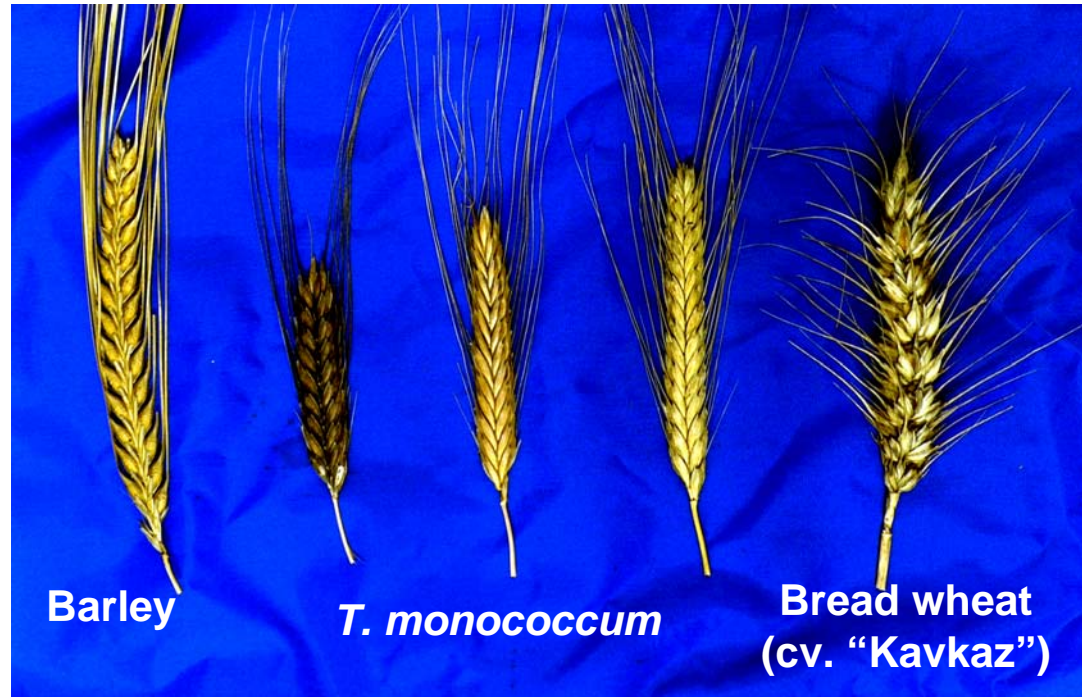


Novel sources of resistance to pathogens in **diploid** and **hexaploid** wheat

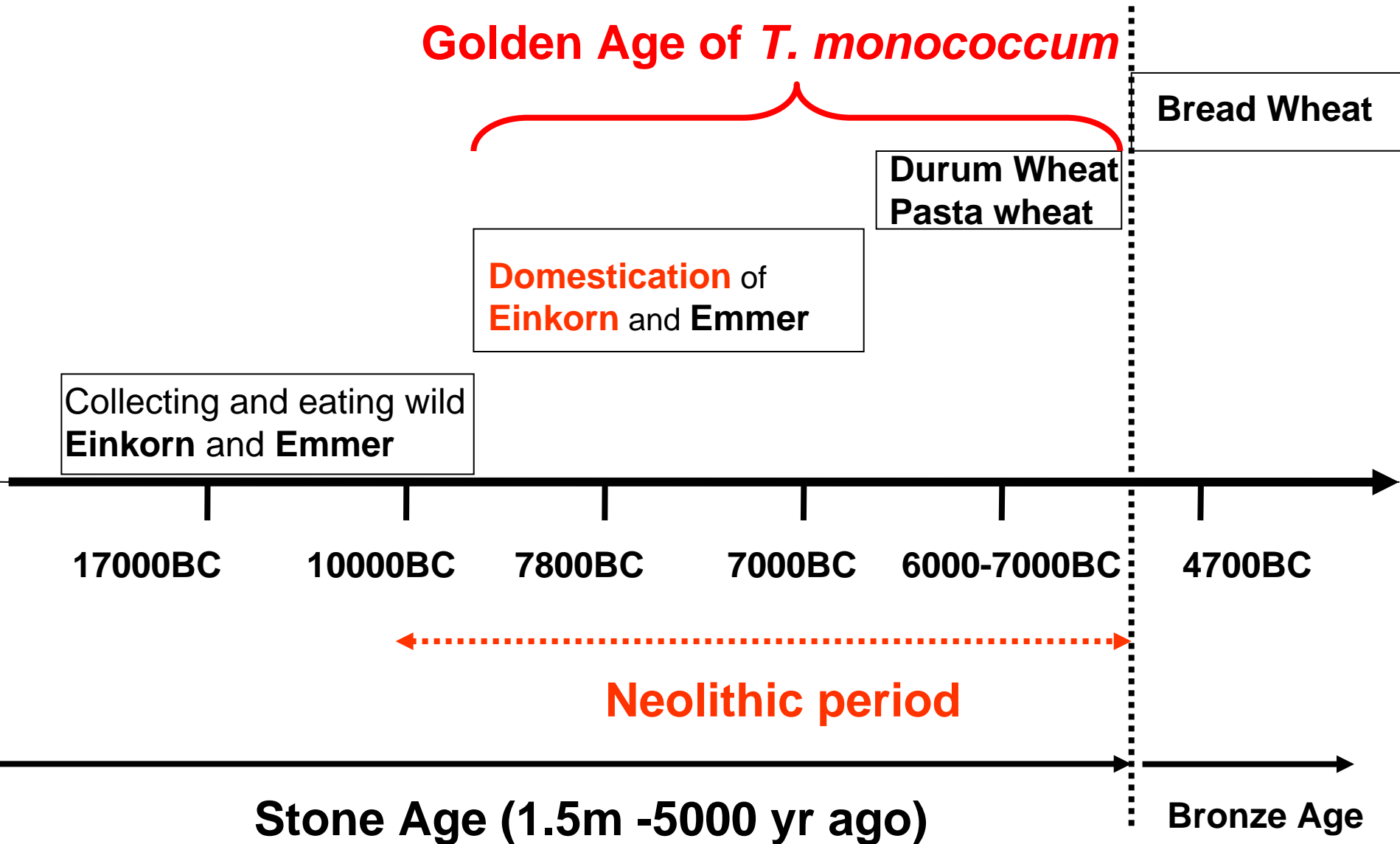
Hai-Chun Jing

T. monococcum ($A^m A^m$, $2n=2x=14$)

an cultivated diploid einkorn wheat



T. monococcum, an ancient grain



T. monococcum collection at RRes

| Origin Country | Numbers | Origin Country | Numbers | Variety | Numbers | Other features | Numbers |
|----------------|---------|----------------|---------|----------------------|---------|--------------------------|-----------|
| Algeria | 1 | Ukraine | 2 | <i>MDR050</i> | 1 | Seasonality | |
| Chechen | 1 | Armenia | 3 | <i>DV 92</i> | 1 | Spring | 207 |
| Czechoslovakia | 1 | Austria | 3 | <i>kaploutras</i> | 1 | Winter | 35 |
| Denmark | 1 | Georgia | 3 | <i>kelcyras</i> | 1 | Facultative | 1 |
| French | 1 | United States | 3 | <i>mansfeldii</i> | 1 | Intermediate | 1 |
| Iran | 1 | Germany | 4 | <i>viridivulgare</i> | 1 | | |
| Israel | 1 | Romania | 4 | <i>laetissimum</i> | 2 | Earliest collection time | Year 1904 |
| Kenya | 1 | unkown | 7 | <i>sofianum</i> | 3 | | |
