



Triticum monococcum Introgression into Bread Wheat

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WGIN Stakeholders' Meeting

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@Rothamsted





Why?

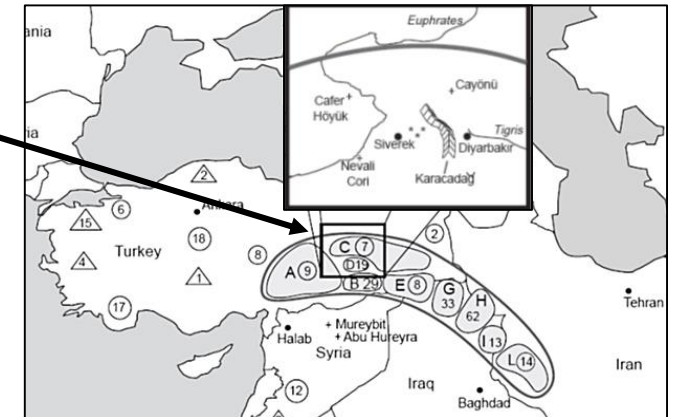
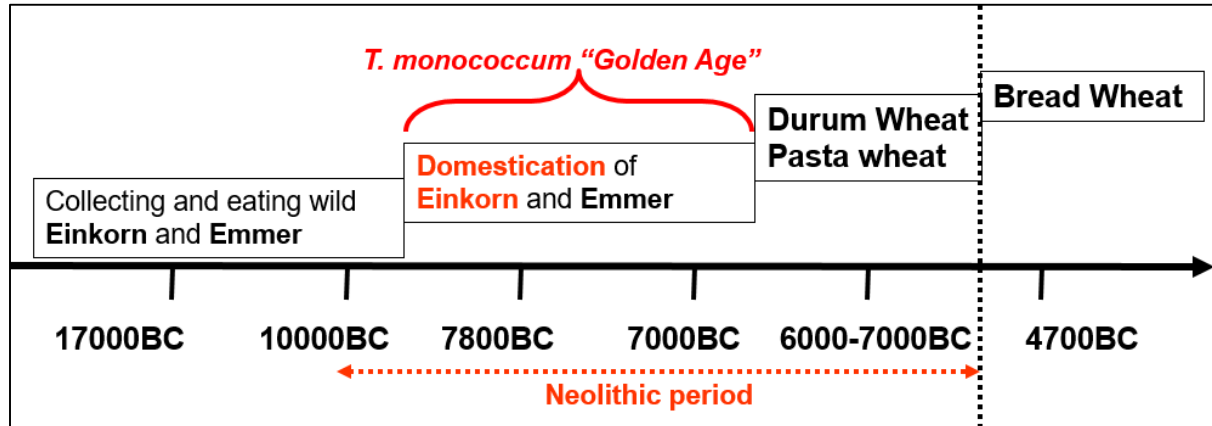
- Commercial hexaploid **bread wheat** (*Triticum aestivum*) grown in monoculture **highly susceptible to** a large number of **diseases**.
- This necessitates frequent spraying with **fungicides** and **insecticides**.
- Many diploid ancestors, including *Triticum monococcum* (Einkorn) and related species **exhibit strong resistance** to most of these diseases.
- Is it **possible to transfer** (introgress) the **natural resistance** traits from *T.mon* **into bread wheat** using conventional crossing strategies?
- Ideally this would result in still high-yielding **bread wheat** partially or fully **resistant to multiple diseases**.



What is *Triticum monococcum*?



- **Einkorn**, “Nature’s First And Oldest Wheat”
- Originates from the **Karacadağ Mountains** (Eastern Turkey) within the **Fertile Crescent**
- domesticated between **6500 – 9000BC**



- diploid wheat species – only has A genome ($A^m A^m$) BUT is not the actual A genome donor of modern wheat

Rogues' Gallery

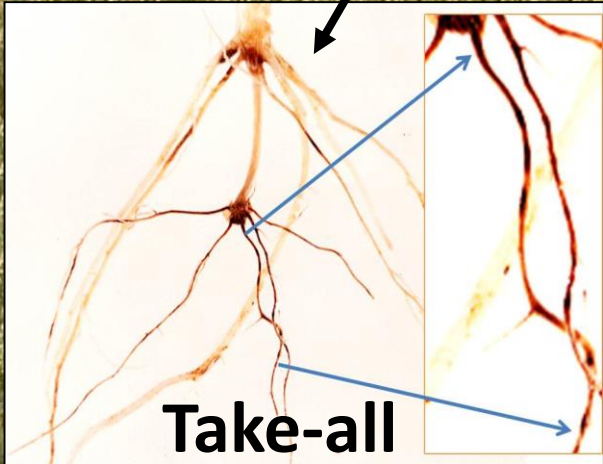
MDR031



MDR308
(DV92)



