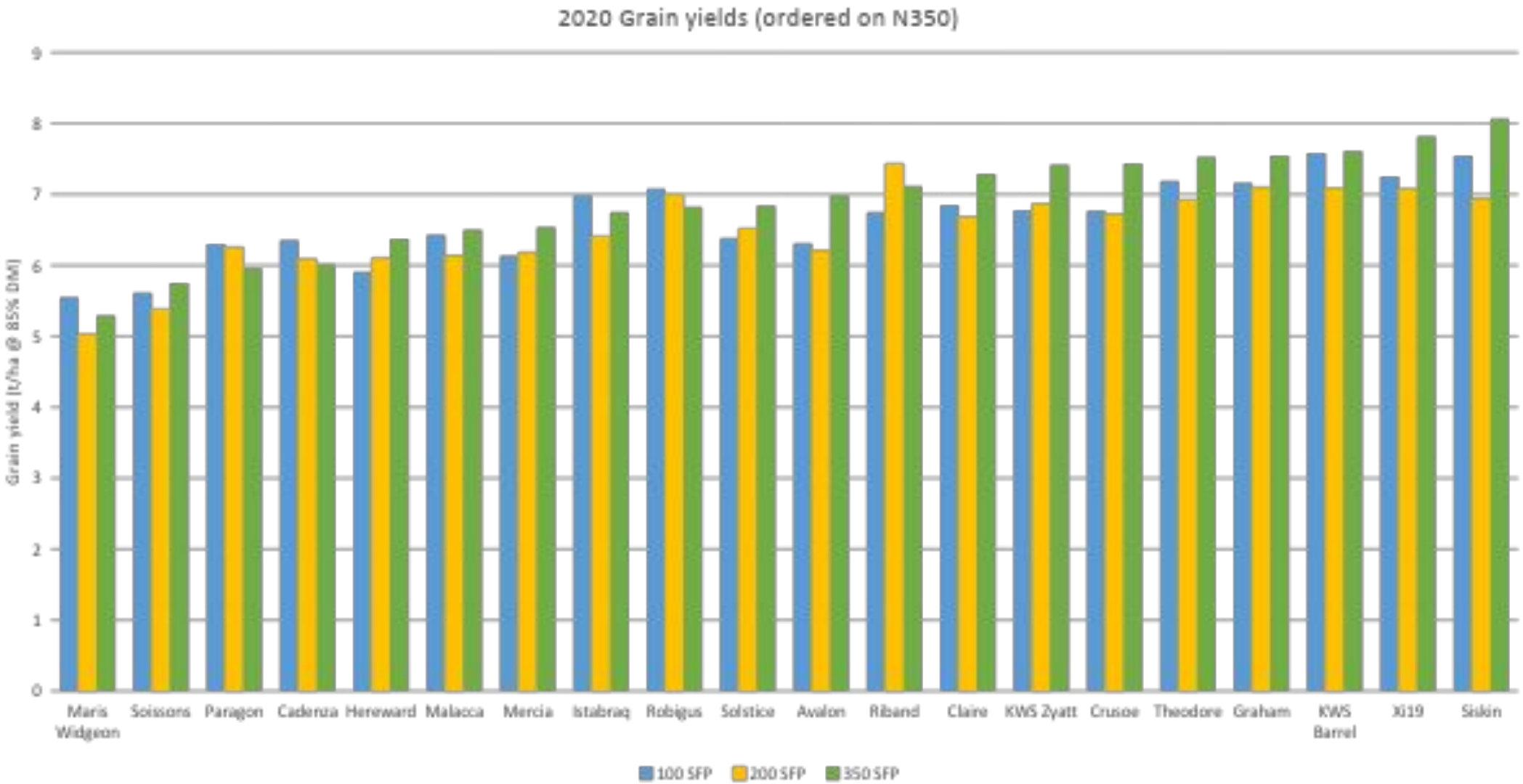


ROTHAMSTED RESEARCH

10 UAV flights & ground based hyperspectral reflectance measurements.
From UAV: crop height, ground cover and NDVI

25/03/20
21/05/20
27/05/20
03/06/20
17/06/20
23/06/20
02/07/20
07/07/20
15/07/20
23/07/20

ROTHAMSTED RESEARCH



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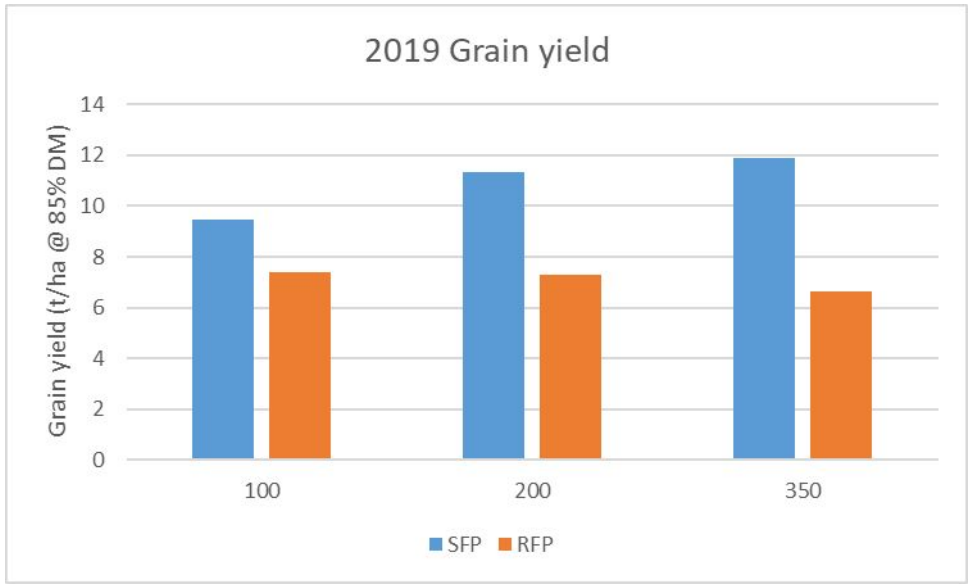
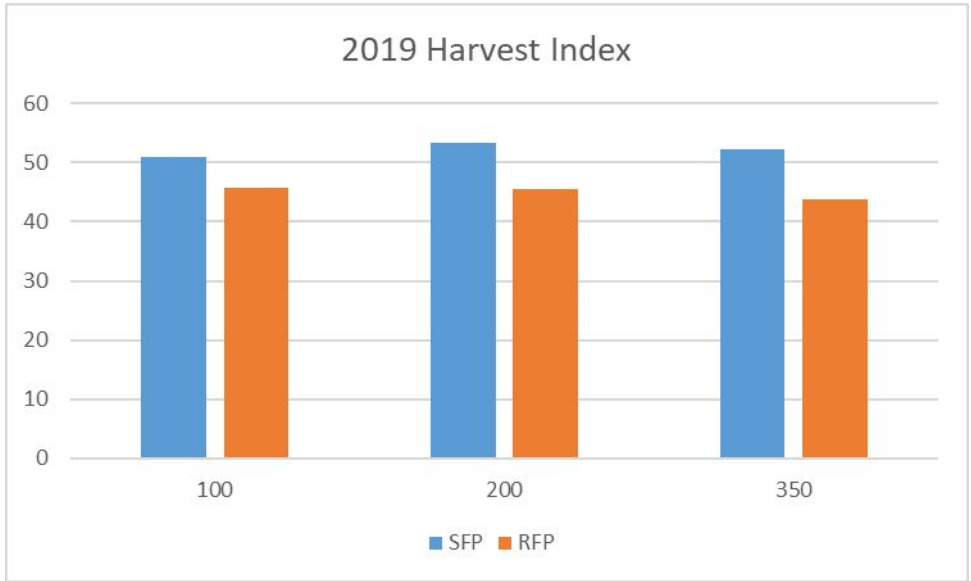
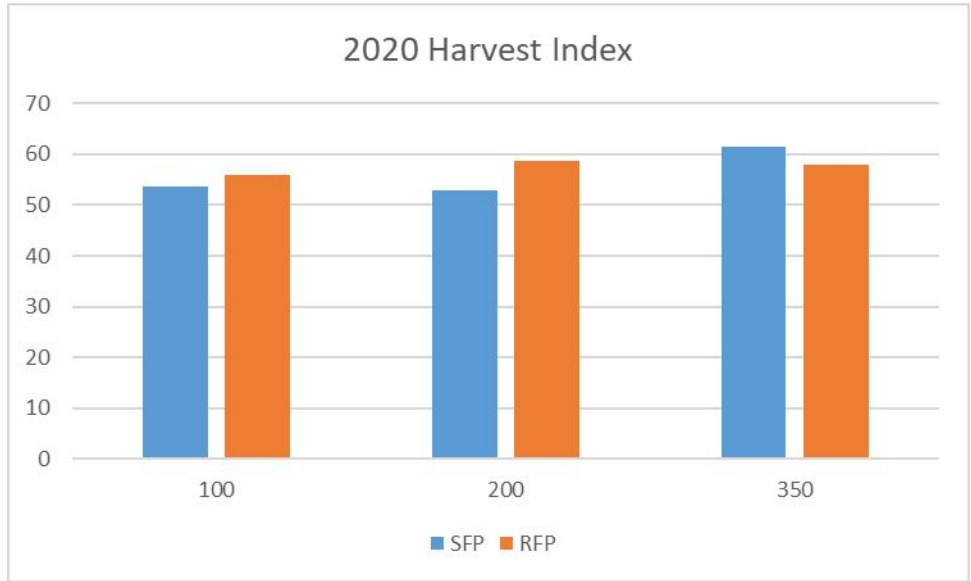
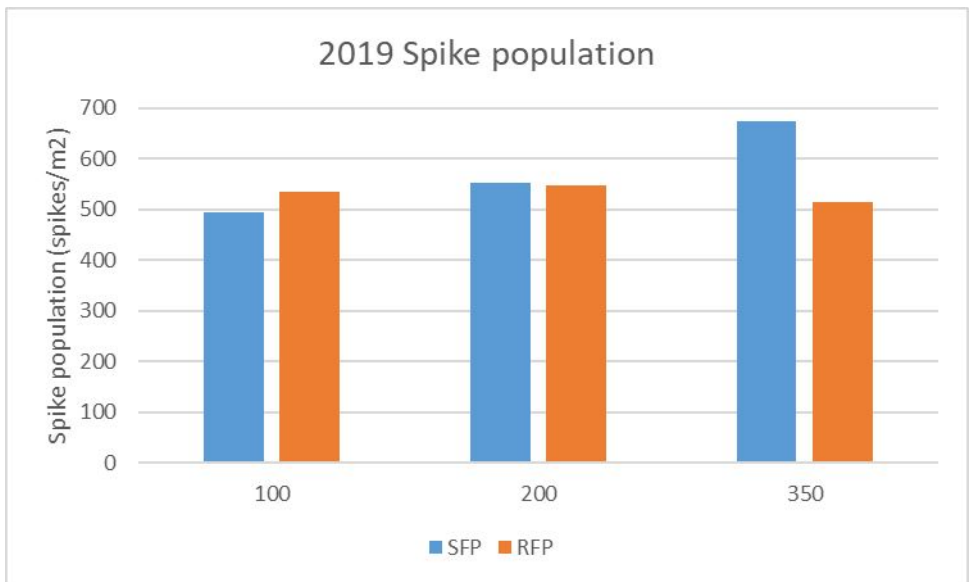
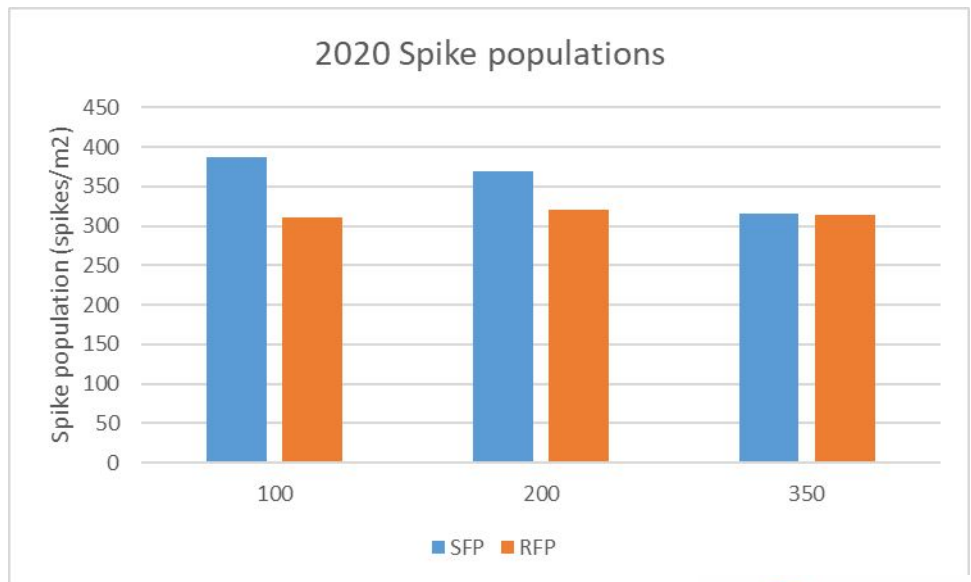