| Russian | 1 | Yugoslavia | 7 | <i>atriaristatum</i> | 5 | Accession with BAC | 1 |
| South Africa | 1 | Balkans region | 8 | <i>hohensteinii</i> | 6 | library | |
| Syria | 1 | Greece | 9 | <i>nigricultum</i> | 6 | | |
| Azerbaijan | 2 | Italy | 9 | <i>monococcum</i> | 9 | Transformable accessions | 2 |
| Ethiopia | 2 | Spain | 9 | <i>flavescens</i> | 13 | | |
| Hungary | 2 | Bulgaria | 11 | <i>hornemannii</i> | 21 | Accessions with EMS | 2 |
| Iraq | 2 | Europe | 39 | <i>macedonicum</i> | 28 | populations | |
| Morocco | 2 | Albania | 45 | <i>vulgare</i> | 66 | | |
| Sweden | 2 | Turkey | 55 | <i>unknown</i> | 79 | Accession with ion beam | 1 |
| Switzerland | 2 | Total | 246 | Total | 244 | irradiation populations | |

Total = 263

Identification of novel traits

Agronomic and morphological traits

Grain features

Salt tolerance

Drought tolerance

Resistance to various pathogens



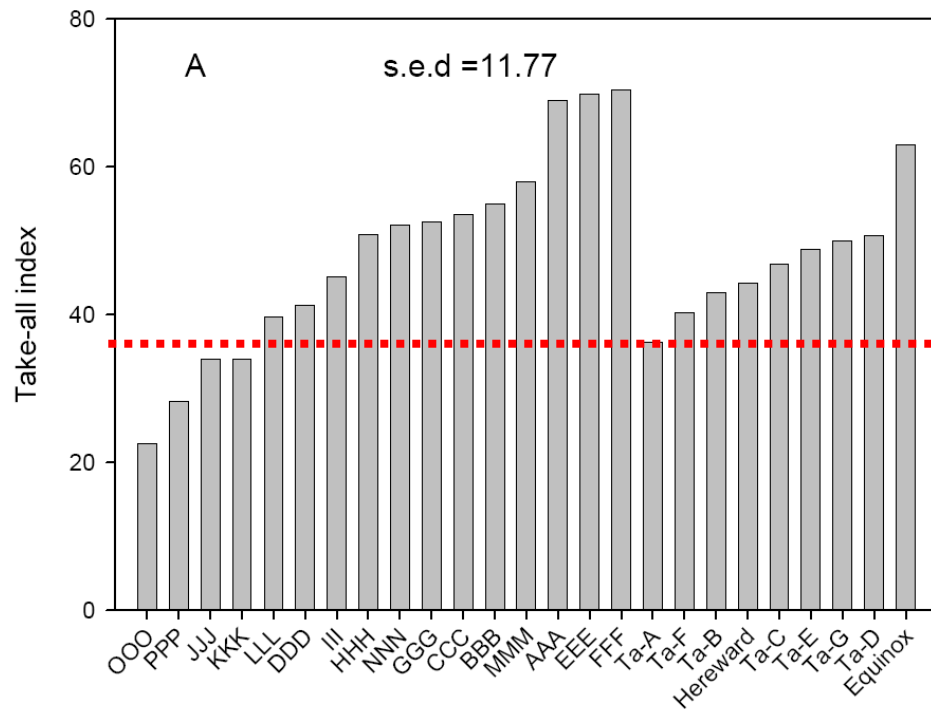
- Eyespots,
- Take-all,
- Septoria tritici blotch
- Yellow rust, leaf rust
- Ergot,
- Viruses
- Fusarium* head blight,
- Aphid,
- Powdery mildew