MDR049



Take-all

a major problem for
2nd / 3rd wheat crops



Yellow rust



Septoria leaf blotch

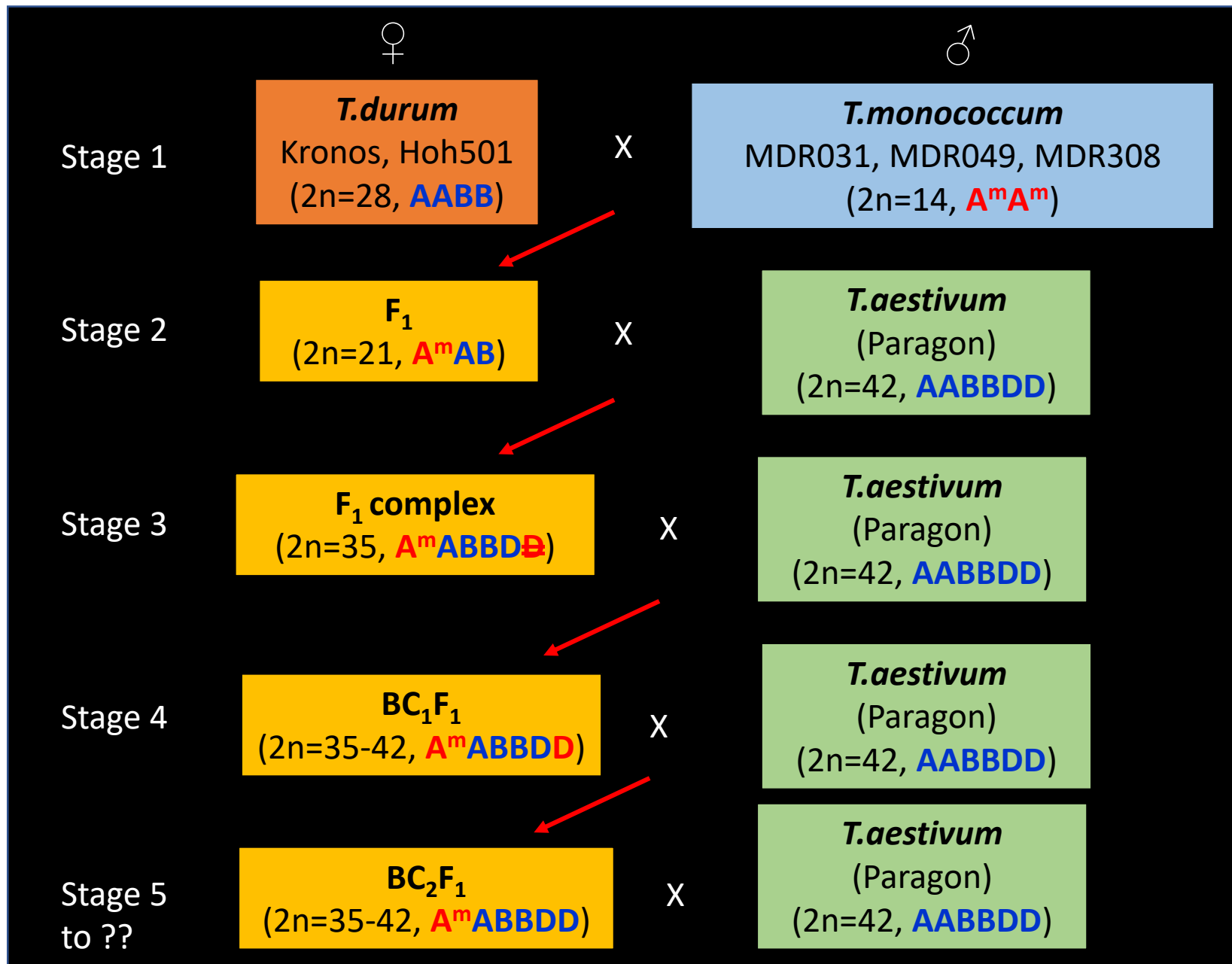


aphids

annually all crops at high risk



Crossing Strategy No.3 – Using Tetraploid *T.durum* as a Bridging Species



stage 1



Kronos



T.mon MDR031



F₁ hybrid