ROTHAMSTED
RESEARCH





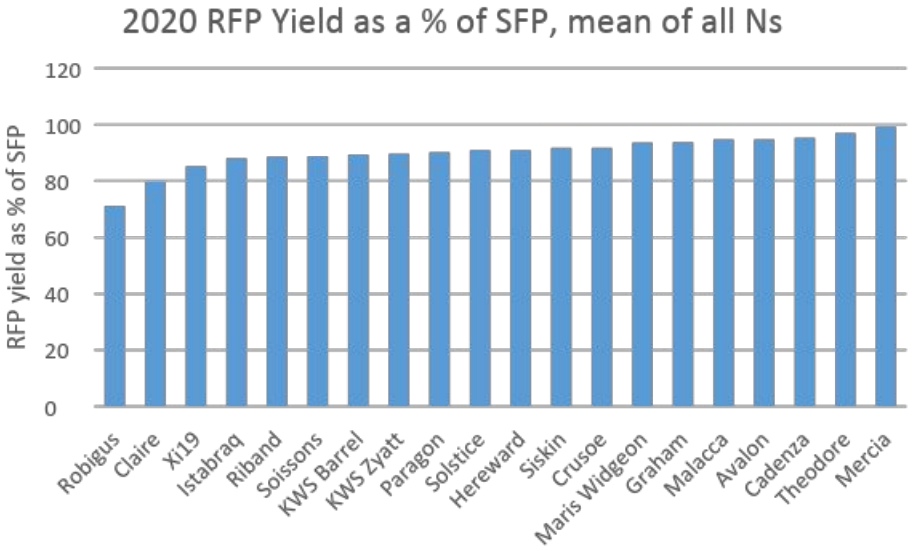


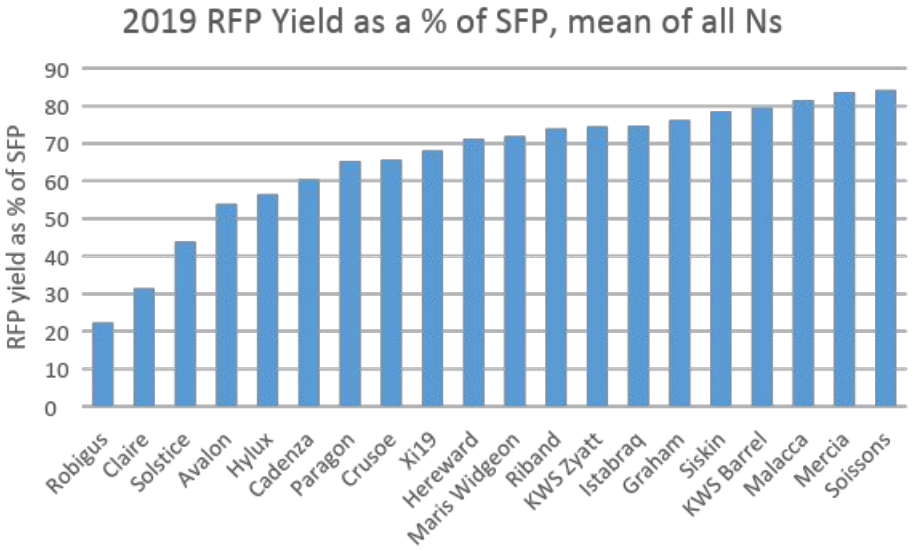


ROTHAMSTED RESEARCH

Standard Farm Practice compared with Reduced Farm Practice

Disease assessed:
14-16/05/20
27-29/05/20
15/06/20
01/07/20

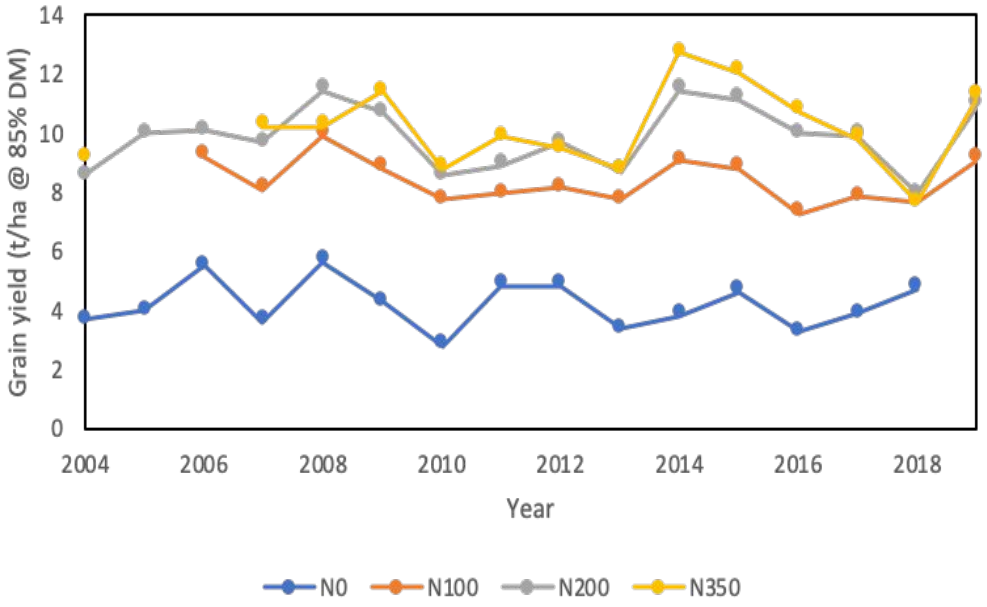


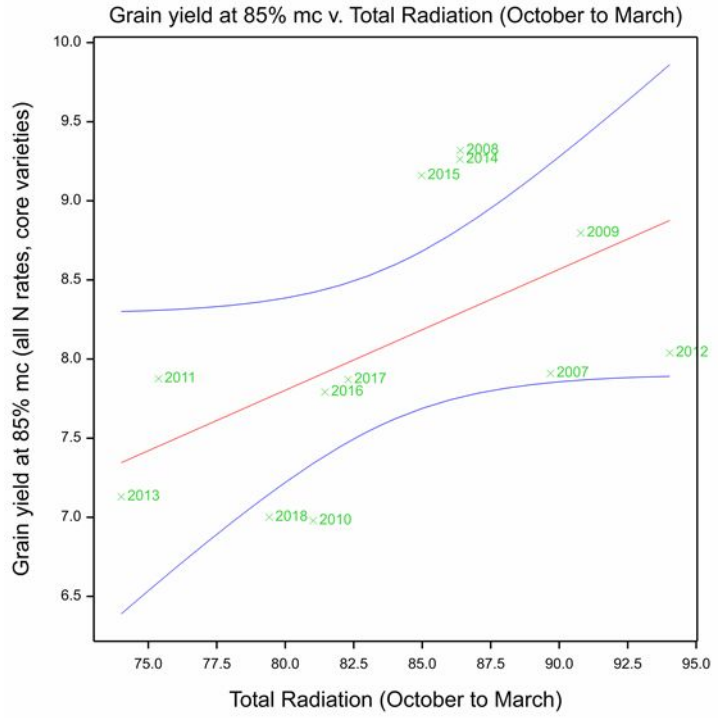


ROTHAMSTED RESEARCH

An evaluation of recent trends in nitrogen use efficiency of UK wheat – final repot submitted 07/09/20

Compared N treatments, varieties (including year of introduction) & weather, 2004-2019





ROTHAMSTED RESEARCH

2021 Expt

- Sown 28/09/20
- Same 20 varieties as 2020:

ROTHAMSTED RESEARCH

Acknowledgements

- Farm staff for completing the field trial in a difficult year
- March Castle – all UAV flights and data processing
- David Steele – field work and sample processing
- Saroj Parmor – chemical analysis
- Debs - Wright Disease assessments

ROTHAMSTED RESEARCH

Wheat Genetic Improvement Network

ROTHAMSTED RESEARCH

Department for Environment Food & Rural Affairs

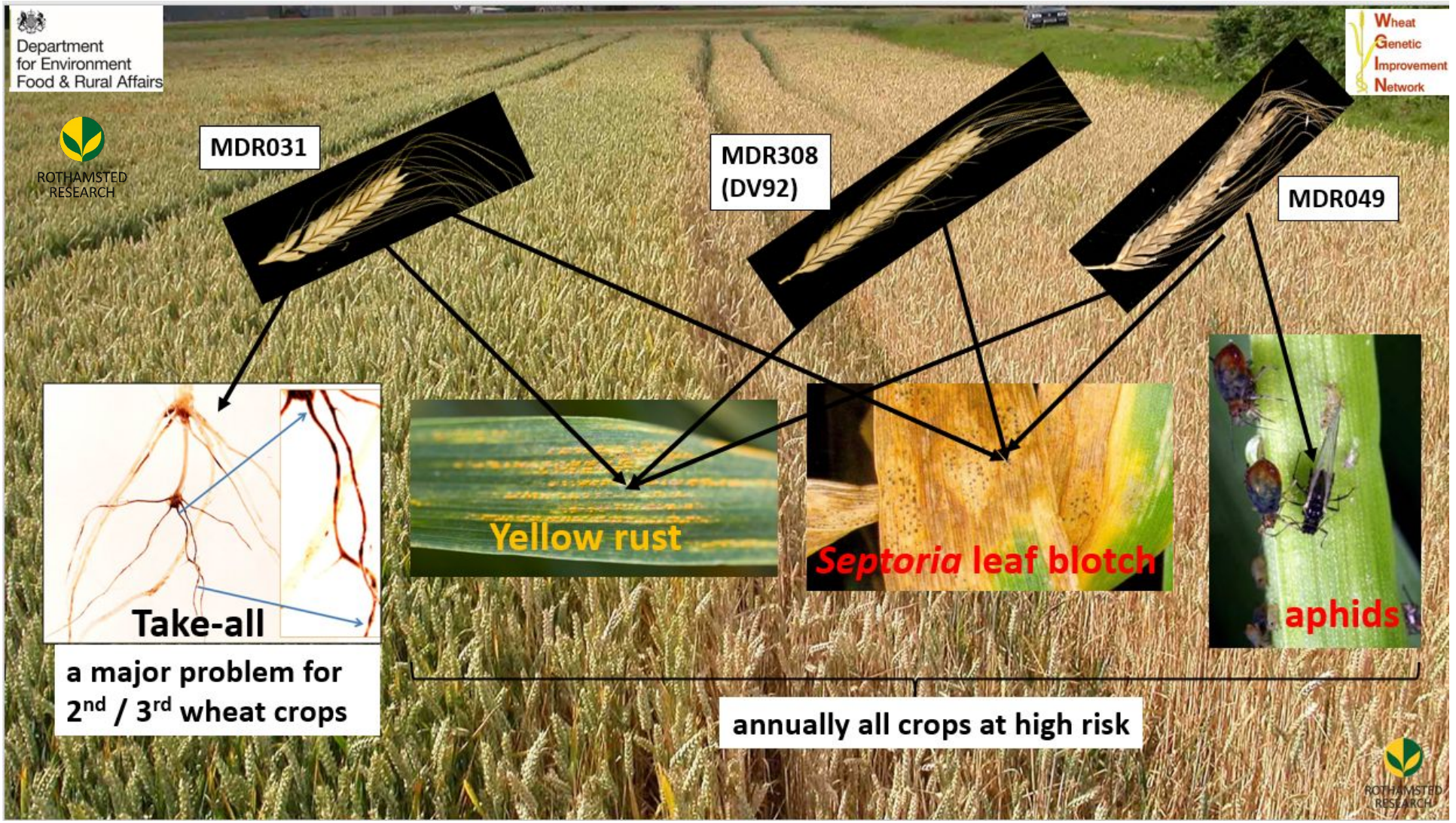
Triticum monococcum Introgression Field Trial