Take-all disease is a severe threat to 2nd and 3rd wheats

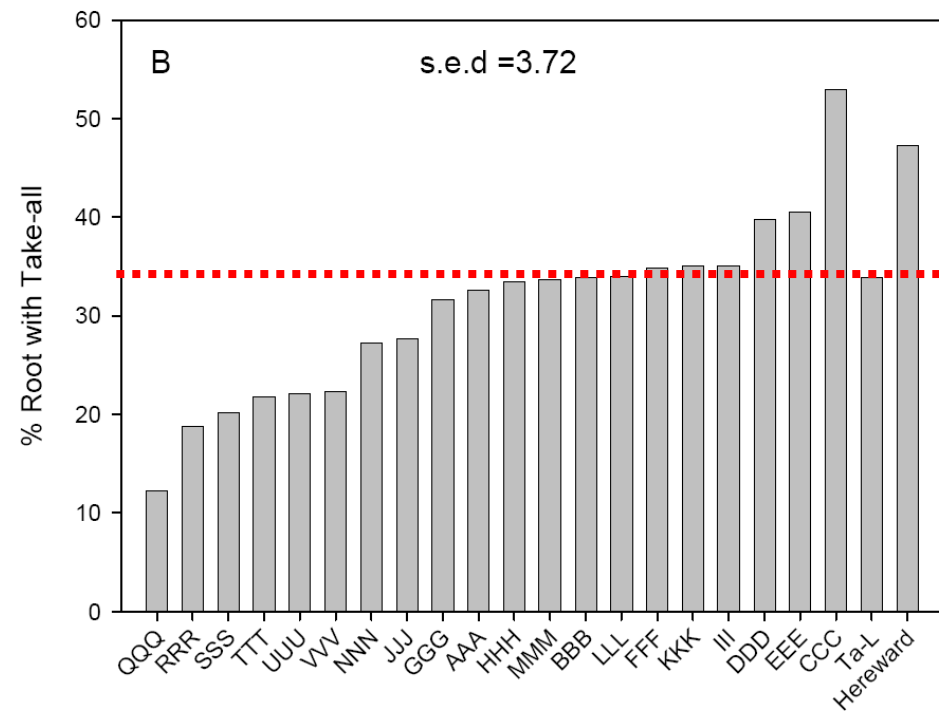


Genetic variation in Take-all susceptibility

Field assay



Pot assay



Eyespot resistance in *T. monococcum*



**Common wheat
(susceptible)**

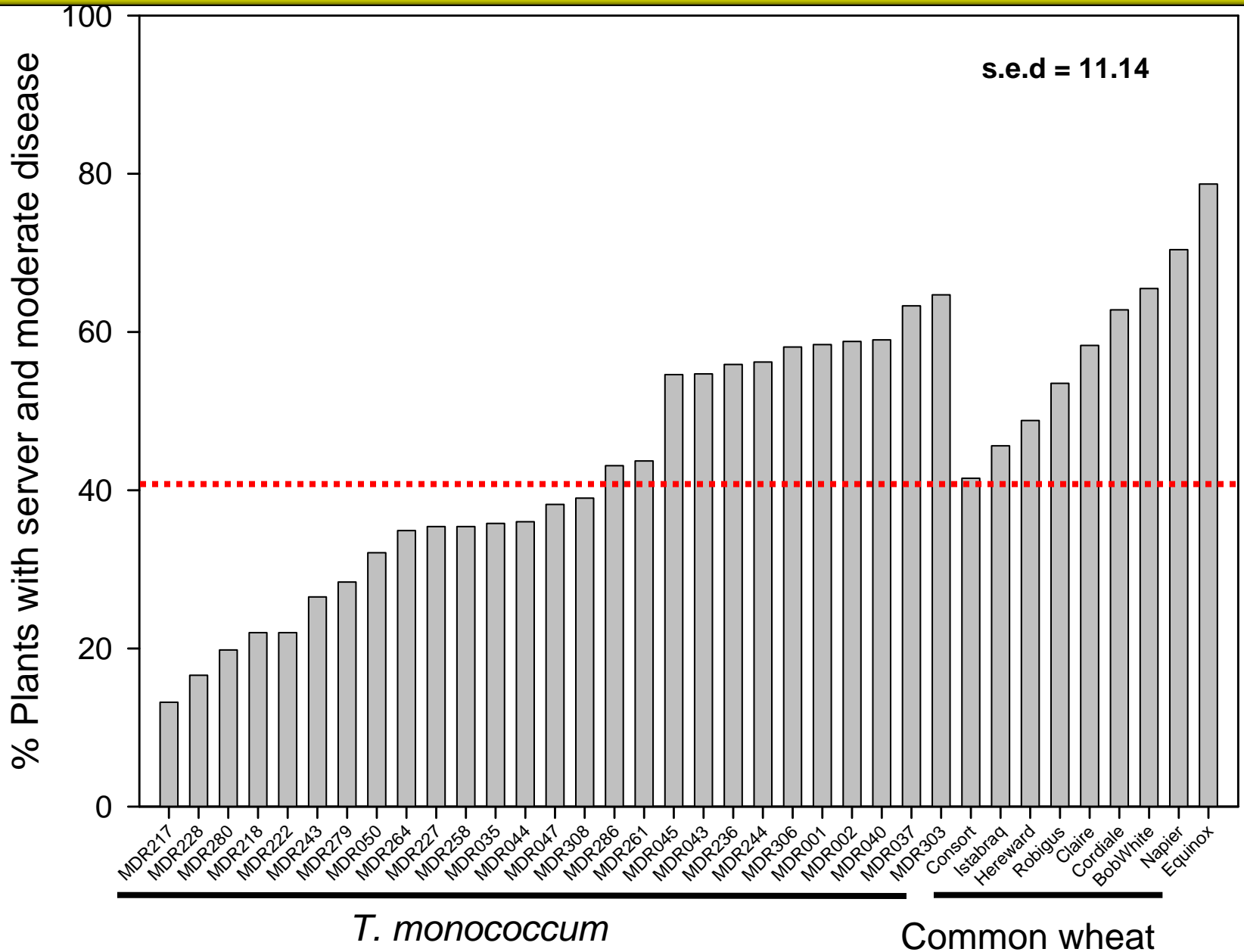


***T. monococcum*
(susceptible)**

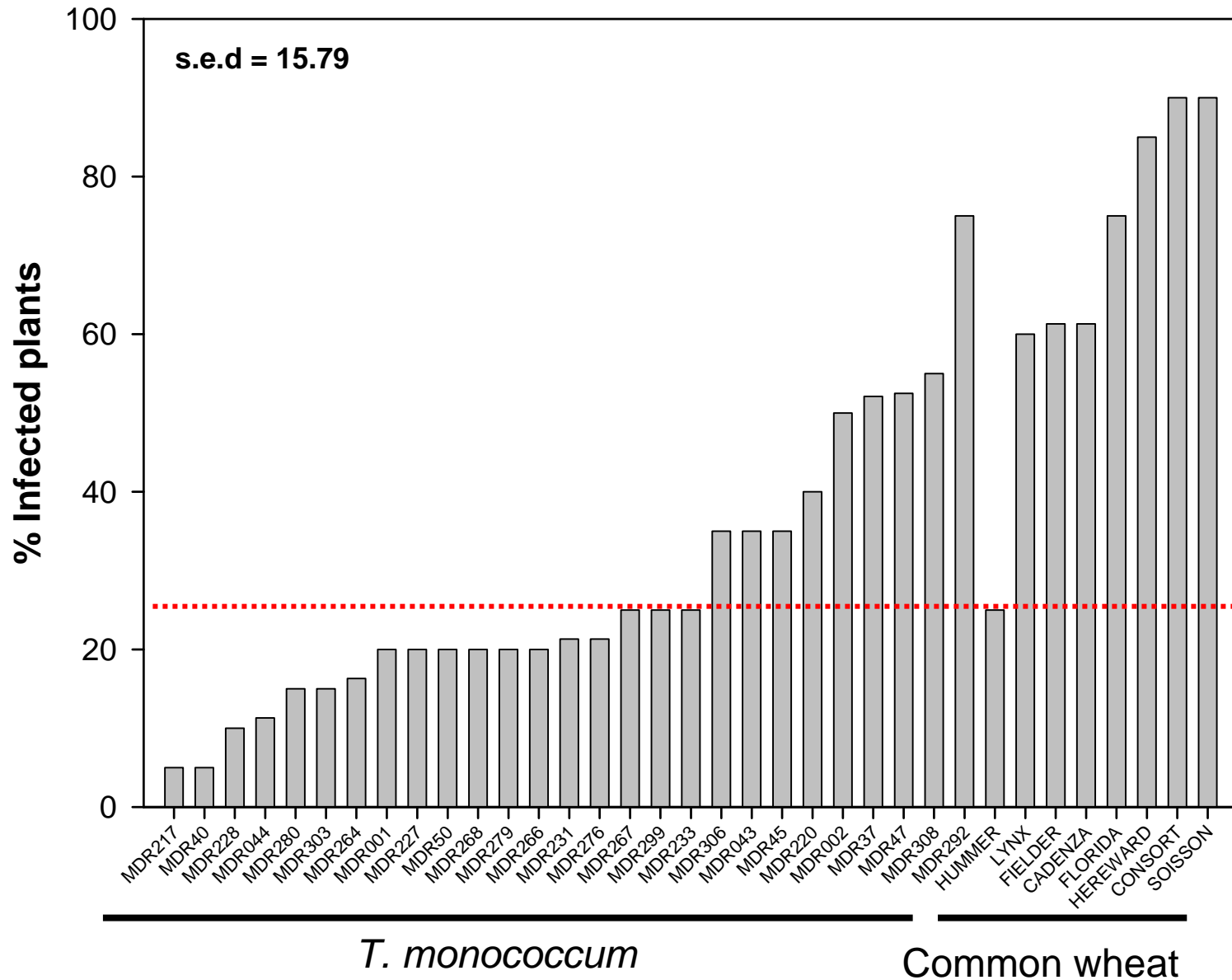


***T. monococcum*
(resistant)**

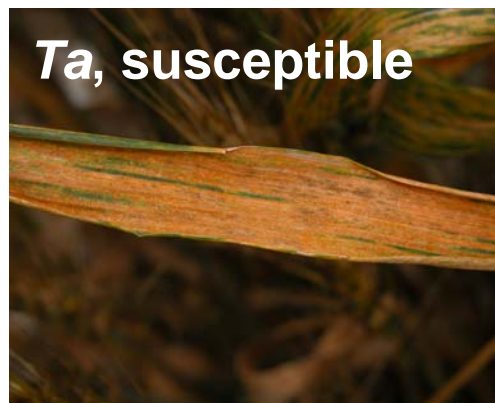
Eyespot field experiments



Eyespot pot assay



Yellow rust resistance



Yellow rust resistance

| Lines | Symptoms | Lines | Symptoms | Lines | Symptoms | Lines | Symptoms |
|------------------|----------|---|----------|---------------|----------|------------------|-----------|
| MDR 2 | 0, | MDR 25 | B0, | MDR 38 | 0, + B0, | MDR 1 | n0, |
| MDR 26-1 | 0, | MDR 25 | B0, | MDR 38 | 0, + B0, | MDR 24-1 | n0, |
| MDR 26-5 | 0, | MDR 37 | B0, | MDR 45 | 0, + B0, | MDR 24-4 | n0, |