F₁ hybrid

Kronos

stage 2

F₁ hybrid

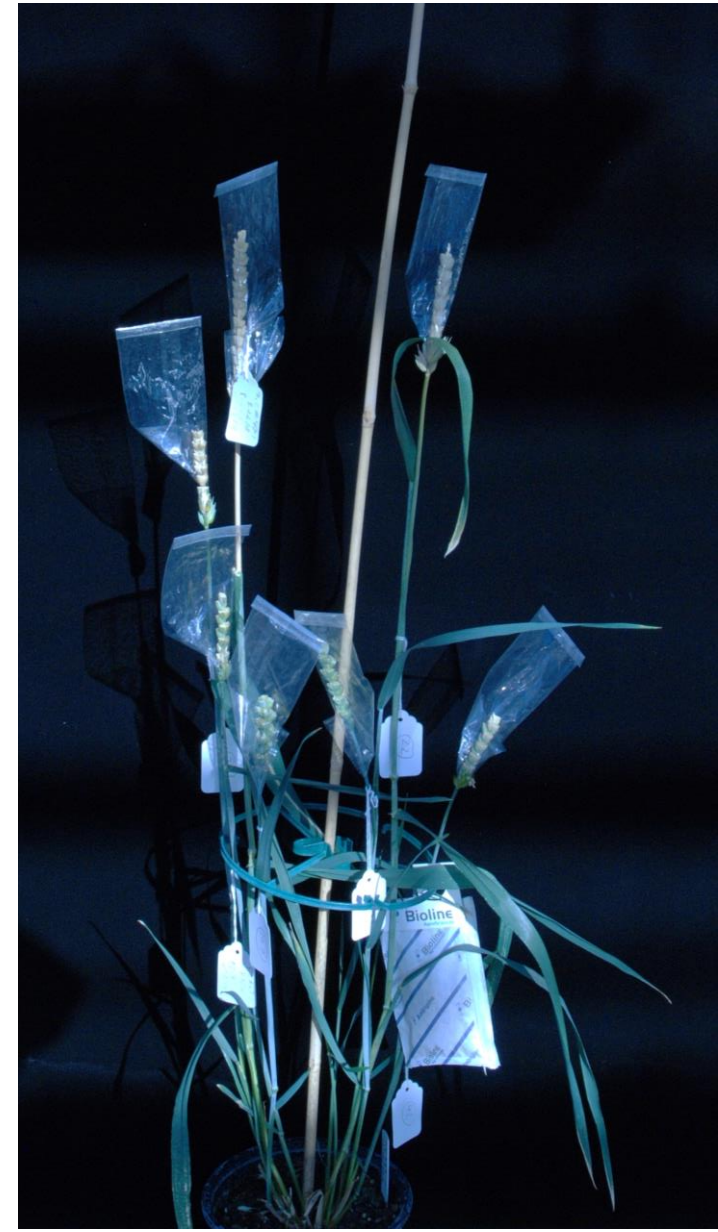
♀

Paragon

♂

F₁ complex

F₁ complex plant F₁C#47-1





F₁ complex plant
F₁C#47-1
♀

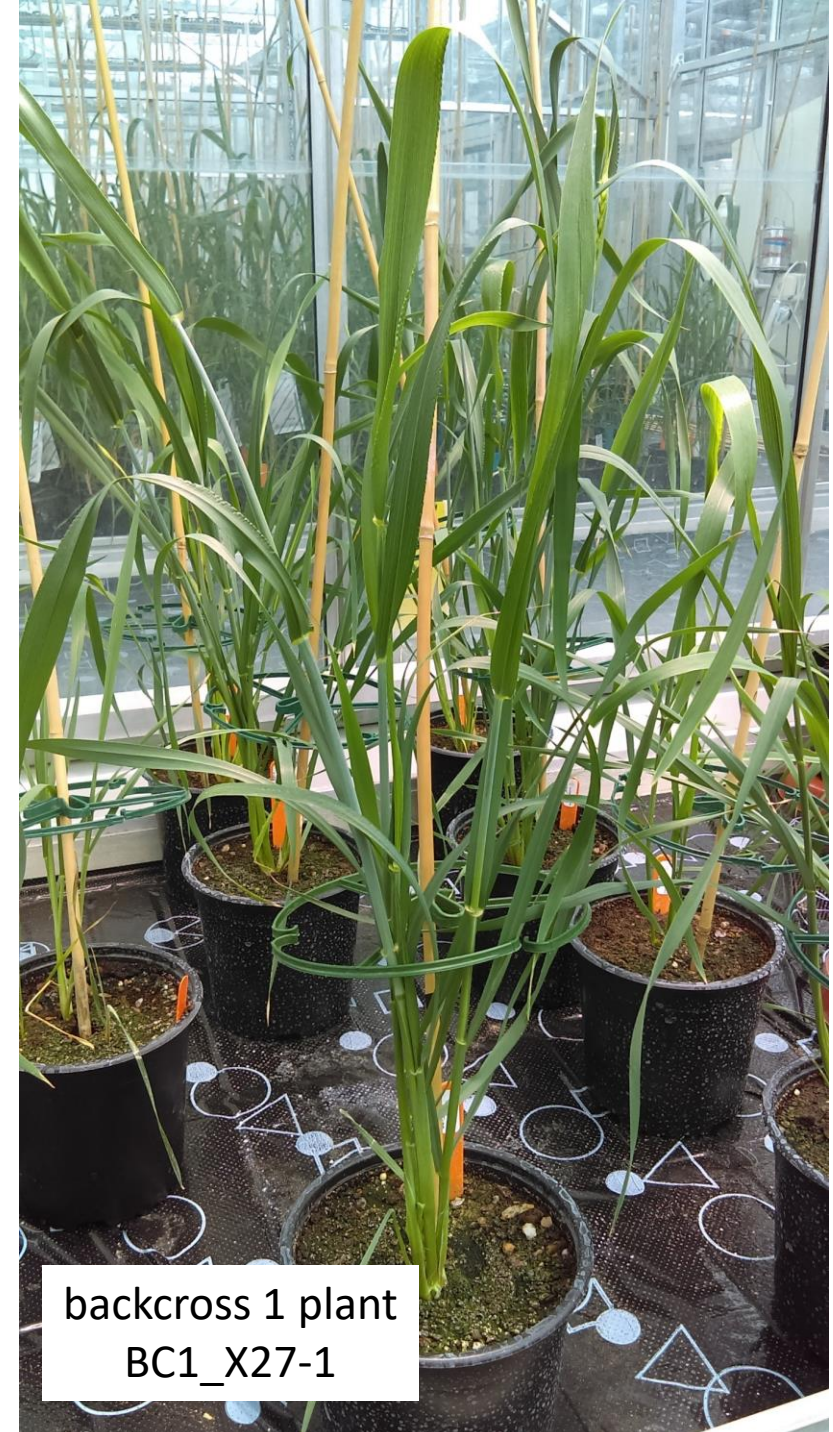
stage 3



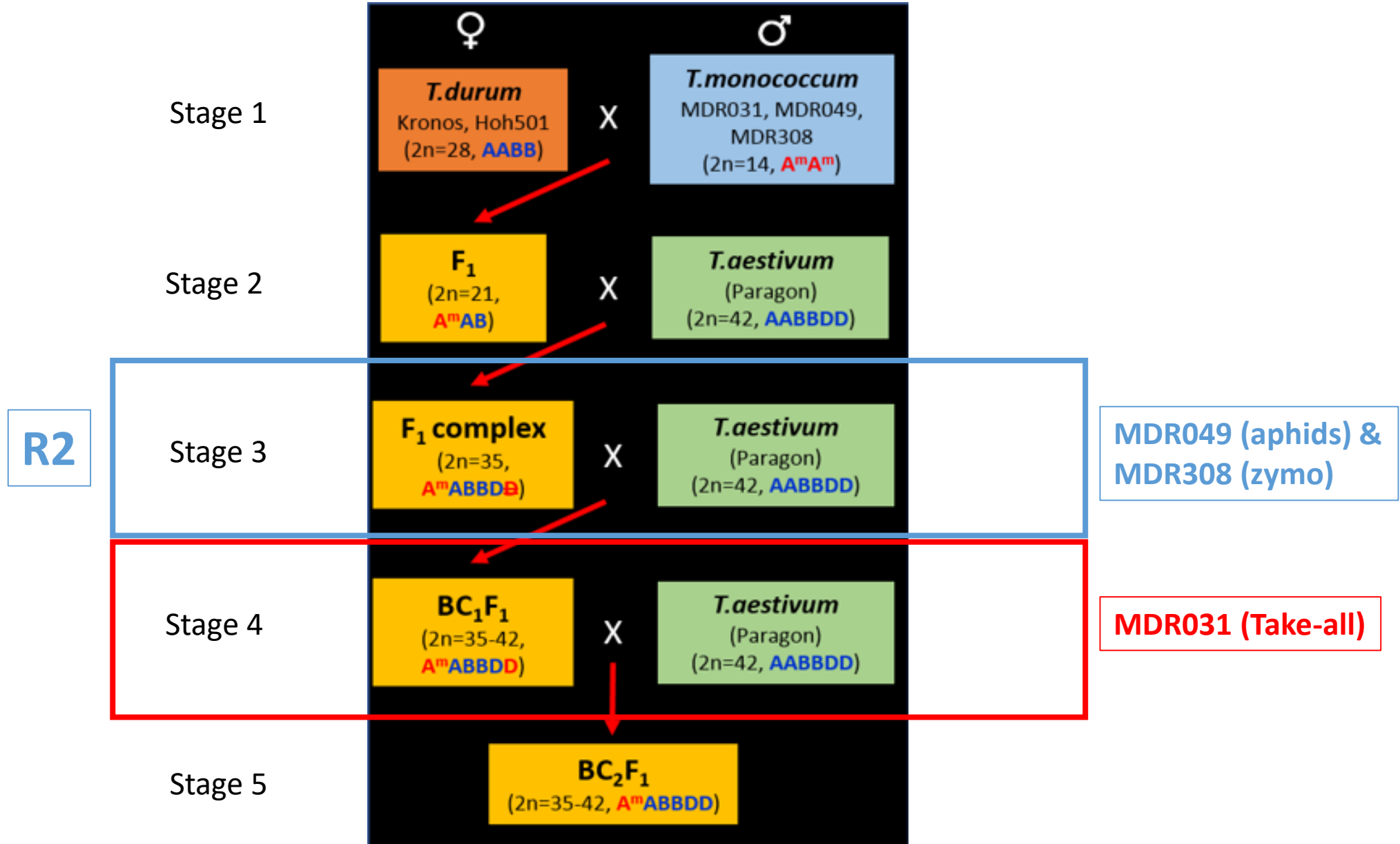
backcross 1 plant
BC1_X27-1