(update 563.5)

virtual WGIN MM Nov 27th 2020

Michael Hammond-Kosack (RRes)

Triticum monococcum (diploid species with AA genome) a good source of resistance to various pathogens and pests



T. monococcum introgression

using *T. durum* as a bridging species

- progress so far

Wheat Genetic Improvement Network

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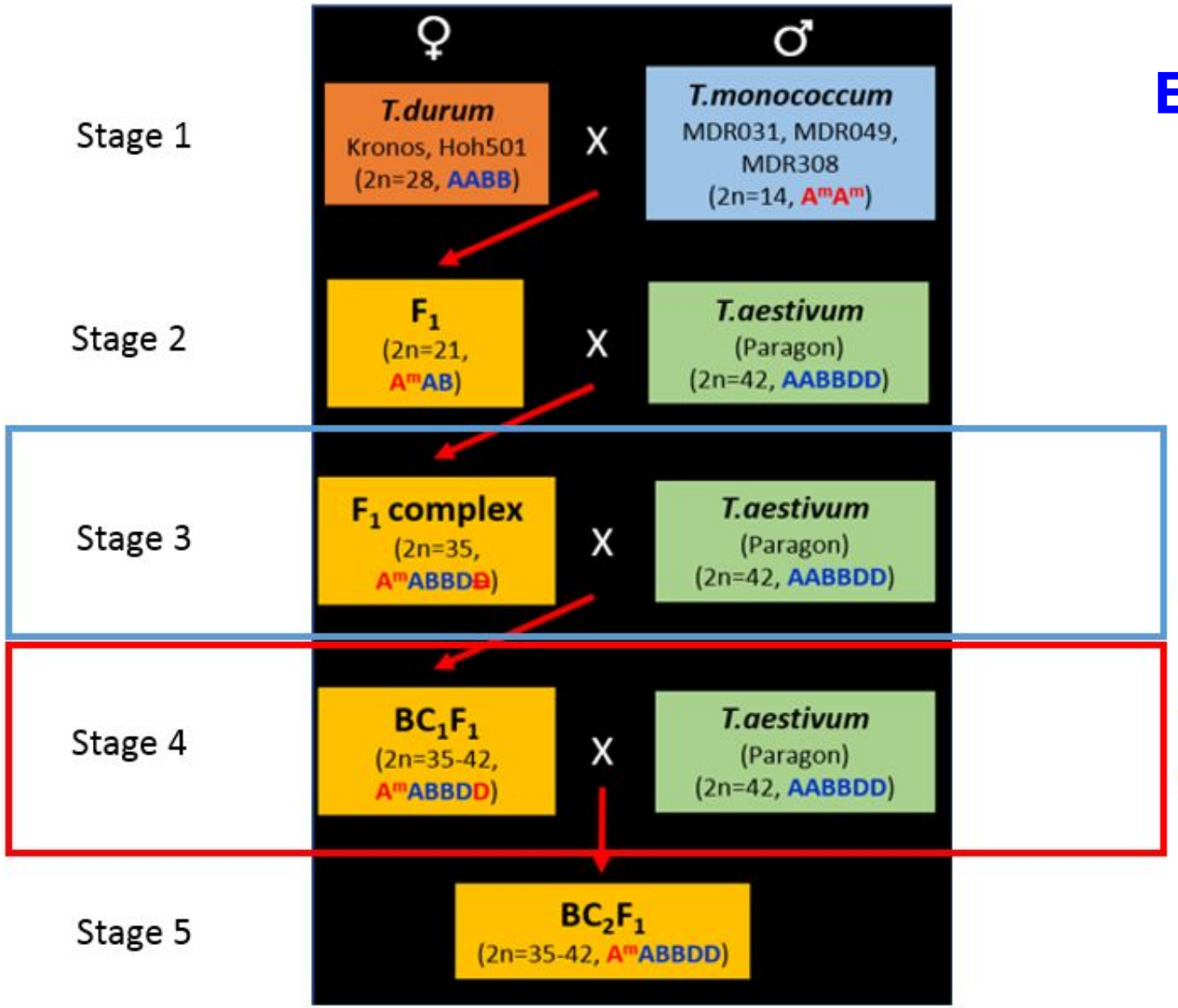


~0.5 %

increased fertility

~50 %

Extensive phenotyping throughout

MDR049 (aphids) & MDR308 (zymo) — **completed**

MDR031 (Take-all) — **completed**

T. monococcum introgression field trial April – Oct 2020

Purposes : 1. To assess various traits as a 1st wheat crop

- Plant growth
- Plant development
- Plant stature
- Responses to Yellow Rust and Septoria
- Ear morphology and grain shape

2. Seed multiplication

WGIN's 1st *Triticum monococcum* Introgression Field Trial

Design #	ALL SELFS (S-#)	F1hybrid		F1C	BC1	BC2
1	BC1-X12-1	Kronos	MDR031	Fielder	Paragon	Paragon
2	BC1-X12-3					
3	BC1-X87-1			Paragon		
4	BC1-X173-1					
5	BC1-X27-1					
6	BC1-X147-1					
7	BC1-X75-1	Hoh501				
8	BC1-X88-1					
9	BC1-X122-1					
10	BC1-X161-3					
11	BC1-X186-2					
12	BC1-X187-1					
13	BC1-X187-2					
14	BC1-X187-3					
15	BC1-X74-1					
16	BC1-X115-1					
17	BC1-X189-2					
18	BC1-X224-1					
19	BC1-X224-2					
20	R2#2-7		MDR049			
21	R2#13-1-1		MDR308			
22	R2#14-1-1					
23	R2#16-7		MDR031			
24	BC2-X65-1					
25	BC2-X113-1					
26	BC2-X113-3					
27	BC2-X150-1					
28	BC2-X150-2					
29	BC2-X150-3					

Design #	
33-36	Paragon
37	Fielder
38	Cadenza
39	Kronos
40	Hoh501
30	MDR031
31	MDR049
32	MDR308

Take-all R
Aphid R
Septoria R

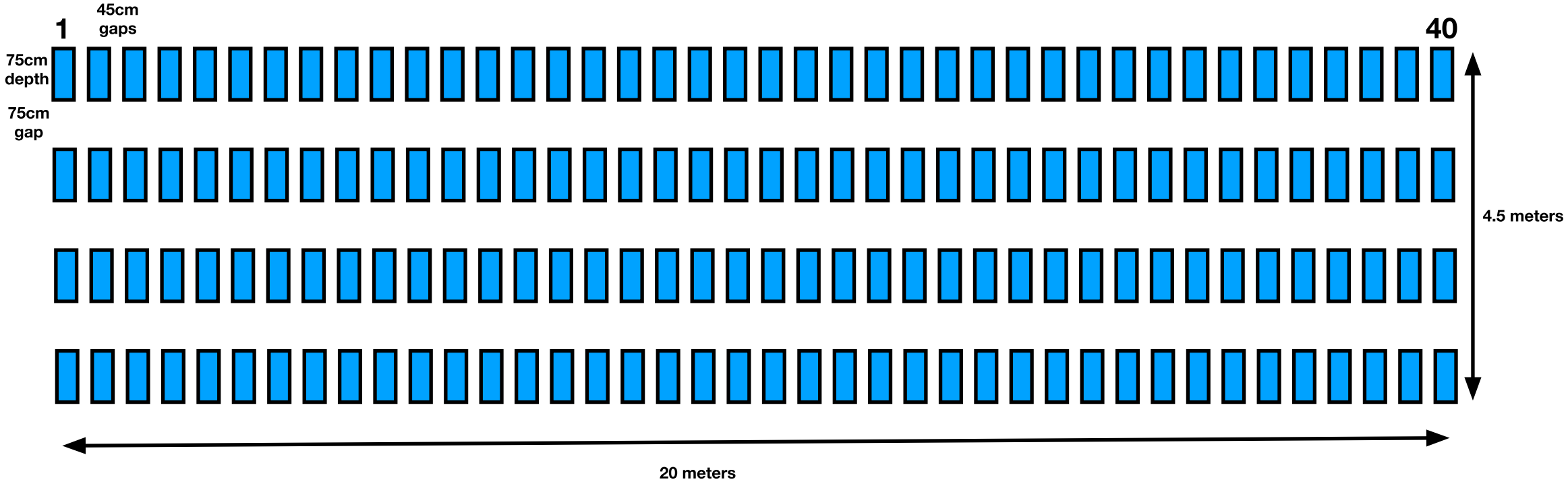
Trial Design and Layout

plant row	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
block 1	39	16	25	18	28	33	15	4	26	5	29	8	37	21	19	10	23	32	36	20	24	1	22	9	30	35	40	14	27	17	3	12	34	31	11	6	38	2	7	13
block 2	20	31	10	30	9	3	12	8	37	35	4	6	11	39	13	22	1	17	16	33	38	32	19	2	25	28	7	29	5	34	27	40	14	36	26	24	23	18	15	21
block 3	2	40	24	32	13	22	29	34	23	11	18	25	14	7	35	38	9	31	12	27	16	26	15	21	36	6	4	3	37	20	39	28	10	5	19	33	30	1	8	17
block 4	14	19	1	6	36	7	38	27	17	21	5	40	28	24	3	26	34	15	2	30	8	12	39	33	11	23	10	31	13	18	32	20	16	22	9	29	4	37	35	25

Paragon (33…36; see renumbered list below)

1 cell in table above (1 experimental unit) = 1 row of 6 pseudo-replicate plants

6 plants per row with 15 cm intervals



29th May - 1st June 2020 marked out and 900 + seedlings planted out from the glasshouse

water bowser
(thanks, Ben)

3. trial lay-out

4. the first row planted

5. getting there

6. All done…

Watering 29th May to 12th August 2020
In total 7,500 litres plus the occasional rain,
then various thunderstorms took over

7. ...apart from watering twice a day (2 x 100l)

Hand harvesting all relevant plots

17th – 18th Sept

~ 30 plants potted up and moved to the polytunnel

20th Sept
Ears harvest 13th Oct

What traits were successfully scored ?

Yellow Rust assessments on flag leaf and 2nd leaf

Septoria leaf blotch – none

Aphid infestations Focus R2#2-7 vs MDR049 – not possible, very low aphids

Ear morphology – photograph of 1st ear into anthesis for each plant

Ear glossy or non-glossy (waxy)

Awn absence / presence and length

Growth stages GS 22 to GS65 (Zadoks)

Flag leaf length*

Leaf senescence post anthesis *

* Jess Hammond (RRes apprentice)

Total number of flowering tillers / plant

- instead total number of harvested ears per plant

Plant heights* and peduncle lengths*

Grain harvest

Grain shape – photograph of grain recovered from each plant

Total grain number per plant

Black – originally planned Red – planned but not possible Blue – additional traits scored

Yellow rust – a lot : scored on 11th and 21st July, 2nd and 12th August, 5th Sept