| MDR 27-1 | 0, | MDR 37 | B0, | MDR 45 | 0, + B0, | MDR 29-1 | n0, |
| MDR 27-2 | 0, | MDR 47 | B0, | | | MDR 29-3 | n0, |
| MDR 28-1 | 0, | MDR 47 | B0, | | | MDR 31-1 | n0, |
| MDR 28-2 | 0, | | | | | MDR 31-5 | n0, |
| MDR 40-3 | 0, | | | | | MDR 33-4 | n0, |
| MDR 40-4 | 0, | | | | | MDR 33-5 | n0, |
| MDR 48-3 | 0, | | | | | MDR 34-1 | n0, |
| MDR 48-4 | 0, | | | | | MDR 34-3 | n0, |
| MDR 303-1 | 0, | | | | | MDR 43-2 | n0, |
| MDR 303-2 | 0, | | | | | MDR 43-3 | n0, |
| MDR 305-1 | 0, | | | | | MDR 50 | n0, |
| MDR 305-2 | 0, | B0, -brown fleck, typical non-host responses | | | | MDR 302-1 | n0, |
| MDR 307-1 | 0, | 0, -small necrotic flecks | | | | MDR 302-2 | n0, |
| MDR 307-2 | 0, | n0, -slightly larger necrotic flecks | | | | MDR 306-1 | n0, |
| DV92 | 0, | nn0, -larger fleckes | | | | MDR 306-2 | n0, |
| | | LTN, leaf tip necrosis | | | | MDR 36-4 | n0, LTN |
| MDR 39-1 | 0, LTN | | | | | | |