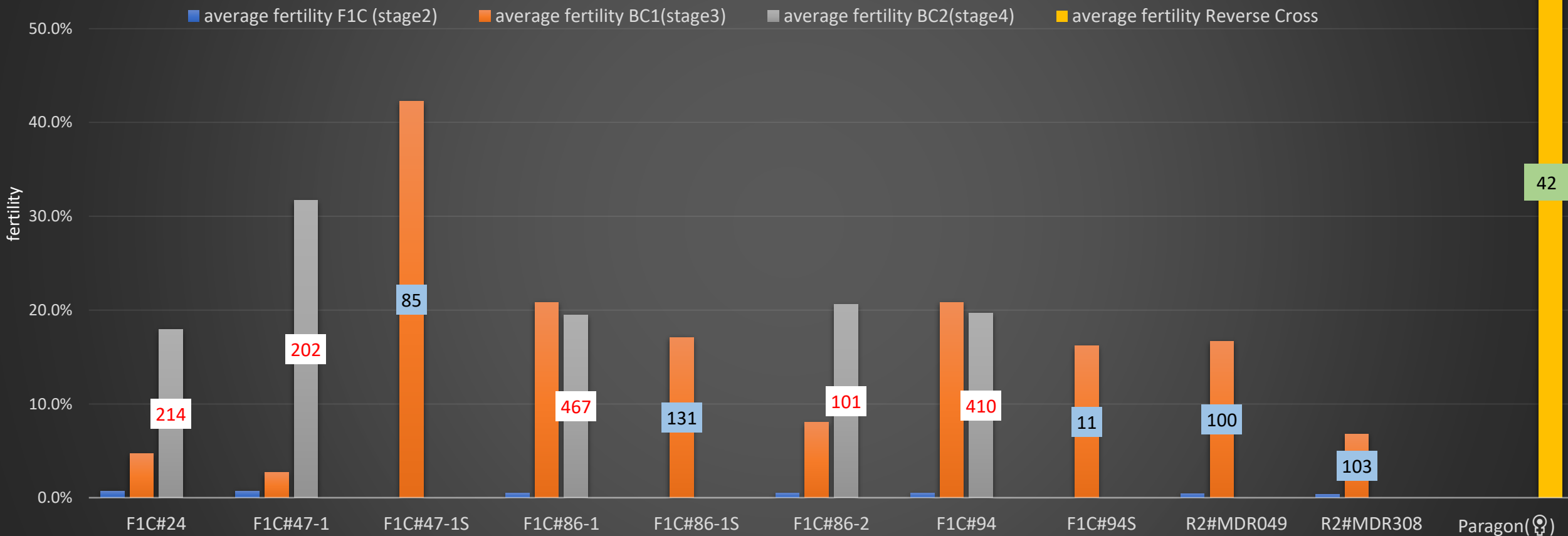
Paragon
♂



backcross 1 plant
BC1_X27-1



Fertility Increase during *T.mon* Introgression



BC₁ grains generated:

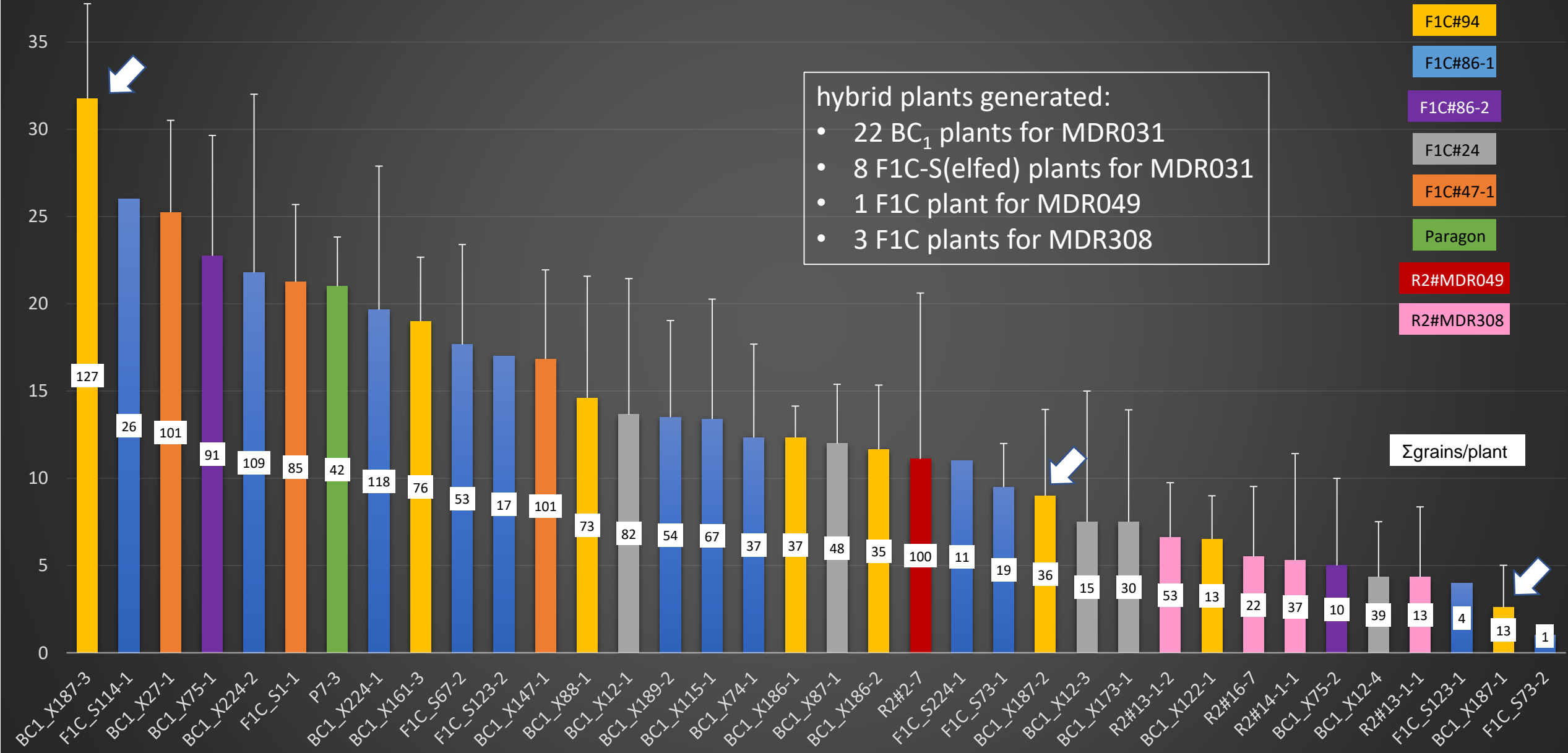
1. round 2 for MDR049 & MDR308 – F₁C#MDR*** (♀) x Paragon (♂),
2. selfed F₁C#MDR031 plants: F₁C#***S (♀) x Paragon (♂),