Basal and upper leaves heavily YR infected

2 control + 4 lines

39. Kronos
40. Hoh501
2. BC1 – X12-3
6. BC1 - X147-1
8. BC1 – X88-1
29. BC2 – X150-3

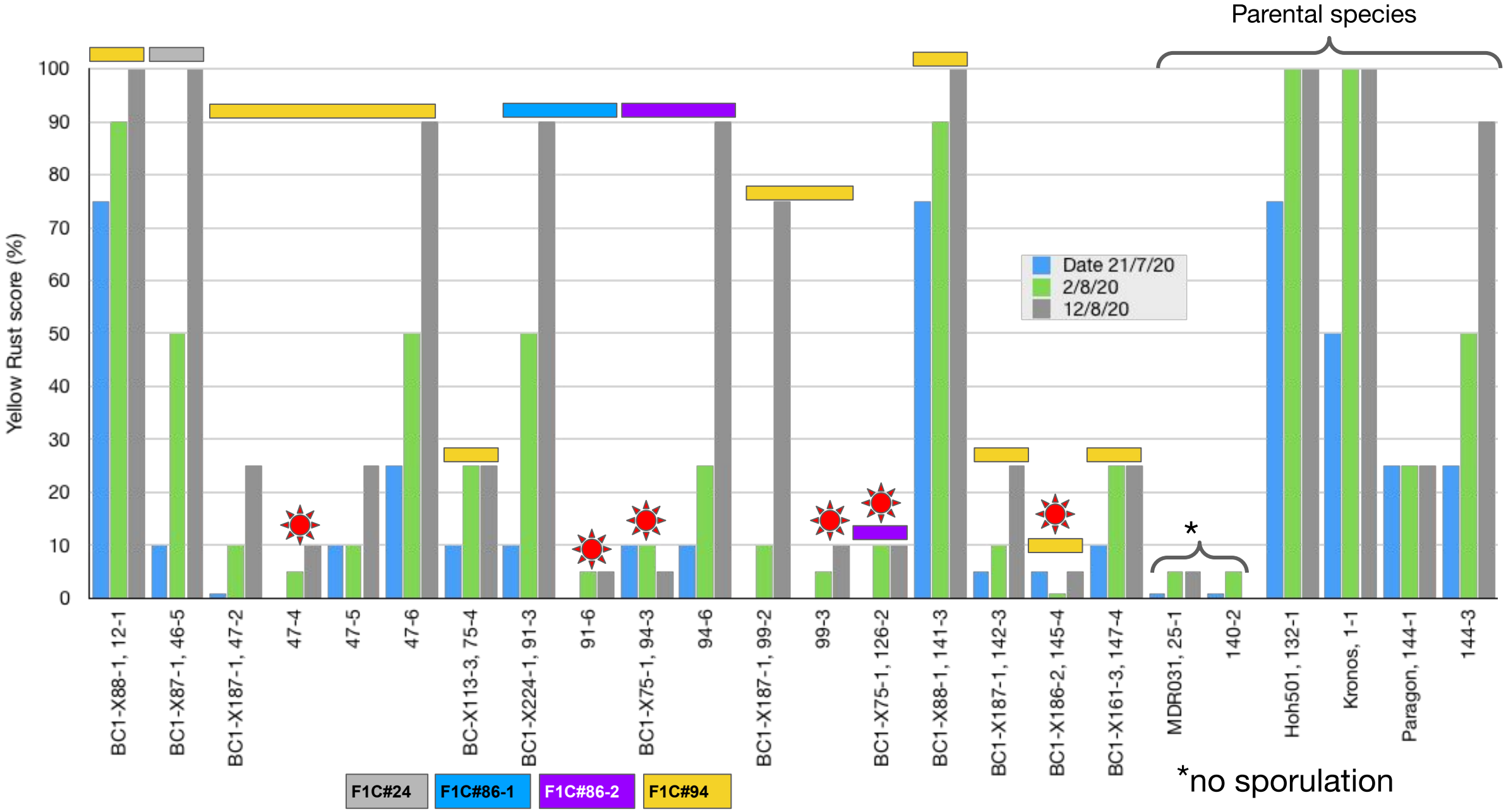
2 *Tm* lines – no YR lesions
MDR031 and MDR308

1 *Tm* lines – briefly small YR lesions in late July only
MDR049

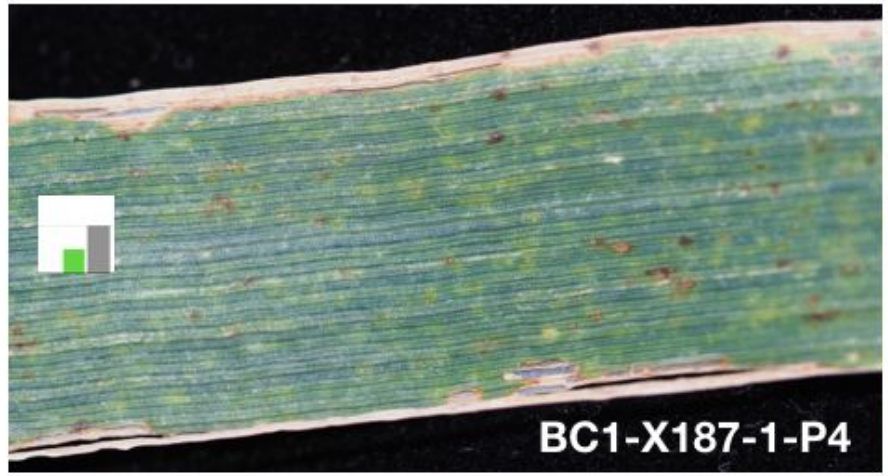
Paragon – intermediate levels of YR lesions

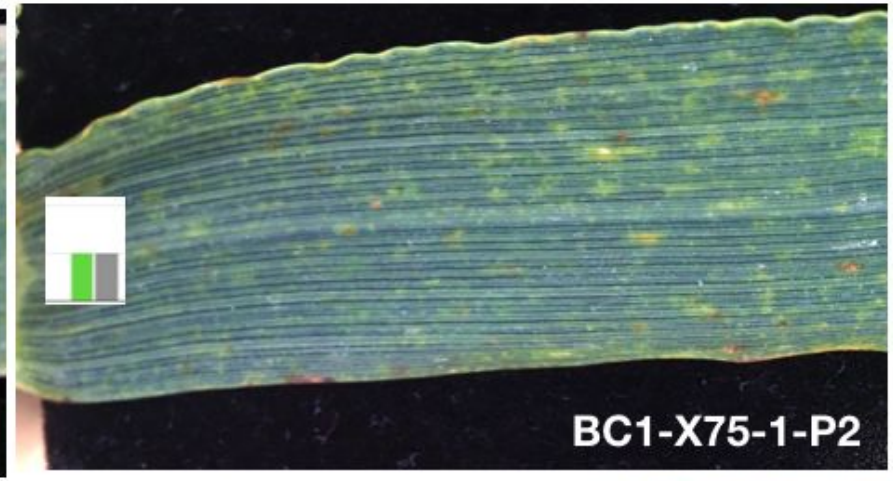
Design #	ALL SELFS (S-#)	F1hybrid		F1C	BC1	BC2
1	BC1-X12-1	Kronos	MDR031	Fielder	Paragon	Paragon
2	BC1-X12-3					
3	BC1-X87-1			Paragon		
4	BC1-X173-1					
5	BC1-X27-1					
6	BC1-X147-1					
7	BC1-X75-1	Hoh501				
8	BC1-X88-1					
9	BC1-X122-1					
10	BC1-X161-3					
11	BC1-X186-2					
12	BC1-X187-1					
13	BC1-X187-2					
14	BC1-X187-3					
15	BC1-X74-1					
16	BC1-X115-1					
17	BC1-X189-2					
18	BC1-X224-1					
19	BC1-X224-2					
20	R2#2-7		MDR049			
21	R2#13-1-1		MDR308			
22	R2#14-1-1					
23	R2#16-7		MDR031			
24	BC2-X65-1					
25	BC2-X113-1					
26	BC2-X113-3					
27	BC2-X150-1					
28	BC2-X150-2					
29	BC2-X150-3					