| MDR 39-2 | 0, LTN | | | | | MDR 281-1 | n0, + B0, |
| MDR 44-1 | 0, LTN | | | | | MDR 281-3 | n0, + B0, |
| MDR 44-5 | 0, LTN | | | | | | |
| MDR 46-1 | 0, LTN | | | | | MDR 32-1 | nn0, |
| MDR 46-2 | 0, LTN | | | | | MDR 32-2 | nn0, |
| MDR 36-3 | 0, LTN | | | | | MDR 49-4 | nn0, |
| MDR 30-4 | 0, LTN | | | | | MDR 49-5 | nn0, |
| MDR 30-5 | 0, LTN | | | | | | |

Field assessment of resistance

Hexaploid wheat



Triticum monococcum



Field assessment over 5 years

Controlled environment tests of resistance



| Isolate | Origin |
|------------------|-------------|
| IPO87019 | Uruguay |
| IPO88004 | Ethiopia |
| IPO89011 | Netherlands |
| IPO94269 | Netherlands |
| IPO92006 | Portugal |
| IPO001 | Netherlands |
| IPO90012 | Mexico |
| IPO323*** | Netherlands |
| IPO95052 | Durum wheat |

Responses of **120** accessions to **nine** *M. graminicola* isolates
(gift from James Brown / Gert Kema)