BC₂ grains generated: BC₁-F₁C# (♀) x Paragon (♂)

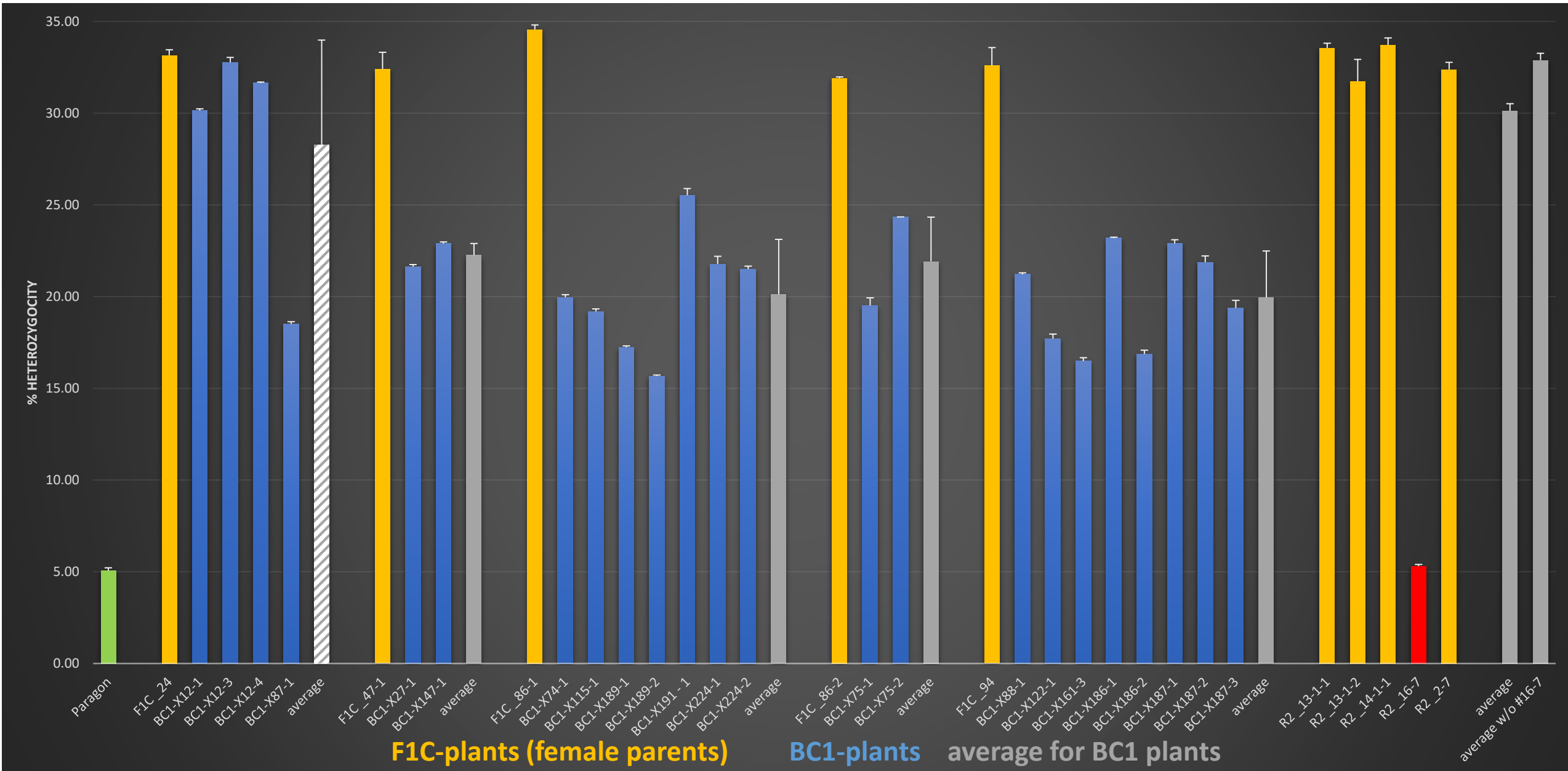
grains generated from reverse cross: Paragon (♀) x BC₁-F₁C# (♂)



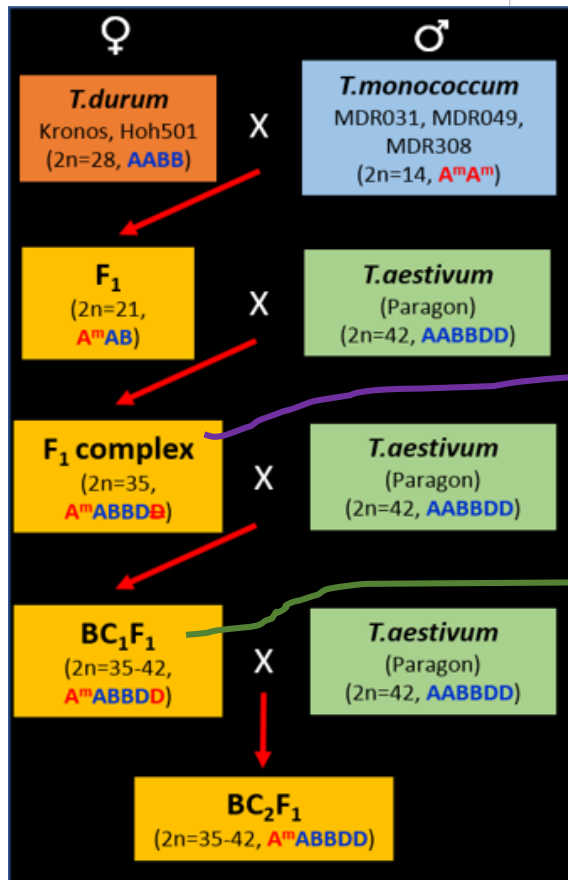
fertility of individual hybrid plants - grains/ear



Difference between F₁C & BC₁ plants and Paragon (from Axiom 35k Breeders' Array Genotyping)