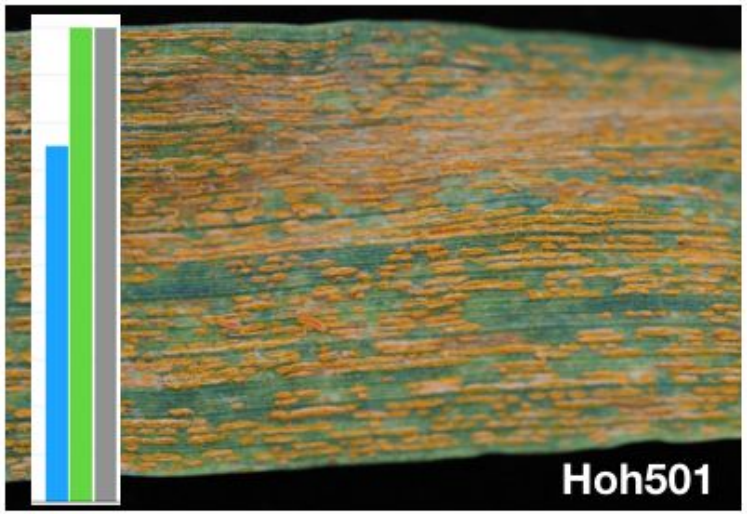
Yellow Rust Scoring of Field Trial

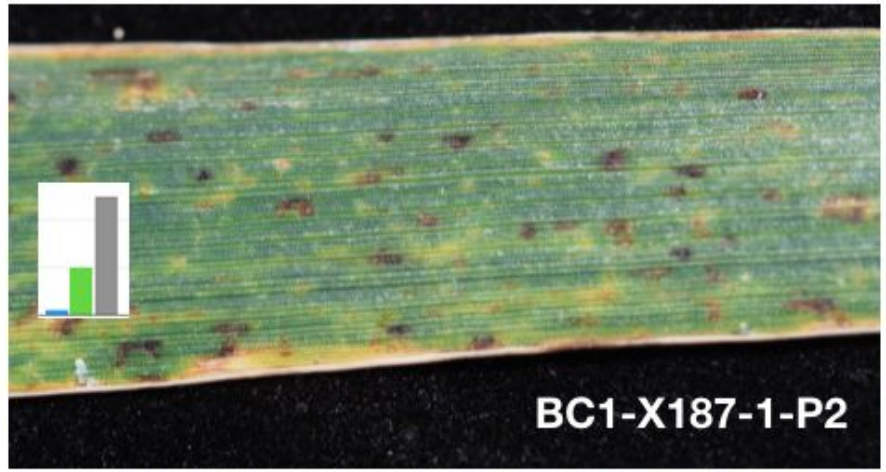


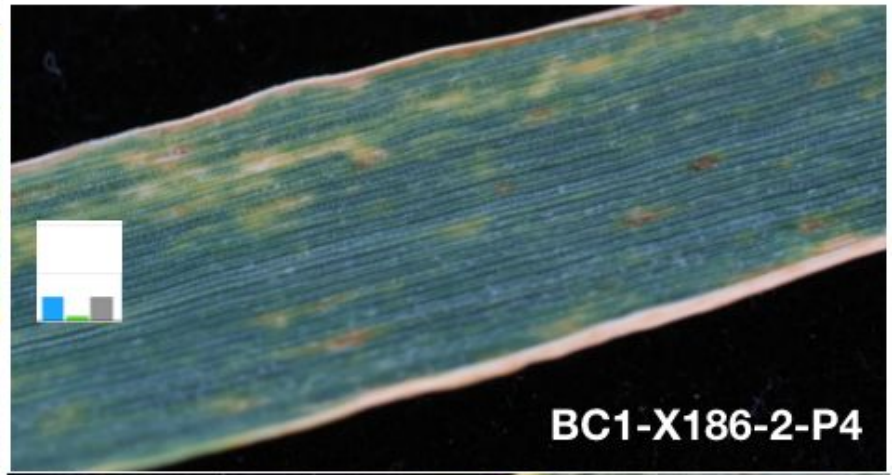

MDR031

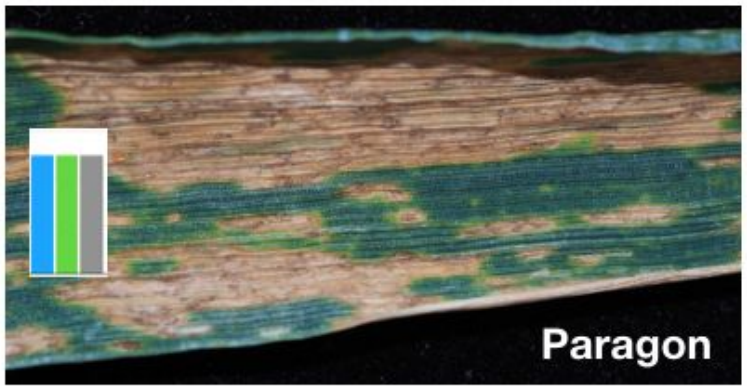

BC1-X187-1-P4

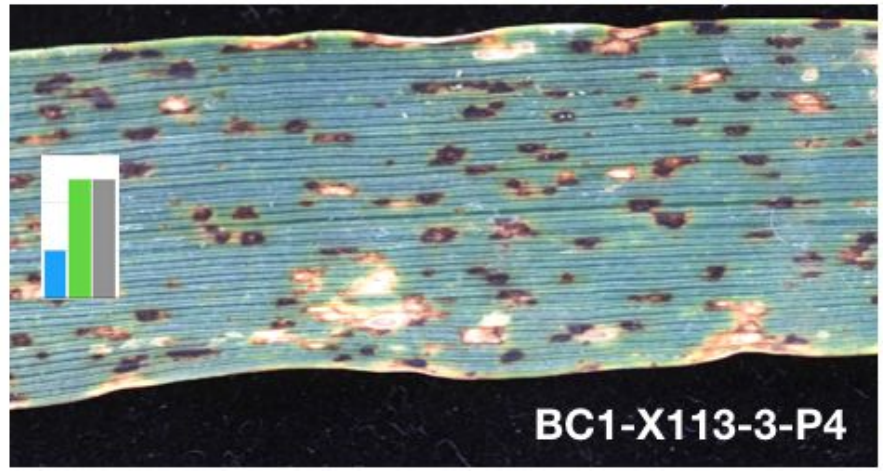

BC1-X75-1-P2

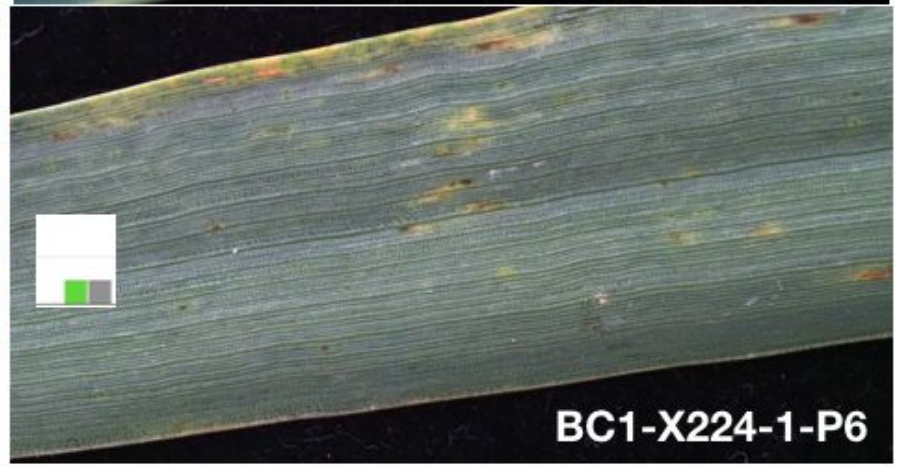

Hoh501


BC1-X187-1-P2

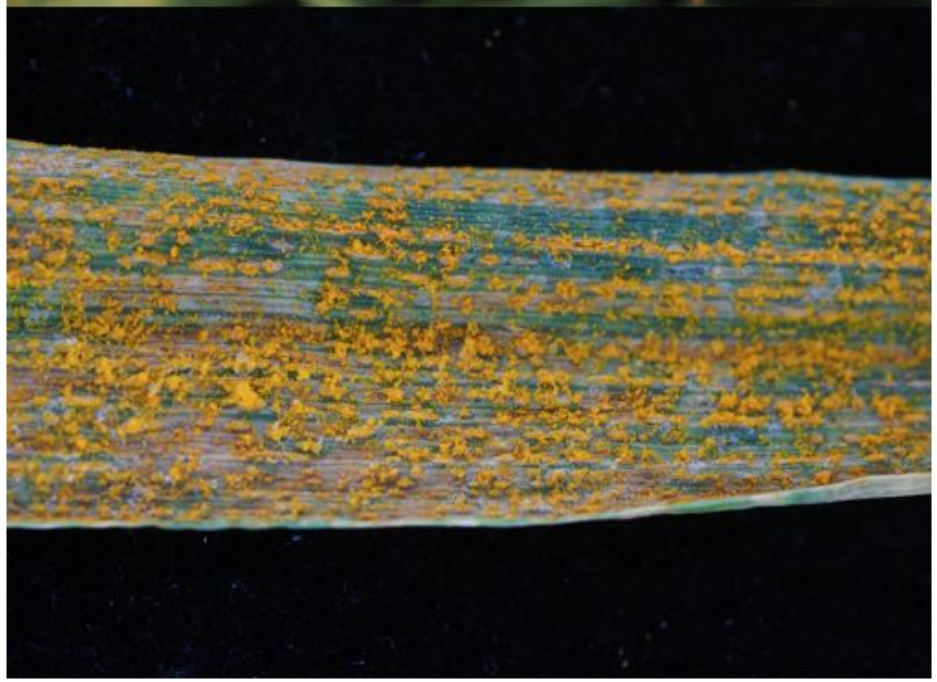

BC1-X186-2-P4


Paragon


BC1-X113-3-P4

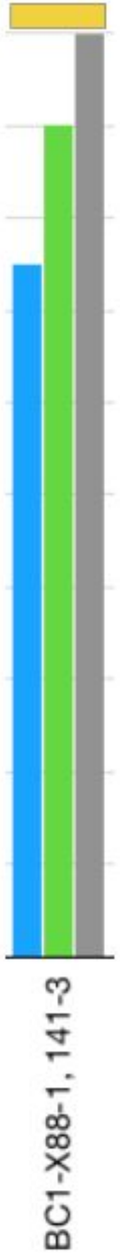

BC1-X224-1-P6

BC1-X88-1



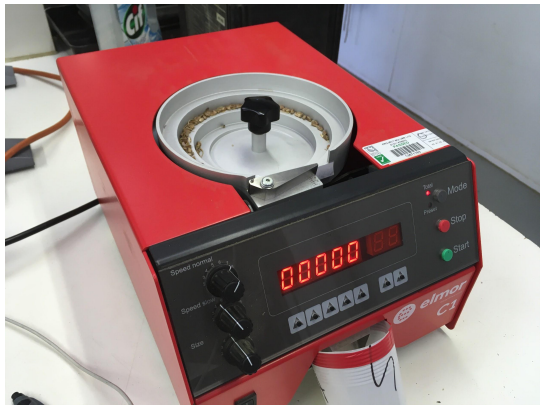
BC1-X187-1

BC1-X88-1



BC1-X187-1

Ear harvest



row	line	plant	ears	grains	gr/ears	[gr/ear]/AVG(Paragon)
106	BC1-X147-1	P1	12	609	51	124%
106	BC1-X147-1	P2	11	546	50	121%
106	BC1-X147-1	P3	14	576	41	100%
106	BC1-X147-1	P4	5	395	79	193%
106	BC1-X147-1	P5	12	290	24	59%
106	BC1-X147-1	P6	9	370	41	100%

grain harvest & counting






Summary

1) The ***Triticum monococcum*** parent MDR031 showed **very strong resistance** to yellow rust (≤5%) without any sporulation observed throughout.

2) Both **Triticum durum species** (Hoh501 and Kronos) used as female parents in the F1hybrid crossing **are fully susceptible.**

3) Paragon, used to generate the F1Complex plants and all subsequent Backcross plants showed moderate resistance (≥25%).

4) Out of **509** individual introgressed plants (grown from 29 lines) scored for Yellow Rust, **6 plants show strong resistance** (≤10%) at the latest scoring date.

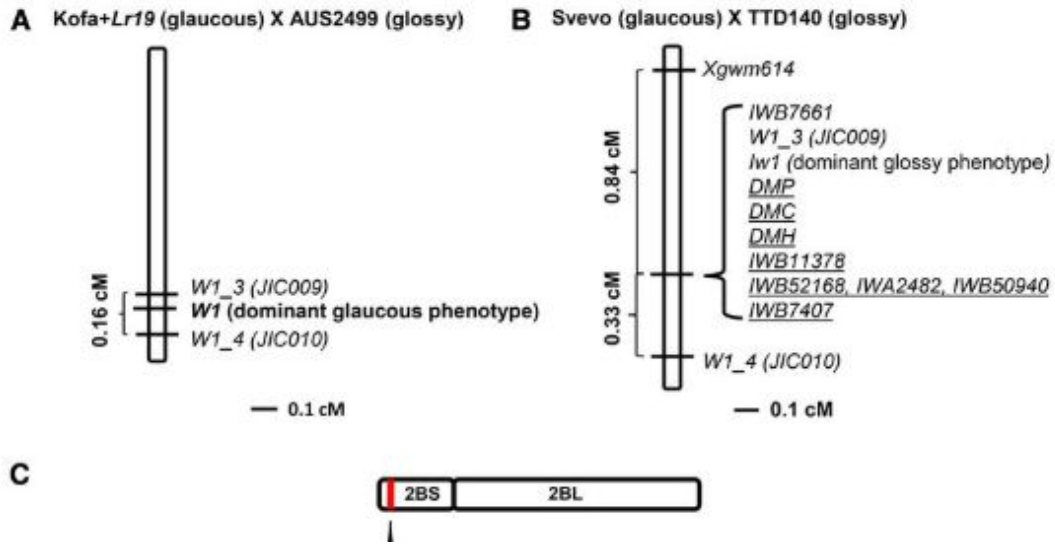
5) Other plants showed limited resistance (≤25%).

6) 5 plants from line **BC1-X187-1** showed resistance in 3 of the 4 repeat blocks.

7) The overall conclusion so far is therefore that we have introgressed yellow rust resistance from MDR031.

Ear Trait
Glaucous or non-glaucous
Waxy or glossy

glaucous (waxy) - light bluish-grey – on flag leaf, stem, spike surfaces, results from deposition of cuticular β-diketone wax on their surfaces



This trait in hexaploid wheat is predominantly governed by four loci, namely, the wax production loci ***W1* and *W2*** and the wax inhibition loci ***Iw1* and *Iw2*.**

W1* and *Iw1 reside on the short arm of **chromosome 2B (2BS)**, ***W2* and *Iw2*** are located on **2DS**

Either one of the wax production loci, *W1* or *W2*, is sufficient to produce a glaucous phenotype.
The wax inhibitor loci have a **dominant epistatic interaction** with the wax production loci, and the presence of **either *Iw1* or *Iw2* (or both) suppresses the glaucous phenotype**

14 *Tm* introgressed lines segregating for glossy / waxy phenotype

Controls

3 *Tm* lines – non-glaucous (glossy)
Kronos – glaucous (waxy)
Hoh501 – glaucous
Paragon – glaucous

Non-glaucous *Tm* Int. lines (glossy)

5. BC1 – X27-1
7. BC1 - X75-1
8. BC1 – X88-1
10. BC1 – X161-3
11. BC1 - X186-2
12. BC1 - X187-1
13. BC1 - X187-2
14. BC1 - X187-3
18. BC1 – X224-1
19. BC1 – X224-1
21. R2# - 13-1-1
24. BC2 – X65-1
25. BC2 - X113-1
28. BC2- X150-3

- Introgression on 2BS or 2DS replacing alleles
- Introgression at another location influencing expression of *W1, W2, lw1* and /or *lw2*

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9	BC1-X122-1					
10	BC1-X161-3					
11	BC1-X186-2					
12	BC1-X187-1					
13	BC1-X187-2					
14	BC1-X187-3					
15	BC1-X74-1					
16	BC1-X115-1					
17	BC1-X189-2					
18	BC1-X224-1					
19	BC1-X224-2					
20	R2#2-7		MDR049			
21	R2#13-1-1		MDR308			
22	R2#14-1-1					
23	R2#16-7		MDR031			
24	BC2-X65-1					
25	BC2-X113-1					
26	BC2-X113-3					
27	BC2-X150-1					
28	BC2-X150-2					
29	BC2-X150-3					

What's next ?

Plan was to

Prepare seed for the 3rd wheat – take-all trial to be drilled Oct 2020

Not possible because harvested ears on 17th /18th Sept and 13th Oct (polytunnel)

Currently preparing seed for spring multiplication trial as one row per original plant to be drilled March 2021

Then once the seed is bulked, drill 3 trials in Oct 2021
3rd wheat – take-all trial - fully fungicide treated
1st wheat Yellow Rust trial with lines for 50 - 100 of the best 2020 field plants
1st wheat Septoria trial with all lines + selective fungicide regime to control YR

7th July 2020 – Field trial 40 days old

20th August 2020 – Field trial 88 days old

Questions for the Breeders

- When to start the SSD ?

- Which plants / lines to nominate for DFW Breeders Observation Panel ?

Many thanks to ….