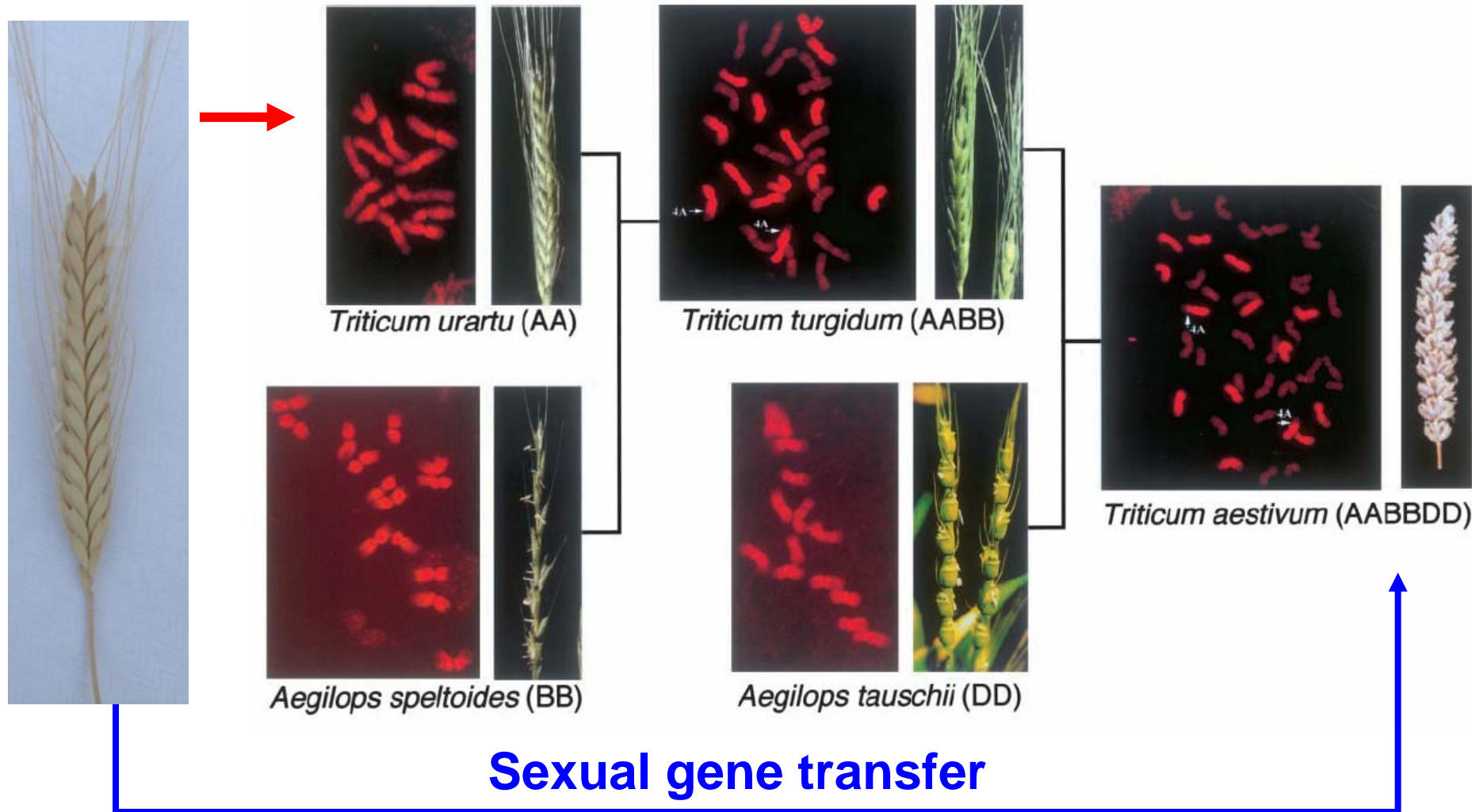
Disease resistance in *T. monococcum*

***T. monococcum* has high levels of resistance to**

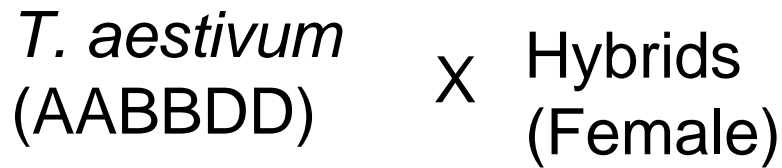
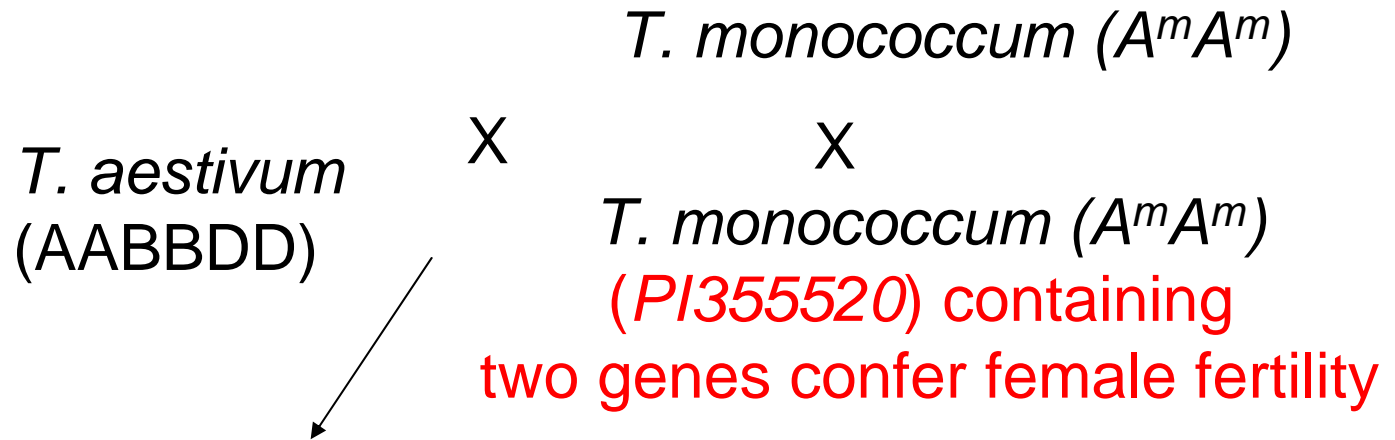
- Septoria tritici blotch
- Take-all
- Eyespots
- Yellow rust, leaf rust