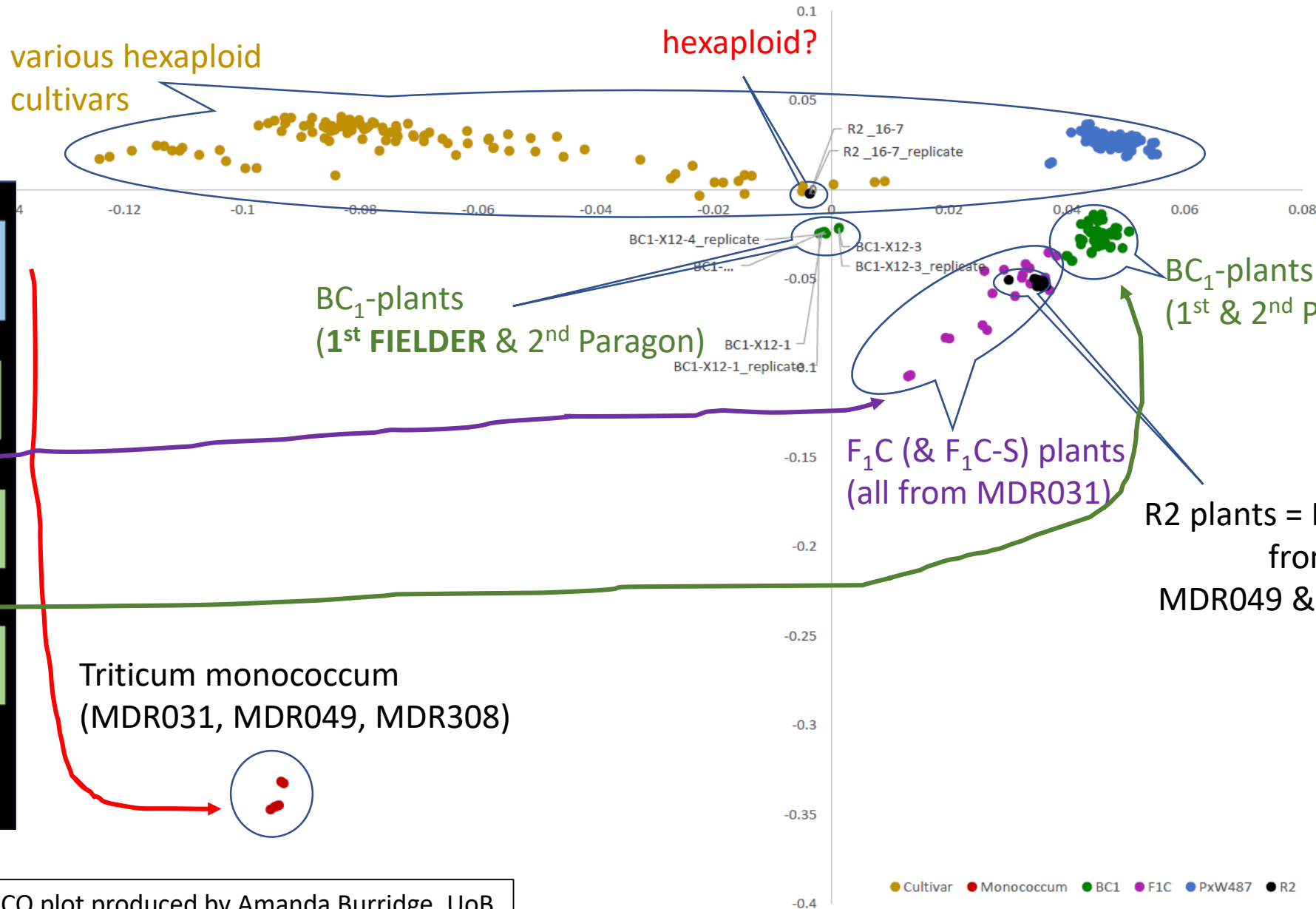


PCO plot shows clear clustering of hybrid plants at the same Introgression stage



various hexaploid cultivars

hexaploid?



PCO plot produced by Amanda Burridge, UoB



Axiom Molecular Markers

AX-94562264 on Chromosome 7A position: 260,316,59bp

sequence:

GCTGAATCCAGCATGGGAGATGTGGGCGATGTGCC[T/G]CTAATCCTGCAATTGGCCATCAACAACGGCTGTGA

every one of ~35000 Axiom Markers is scored for **homozygous** (AA or BB) or **heterozygous** (AB):

1) **homozygous AA** – both paired chromosomes have [T]

GCTGAATCCAGCATGGGAGATGTGGGCGATGTGCC[T]CTAATCCTGCAATTGGCCATCAACAACGGCTGTGA

2) **homozygous BB** – both paired chromosomes have [G]

GCTGAATCCAGCATGGGAGATGTGGGCGATGTGCC[G]CTAATCCTGCAATTGGCCATCAACAACGGCTGTGA

3) **heterozygous AB** – 1 of the paired chromosomes has [T], the other [G]

GCTGAATCCAGCATGGGAGATGTGGGCGATGTGCC[T]CTAATCCTGCAATTGGCCATCAACAACGGCTGTGA

GCTGAATCCAGCATGGGAGATGTGGGCGATGTGCC[G]CTAATCCTGCAATTGGCCATCAACAACGGCTGTGA

4) if both MDR031 and [Paragon/Kronos] are **homozygous but opposite** (MDR031= AA, Par = BB, or reversed), any Axiom marker giving a **heterozygous call (AB) for the hybrid plants indicates an introgression event**