Glasshouse staff – Jill Maple, Fiona Gilzean & Tom Yaxley - Phase 1 lockdown

Field staff - Chris Mackay, Ben Flannery - Phase 1 & 2 lockdown,

Statistician – Suzanne Clark - Phase 1 lockdown

Gail Canning – location of seed stocks in the seed store and advice on GS scoring - Phase 1 & 2 lockdown

Jess Hammond & WGIN summer student Ellen Farnham – scoring plant heights, peduncle lengths and leaf senescence

Gail Canning and Jess Hammond – hand harvest of ears + counting ears / plant

Kim Hammond-Kosack - field layout, planting, watering, growth stages, YR scores

Aphids and BYDV

Developing KASP Markers for Aphid Resistance

Lawrence Bramham

27th November 2020

ROTHAMSTED RESEARCH

Wheat Genetic Improvement Network

Department for Environment Food & Rural Affairs

AHDB

Context

- Barley yellow dwarf virus (BYDV) mainly transmitted by *Sitobion avenae* (grain aphid) and *Rhopalosiphum padi* (bird cherry-oat aphid) in the UK

- Increasing loss of pesticide options: **new challenges for control**

- Genetic resistance to aphids/BYDV: **effective disease control strategy**

- Tandem BYDV and aphid resistance: **mutually beneficial, increasing long-term efficacy**

Sitobion avenae

Rhopalosiphum padi

Phenotyping Aphid Resistance

- Complex aspects underlying plant-aphid-virus interactions (e.g. biophysical/biochemical traits, sensory cues)

- Future trait mapping work based on aphid fecundity (i.e. aphid 'nymph' development and survival)

- Aphid resistance identified in *T. monococcum* lines: **MDR045**, **MDR049**, **MDR657**

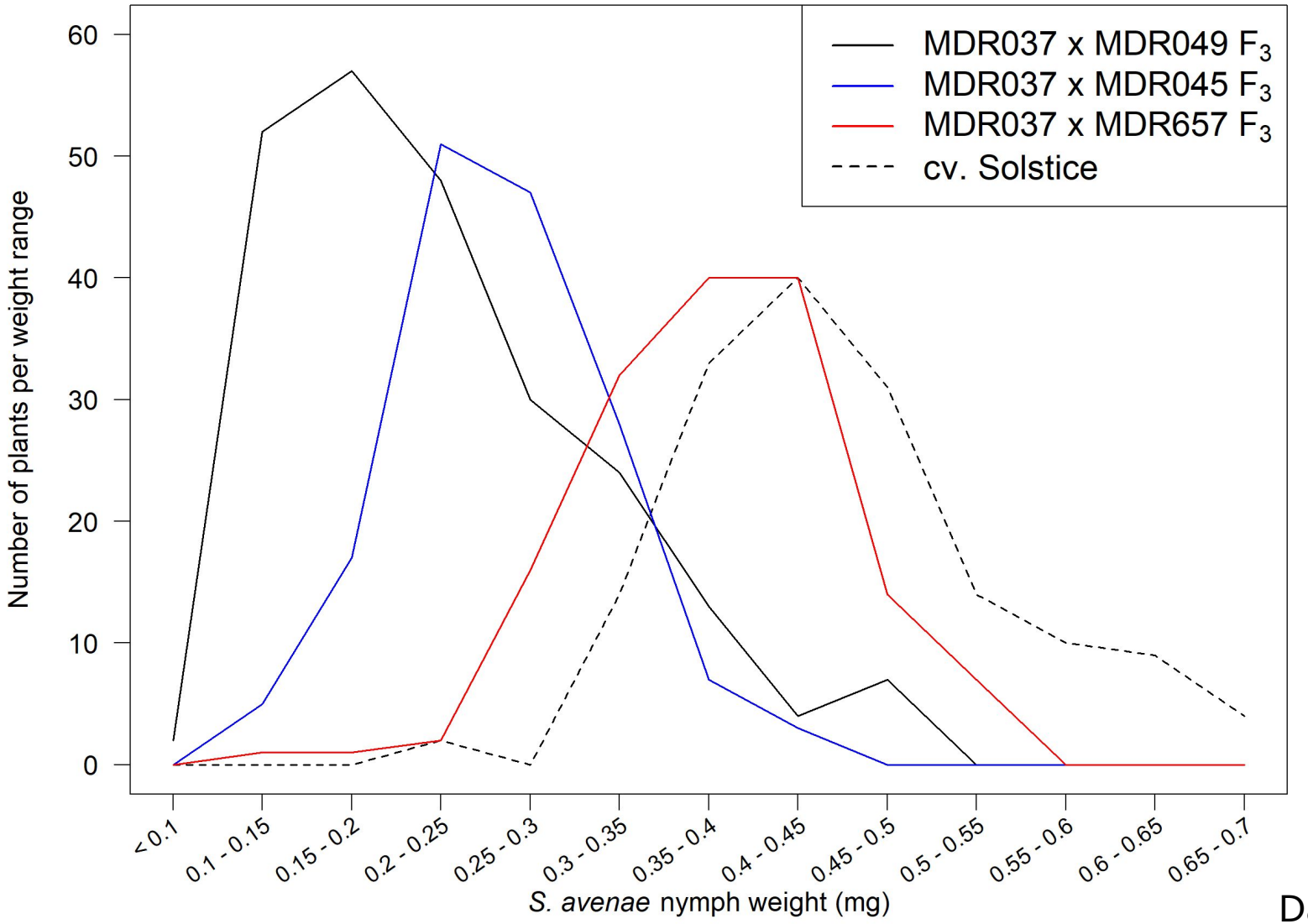
- Linked to difficulties during feeding[1], and influencing pre-alighting behaviour

Apterous *S. avenae* with offspring

[1]Greenslade *et al*., (2016) *Ann. Appl. Biol.* 168: 435-449.

Phenotypic Data

- Nymph weight for **MDR037 (aphid-susceptible) x aphid resistance** F_3 populations:

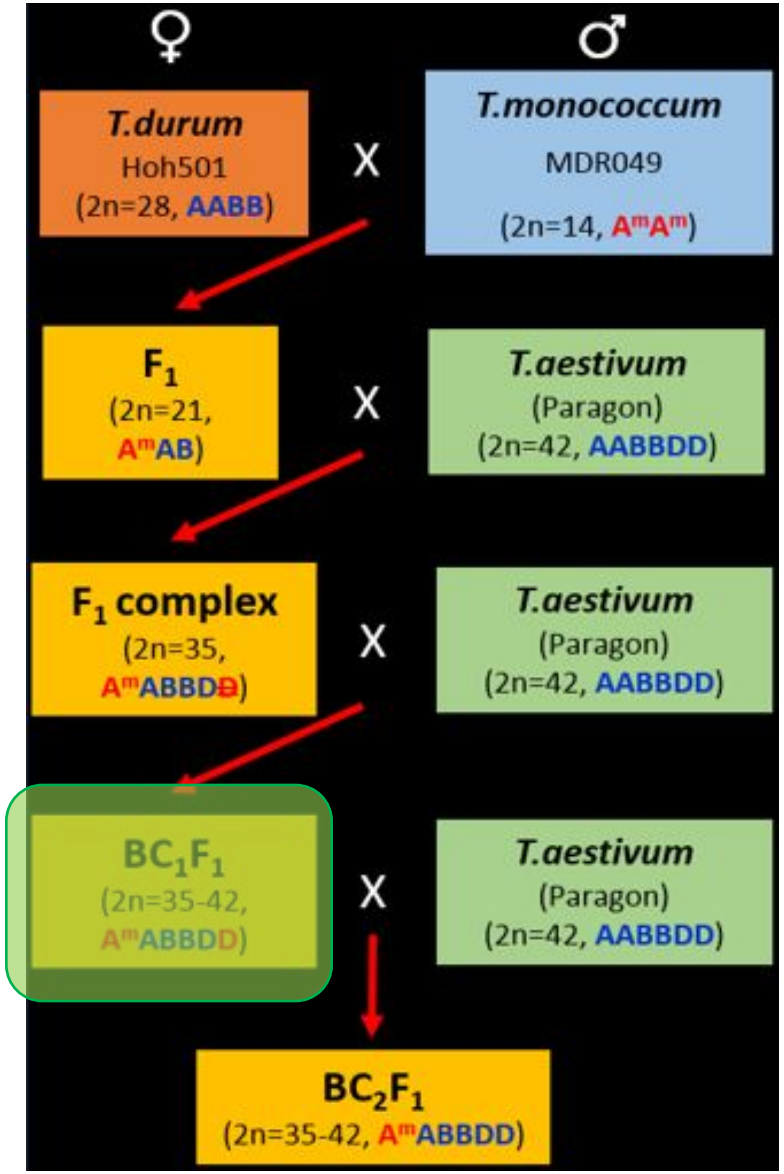


Data from Gia Aradottir

T. aestivum Introgression

- MDR049 F_3 germplasm ready for QTL analyses
- Markers useful for tracking cv. Paragon introgression desirable
- Relatively few reliable markers required for putative MDR037 x MDR049 F_3 QTL mapping, and for tracking introgression

MDR049-linked progress



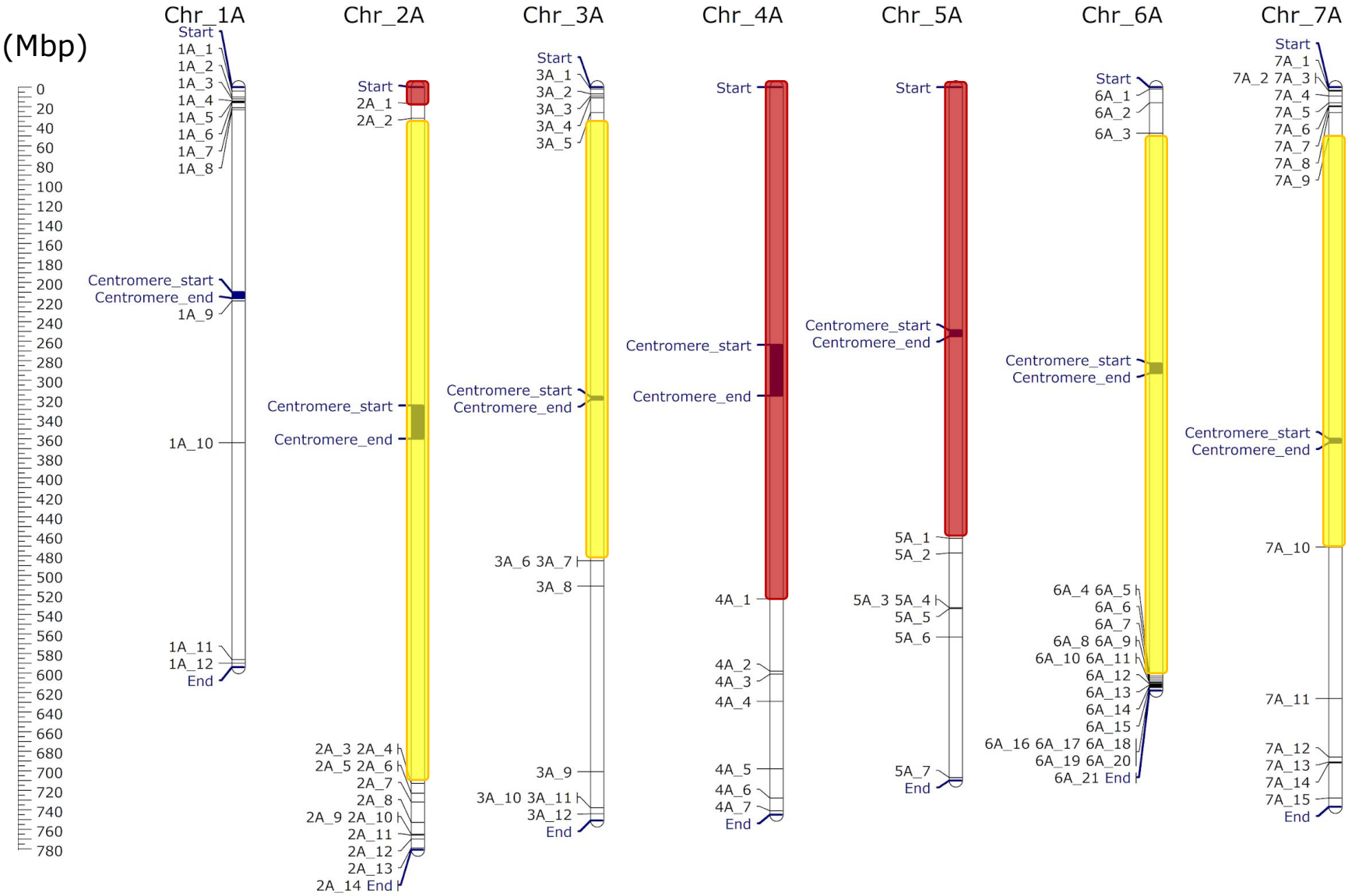
Performed by Michael Hammond-Kosack

Genotyping Options

- **Option 1** = Wheat Breeders' 35K array

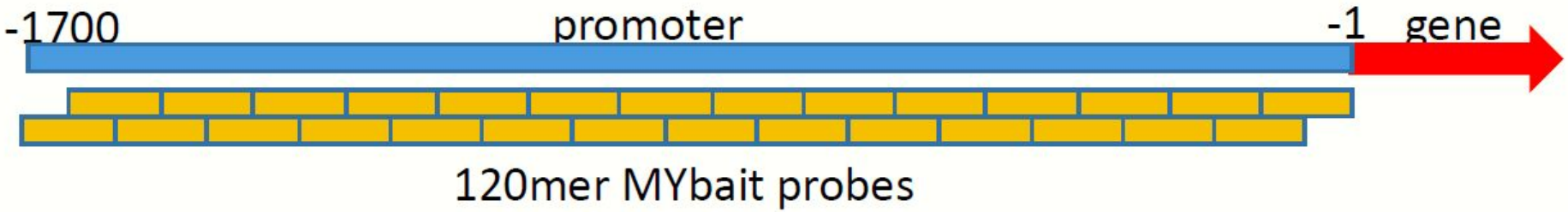
- Parental genotyping suggests 88 viable SNPs
  - Uneven distribution
  - 'blind' regions
  - 'contentious' regions