Trait introgression

T. monococcum A^mA^m



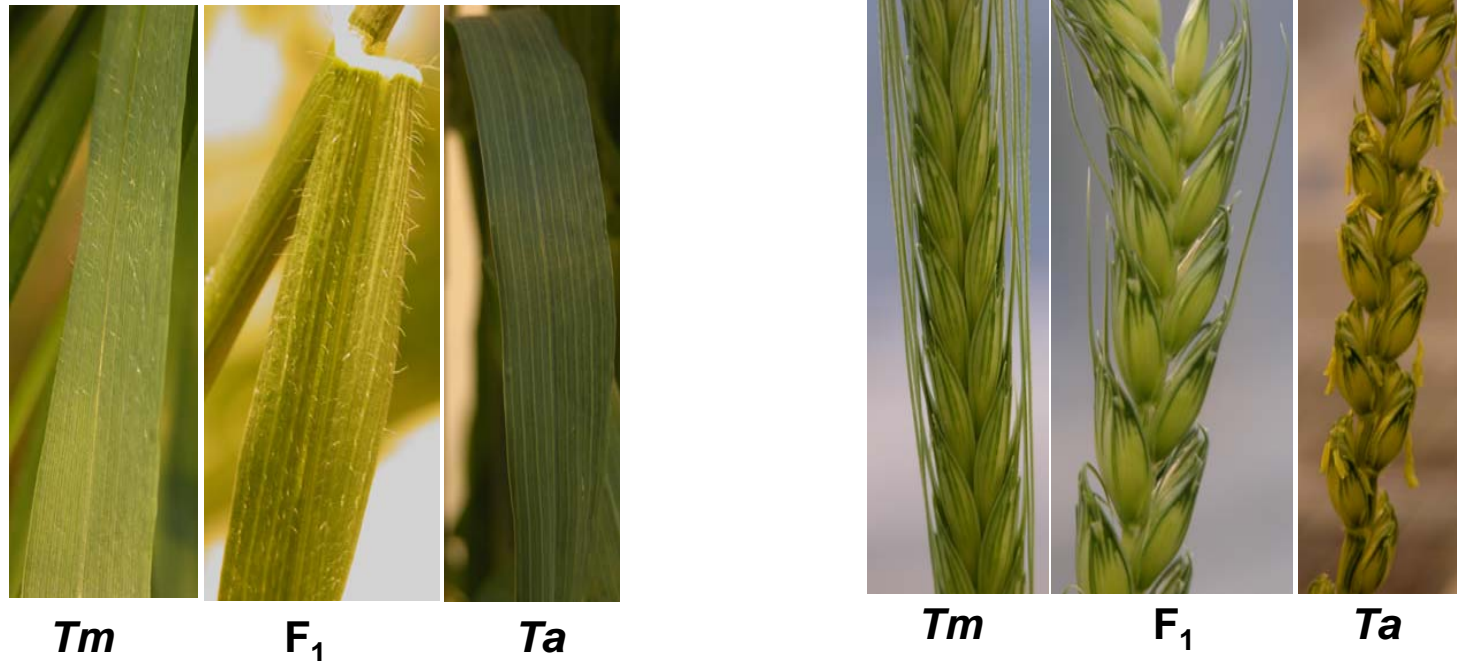
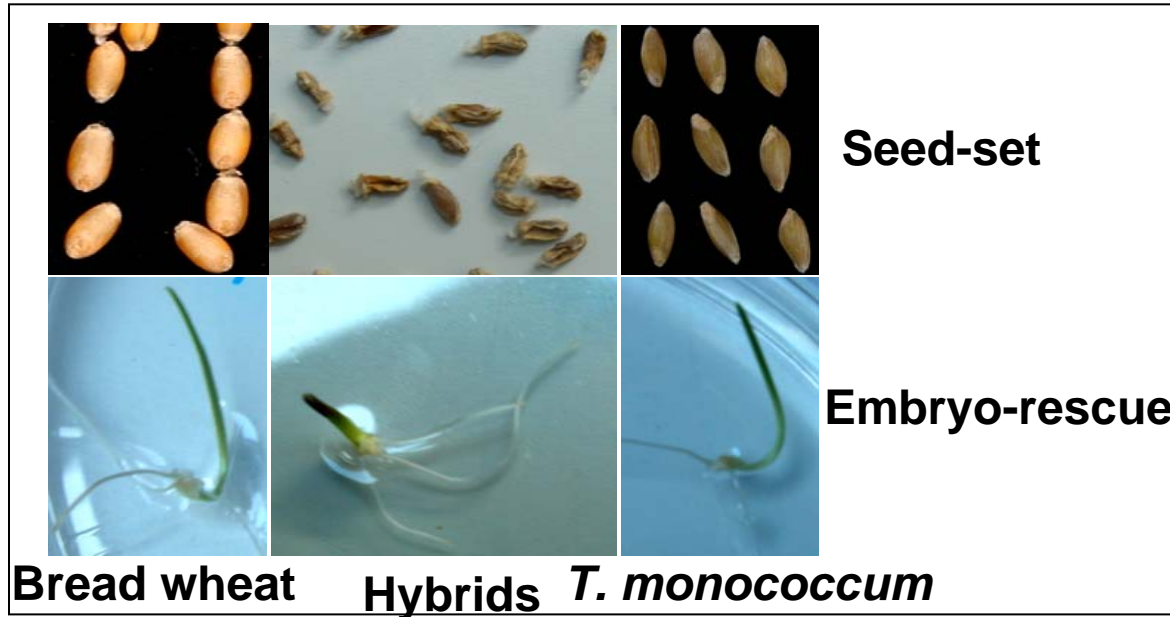
Trait introgression