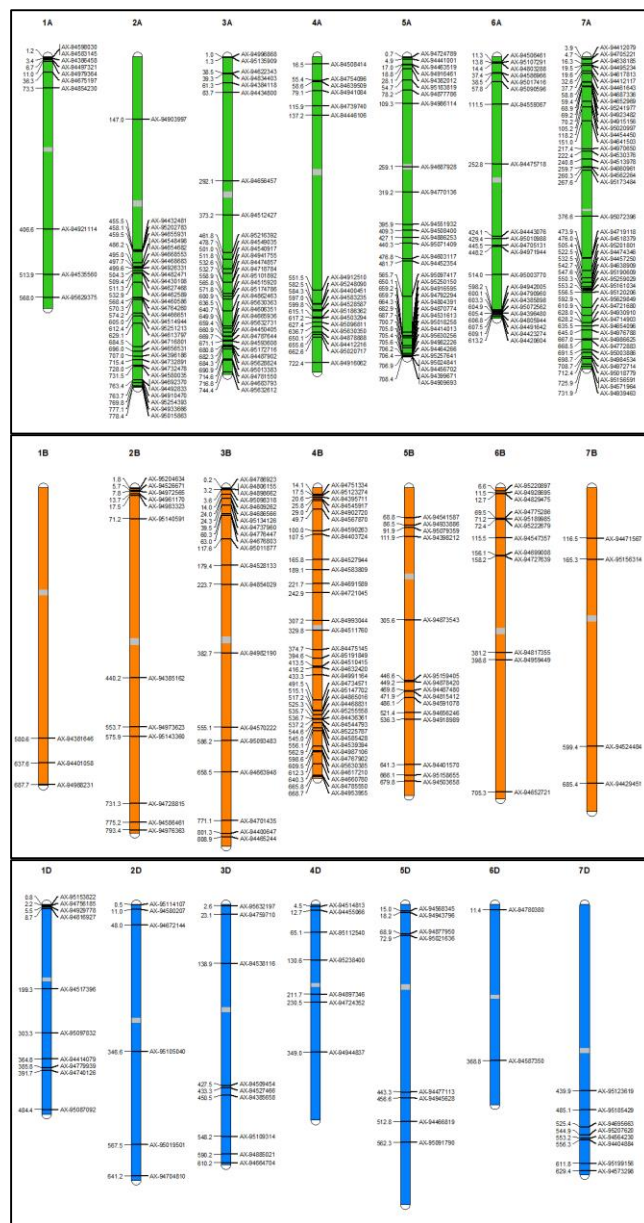
Considerably Higher hetMarker Density in A Genome

hetMarkers total:

- **A Genome** –
182 markers (55%)

- **B Genome** –
99 markers (30%)

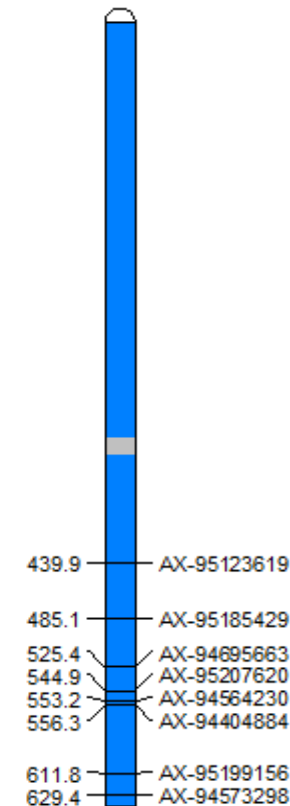
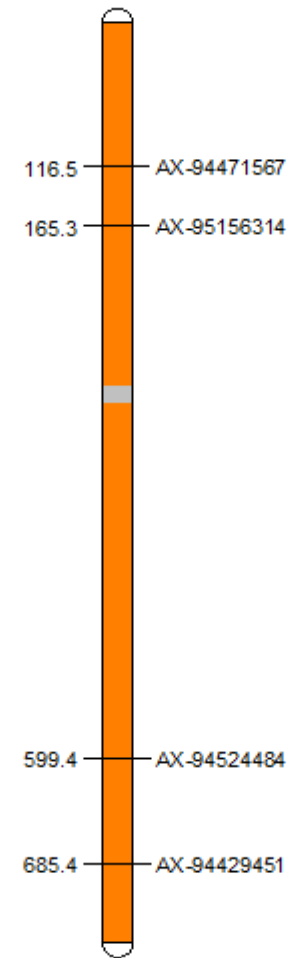
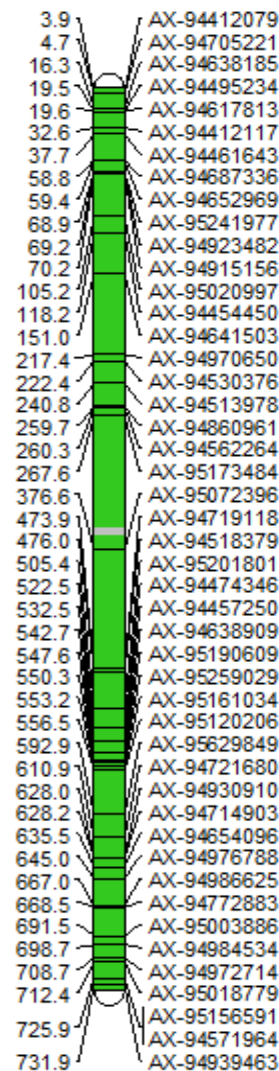
- **D Genome** –
50 markers (15%)



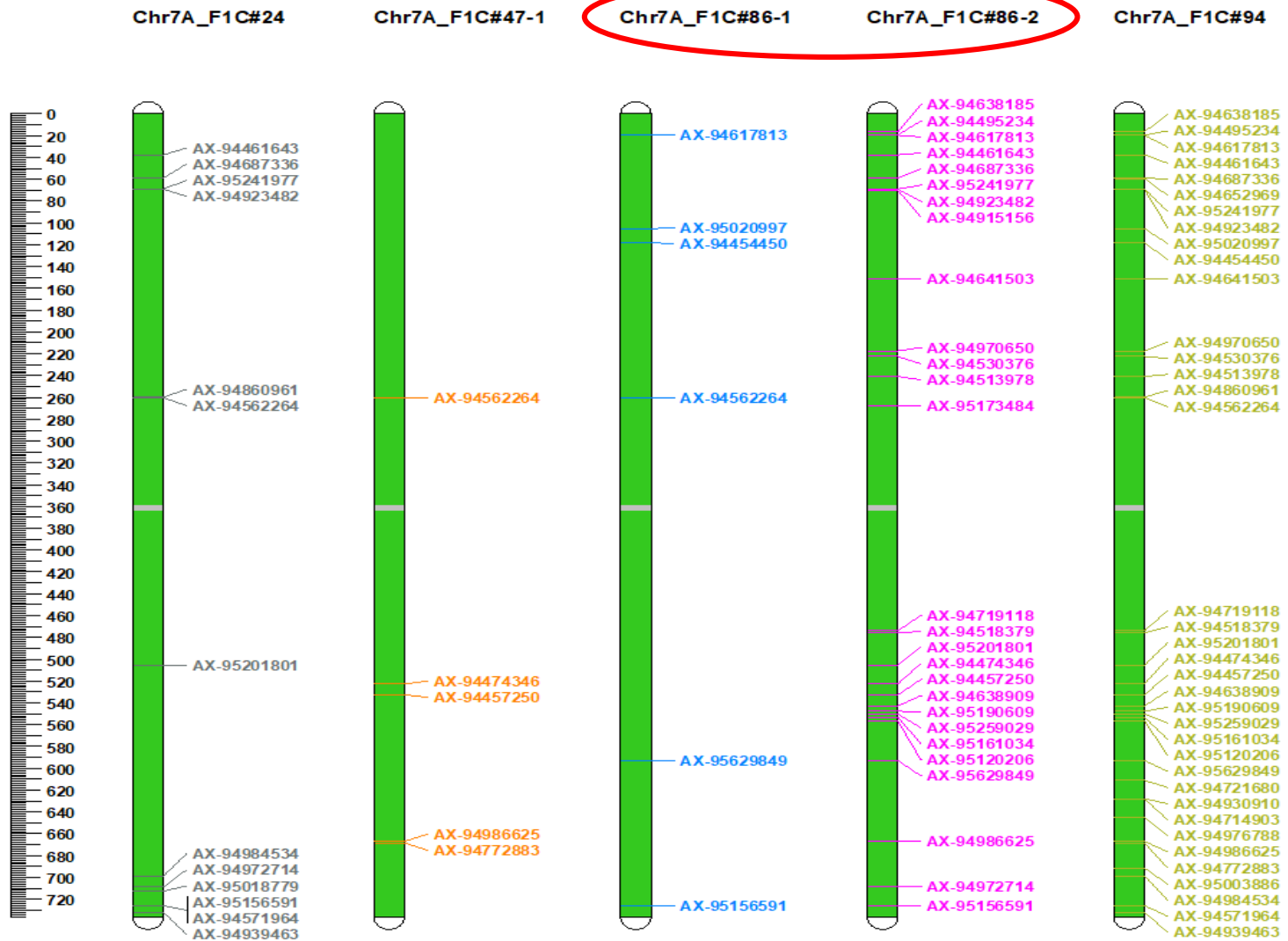
Chr 7A
47 (80%)