- Not ideal for genotyping this specific population, but still informative loci



Genotyping Options

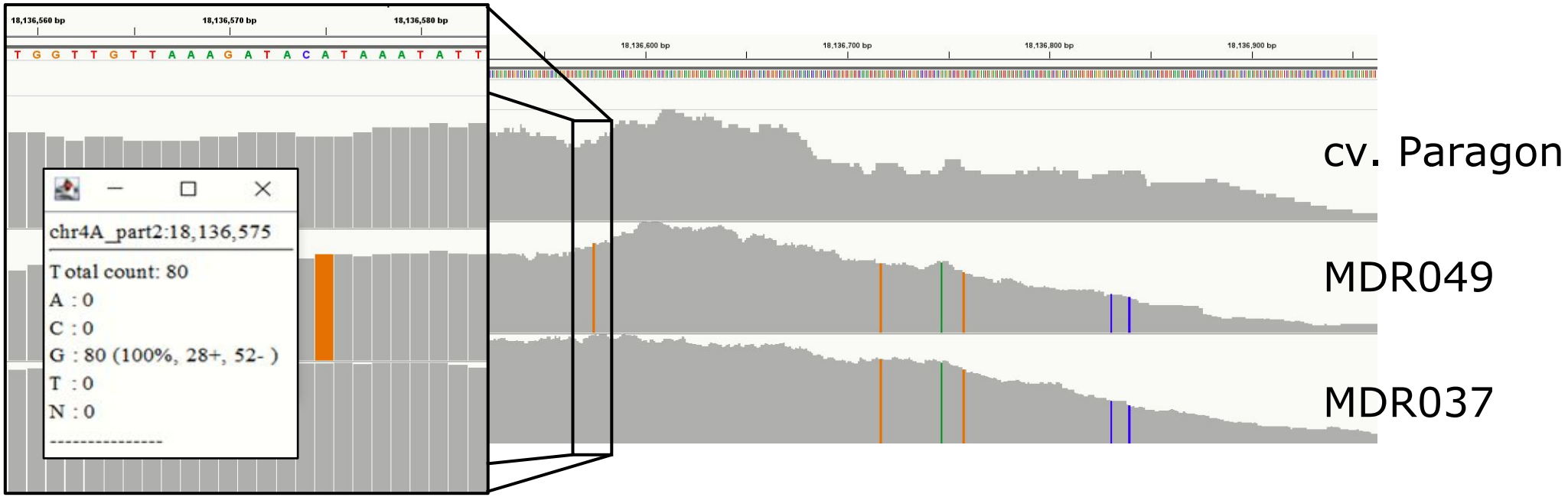
- **Option 2** = Identify additional polymorphisms via alternative SNP array, or reduced-representation NGS approach etc.
- **Option 3** = Utilise WGIN promotome capture data
  - Across *T. monococcum* genome, approximately **311 x** ~1700bp sequenced



  - MDR037, MDR049, MDR045, MDR657 and cv. Paragon included

Genotyping Options

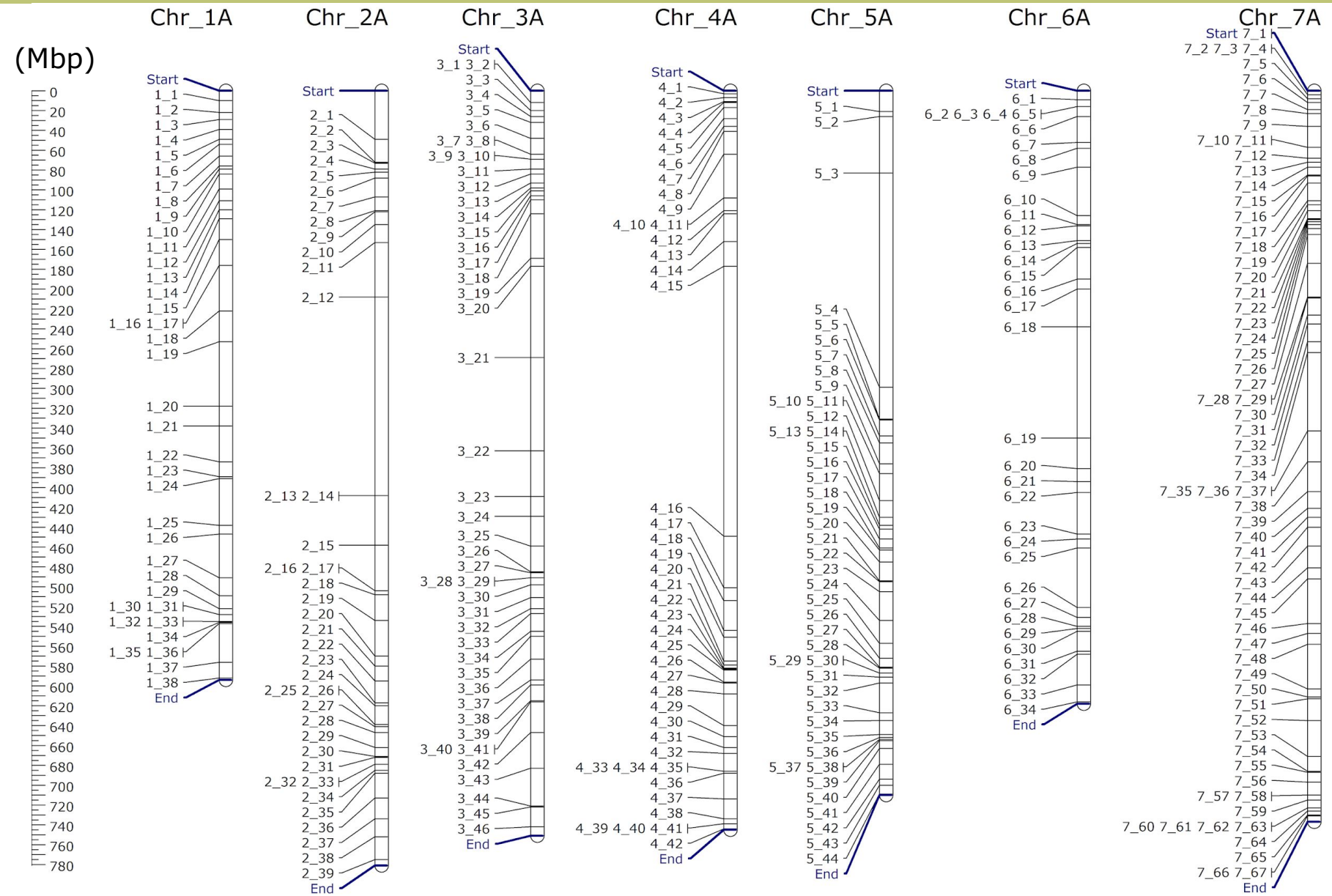
- **Option 2** = Identify additional polymorphisms via alternative SNP array, or reduced-representation NGS approach etc.
- **Option 3** = Utilise WGIN promotome capture data
  - Across *T. monococcum* genome, approximately **311 x** ~1700bp sequenced



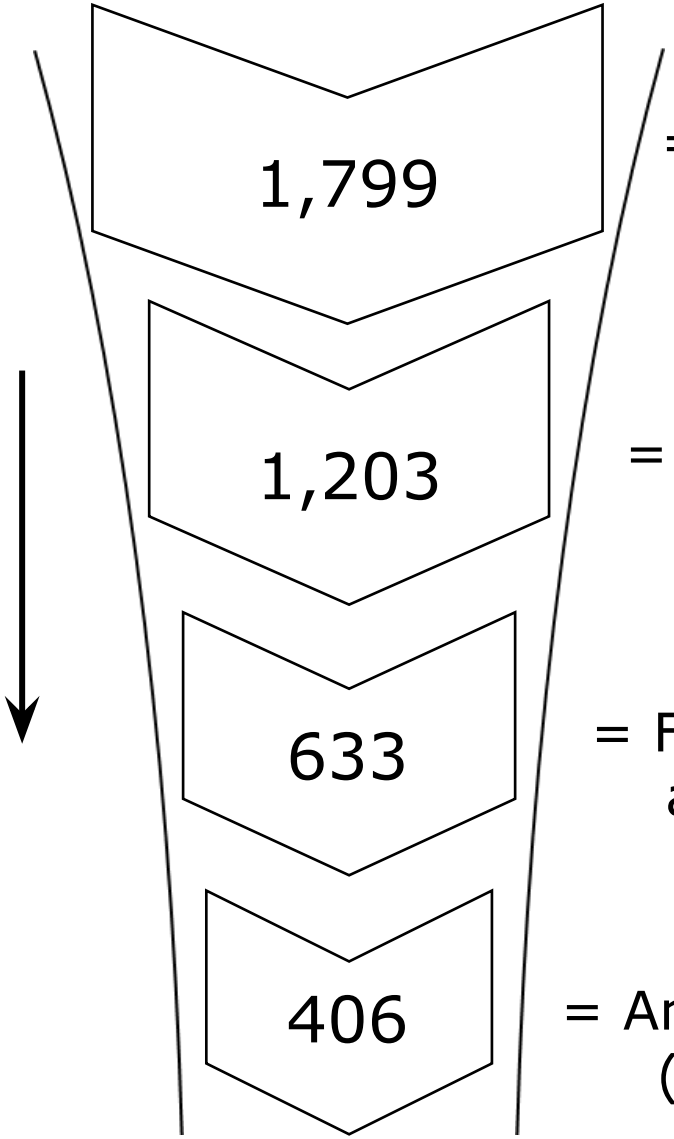
  - Data-mined these regions for robust SNPs to be used for KASP marker development

Promotome Loci on A Genome

- Sequenced loci distribution = **near-ideal for putative QTL analyses**



SNP Screening



Successive filtering

= Total SNPs for MDR037 vs MDR049

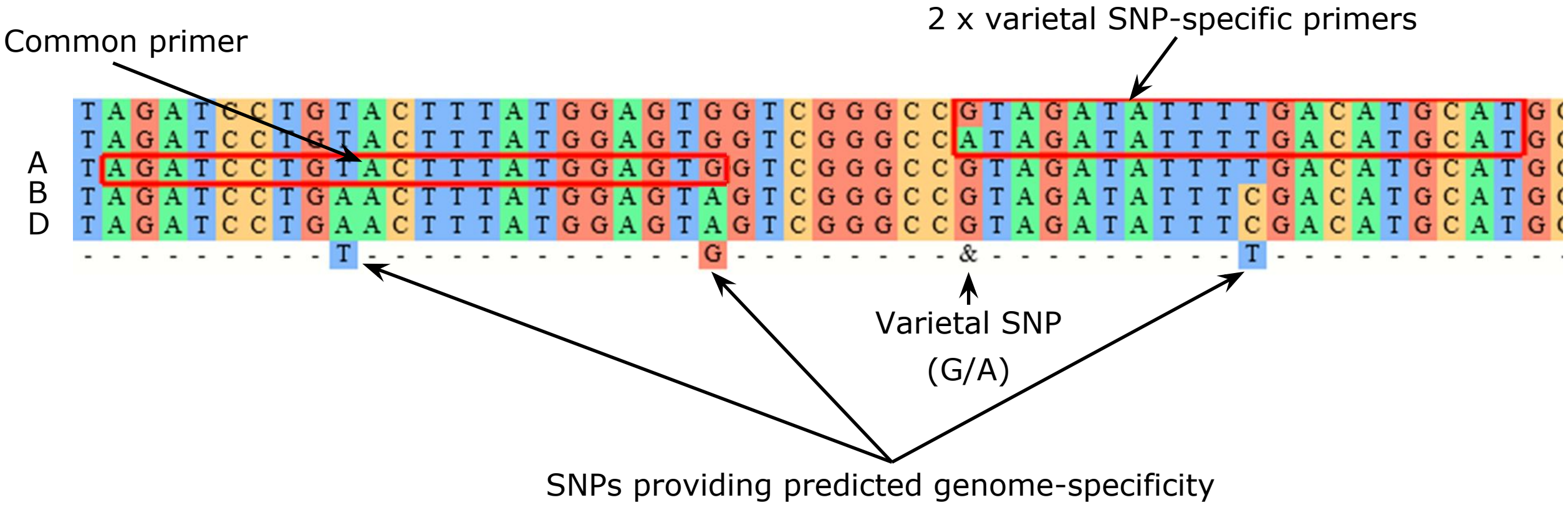
= Filtered for reasonable read depth, and sequencing bias

= Filtered for polymorphic to cv. Paragon, and for SNP being linked with MDR049

= Any viable primers for future KASP development (based on Polymarker bioinformatics pipeline)

KASP Genome Specificity

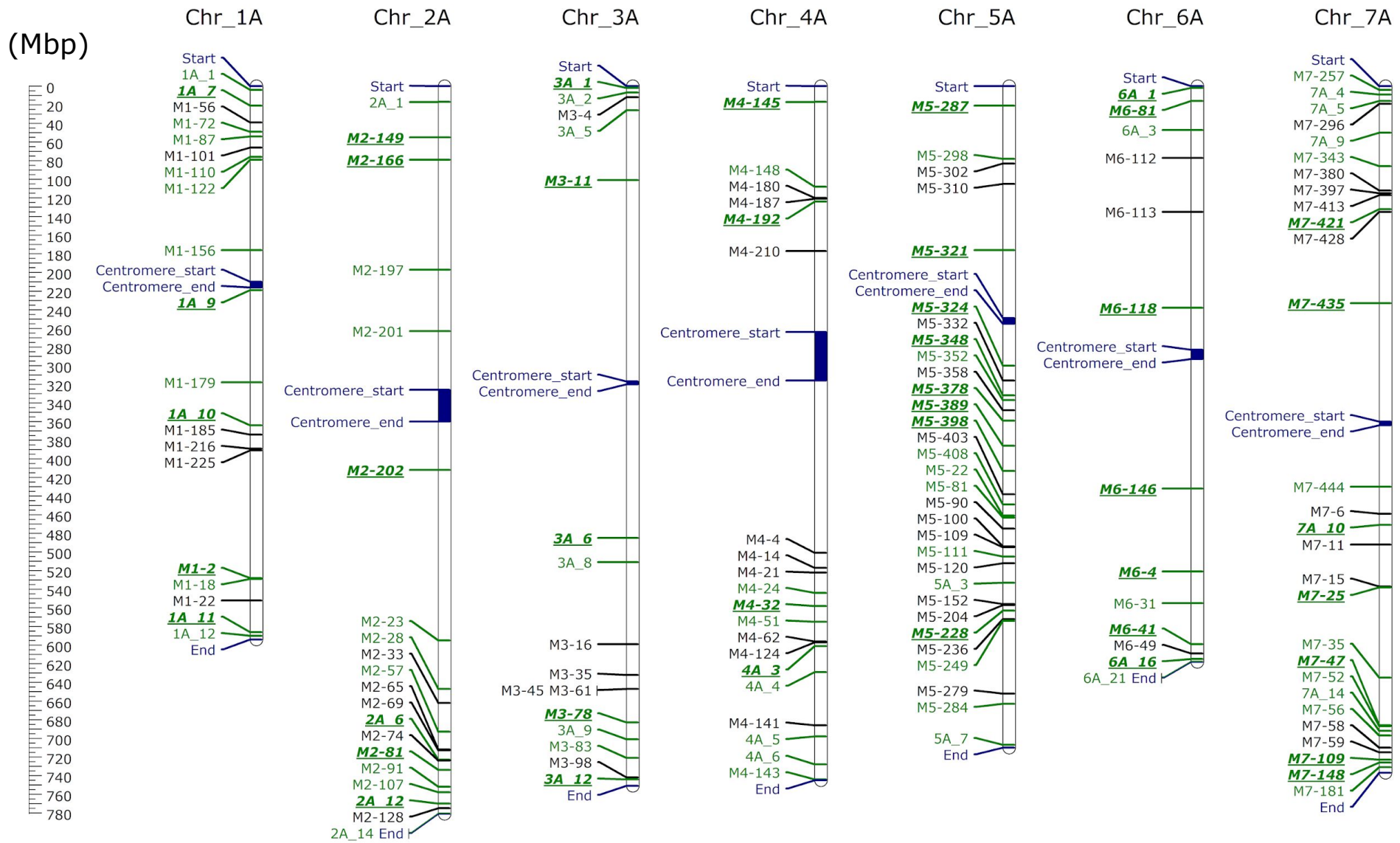
- Polymarker also used to predict genome-specificity:



- Final representative set of distinct (>1Mbp loci) prospective markers identified

Prospective KASP Markers

- SNP array and promotome data:
- Predicted as:
  - ***Genome-specific***
  - Semi-specific
  - Nonspecific
- Total number of distinct loci = **148**



No. prospective KASPs per Chr.:	20	20	16	20	31	13	28

Summary

- MDR037 x MDR049 F_3 population-specific SNPs identified
- Subset taken forward for KASP marker development
- QTL mapping to commence asap
- Informative markers to be hopefully employed with cv. Paragon introgression work

Many thanks to

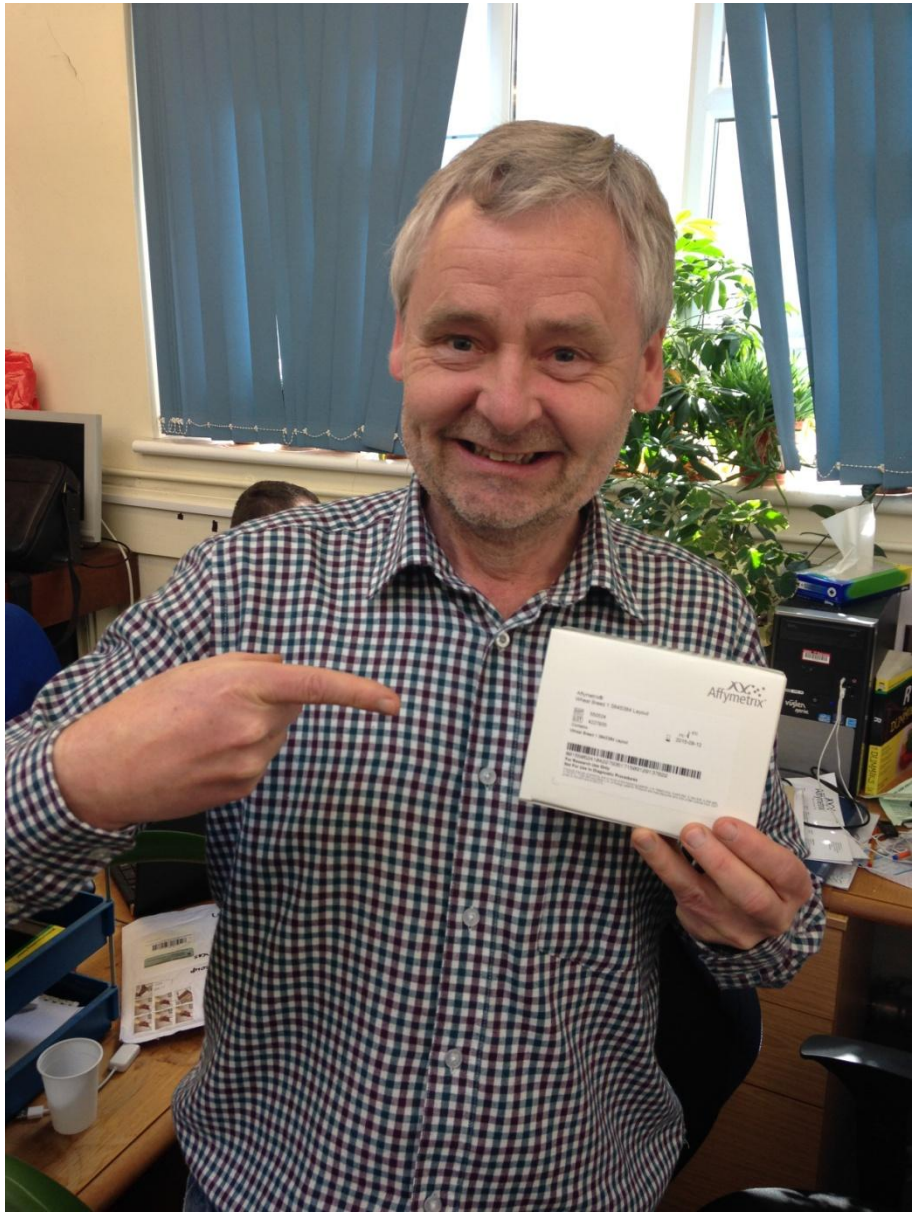
- Gia Aradottir and all involved with phenotyping
- Everyone who worked on the promotome capture data
- RRes Wheat Pathogenomics Team
- Continued assistance from wider wheat community

ROTHAMSTED RESEARCH

Wheat Genetic Improvement Network

Department for Environment Food & Rural Affairs

AHDB



Axiom 35K wheat
Wheat Breeders Array

Using the existing 35K wheat Breeders array, since the summer of 2014

> 20,000 lines genotyped
> 6,000 varieties genotyped
Lots of maps generated

And these are just the ones done via the slola, WISP and DFW.

Breeders' 35K Axiom Array Summary Statistics

- Extract genotypes for a particular variety on the 35K breeders array.

Total number of markers on array: **35143**

Markers that have been mapped: **35042**

Number of SNPs mapped to each chromosome; (expected values are shown in brackets).

	1	2	3	4	5	6	7	Total
A	1647 (1659)	1933 (1868)	1397 (1719)	1342 (1779)	1420 (1719)	1387 (1494)	1693 (1689)	10819 (11927)
B	1824 (1764)	2234 (1928)	2195 (2062)	1226 (1704)	2351 (1808)	1583 (1883)	1519 (1868)	12932 (13017)
D	1722 (1255)	2170 (1509)	1526 (1599)	1046 (1345)	1664 (1554)	1359 (1315)	1804 (1509)	11291 (10086)
Total	5193	6337	5118	3614	5435	4329	5016	35042

But it is six years old and designed with the sequences/knowledge of the time

It is time to redesign the array to make a “Next Generation Wheat Breeders Array”

Like the existing array if it is not public it will not be included on the new array

We envisage that the new array will have:

1. The best SNPs from the existing array (to ensure cross transferability of data from old to new)
2. SNPs in common with other platforms (to help groups compare data across platforms)
3. SNPs “evenly” distributed across all genomes and all chromosomes (physical size, map lengths, number of linkage/haplotype blocks)
4. Co-dominant/functional/promoter/non-genic SNPs
5. Agronomically important SNPs (Rht etc) and SNPs of interest to the community

We now have lots and lots of sequences, SNPs, maps and a lot of information on linkage and haplotypes

And we have some of the best cooperative wheat geneticists and informaticians there are!

We also have the beginnings of a Working Group

NGWBA Working Group (in no particular order and a work in progress):

Alison Bentley and Susanne Dreisigacker (CIMMYT)
Simon Griffiths, Graham Moore, Cristobal Uauy, Ricardo Gonzalz(JIC)
Tally Wright, Keith Gardner (NIAB)
Shifeng Cheng (AGIS)
Gary Barker, Sacha Allen, Amanda Burridge, Mark Winfield, Keith Edwards (Bristol)

We have also spoken to breeders and a few others and we hope to bring them on board soon

We will need to be careful we don’t end up with a “committee array” So Bristol will lead and make the final call

This is going to be complicated so to help develop our strategy we suspect that we will first design a set of SNPs for chromosome 6A. This will focus our mind and help fine tune the bioinformatics required

Currently there is no funds for this, but this is something that Bristol are working on!

We are aiming to have a design before Easter 2021 with a working array next summer

As yet we are not fixed on any particular platform, however, my personal preference is the Axiom platform

We want you:

1. To be aware of this development
2. Be aware that ThermoFisher have said that no matter what happens, the old 35K and 820K array will continue to be one of their products
3. To contribute your skills if you have any that might be useful