Chr 7B
4 (7%)

Chr 7D
8 (13%)



Distribution of Chromosome 7A hetMarkers in the 5 F₁C mother plants generated for MDR031 Introgression



F₁C#86-1 and F₁C#86-2 originate from 2 grains from the same cross on the same ear of the F₁ Hybrid pollinated with Paragon.



F₁C#86-1

F₁C#86-2

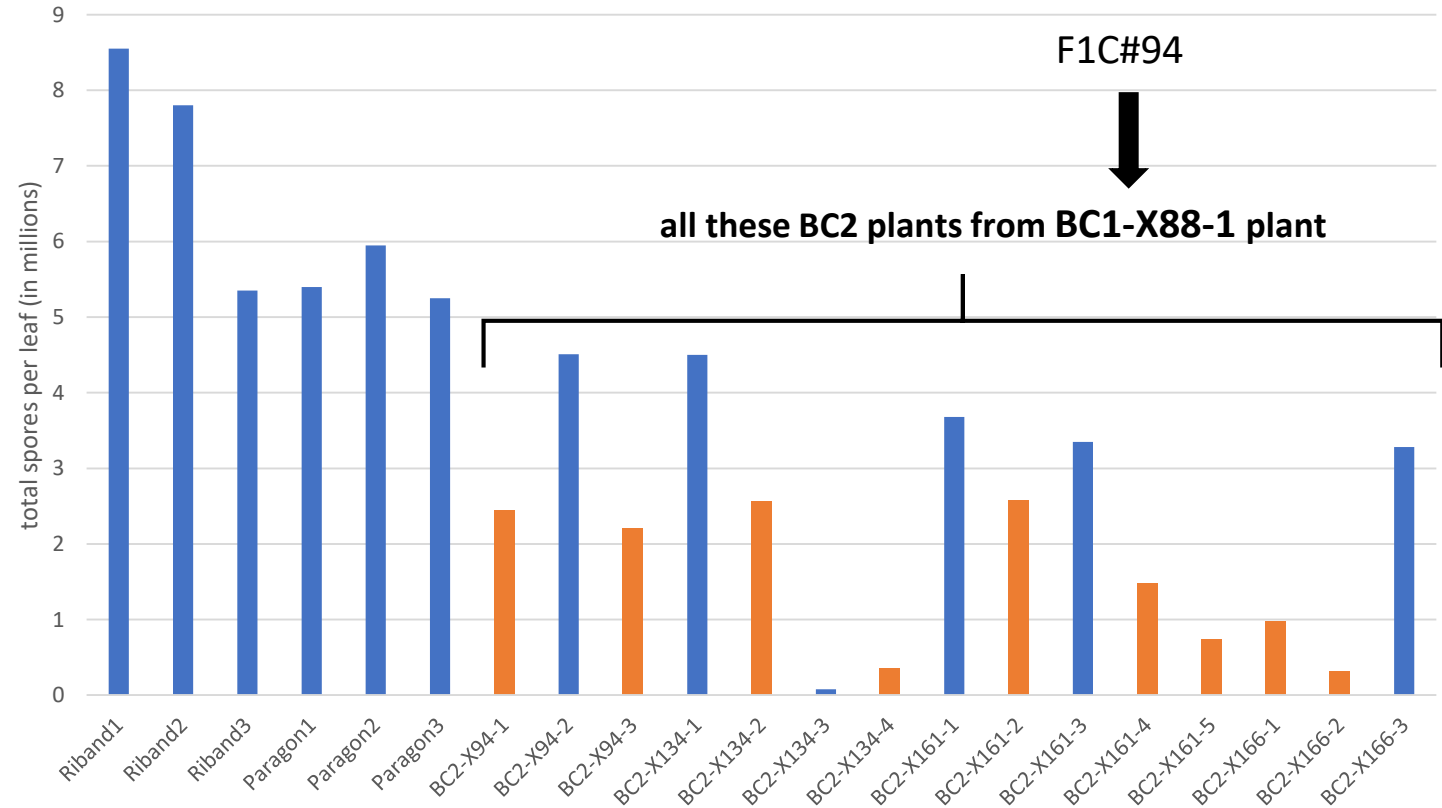


What's Next?

- testing for resistance: **first Zymoseptoria tests completed**, others being designed
- next round of backcrossing to **generate BC₃ grain** started: >98% of BC₂ grains germinated, all (~240 plants) in vernalisation
- **GBS** (Genotyping By Sequencing) (modified procedure) underway at Julius Kuehn-Institute (Germany) with Dragan Perovic to determine extent of integration
- **SSD** (Single Seed Descent) being planned for field trials



First Zymoseptoria assays: promising



considerably reduced spore count -> partial resistance



Thanks to:

- Kim Hammond-Kosack (RRes)
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 - Richard Horsnell (NIAB)
- Jill Maple, Jack Turner, Tom Yaxley (RRes)
 - Defra