BC₁F₁



Trait introgression



Trait introgression

| Cross | Hexaploid | <i>T. monococcum</i> | F ₁ plants | BCF ₁ |
|-------|----------------|----------------------|-----------------------|------------------|
| A | Chinese Spring | PI355520 | 35 | |
| B | Chinese Spring | MDR002 | 50 | 19 |
| C | Chinese Spring | L118 | 58 | 11 |
| D | Chinese Spring | MDR308 | 45 | |
| E | Chinese Spring | MDR046 | 38 | 4 |
| F | Cadenza | PI355520 | 1 | |
| G | Cadenza | MDR002 | 16 | |
| H | Cadenza | L118 | 3 | |
| I | Cadenza | MDR308 | 42 | |
| J | Cadenza | MDR046 | 13 | |
| K | Riband | PI355520 | 8 | 8 |
| L | Riband | MDR002 | 6 | |
| M | Riband | L118 | 1 | |
| N | Riband | MDR308 | 2 | |
| O | Riband | MDR046 | - | |

The A.E. Watkins Wheat Collection

- A.E. Watkins worked in Cambridge in the 1930's
- Wheat seed sent to him from around the world by friends and colleagues
- Collected 4,500 lines, creating a unique snapshot of the world wheat germplasm available at that time.
- 800 lines survive today and interesting because they may contain alleles that do not exist in modern wheat varieties

The A.E. Watkins Wheat Collection

- Field Experiment – 740 lines
- 5 blocks of 8 controls (Oats, Triticale, Rye, and 5 currently grown wheat varieties)
- 20 plots of cultivar Hereward
- Alpha design









Powdery mildew

Brown rust



Brown rust



Yellow rust





Yellow rust

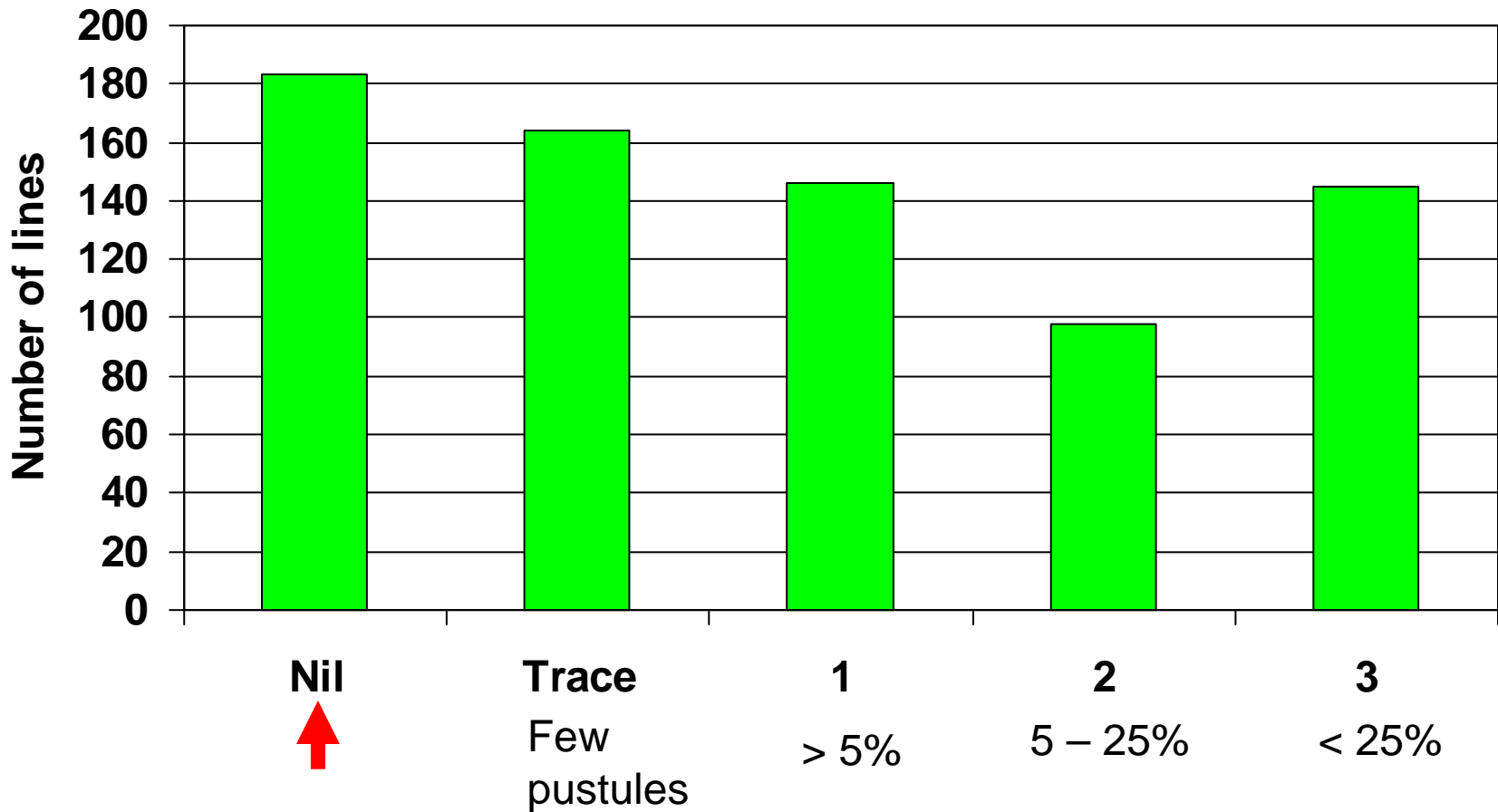


Yellow rust

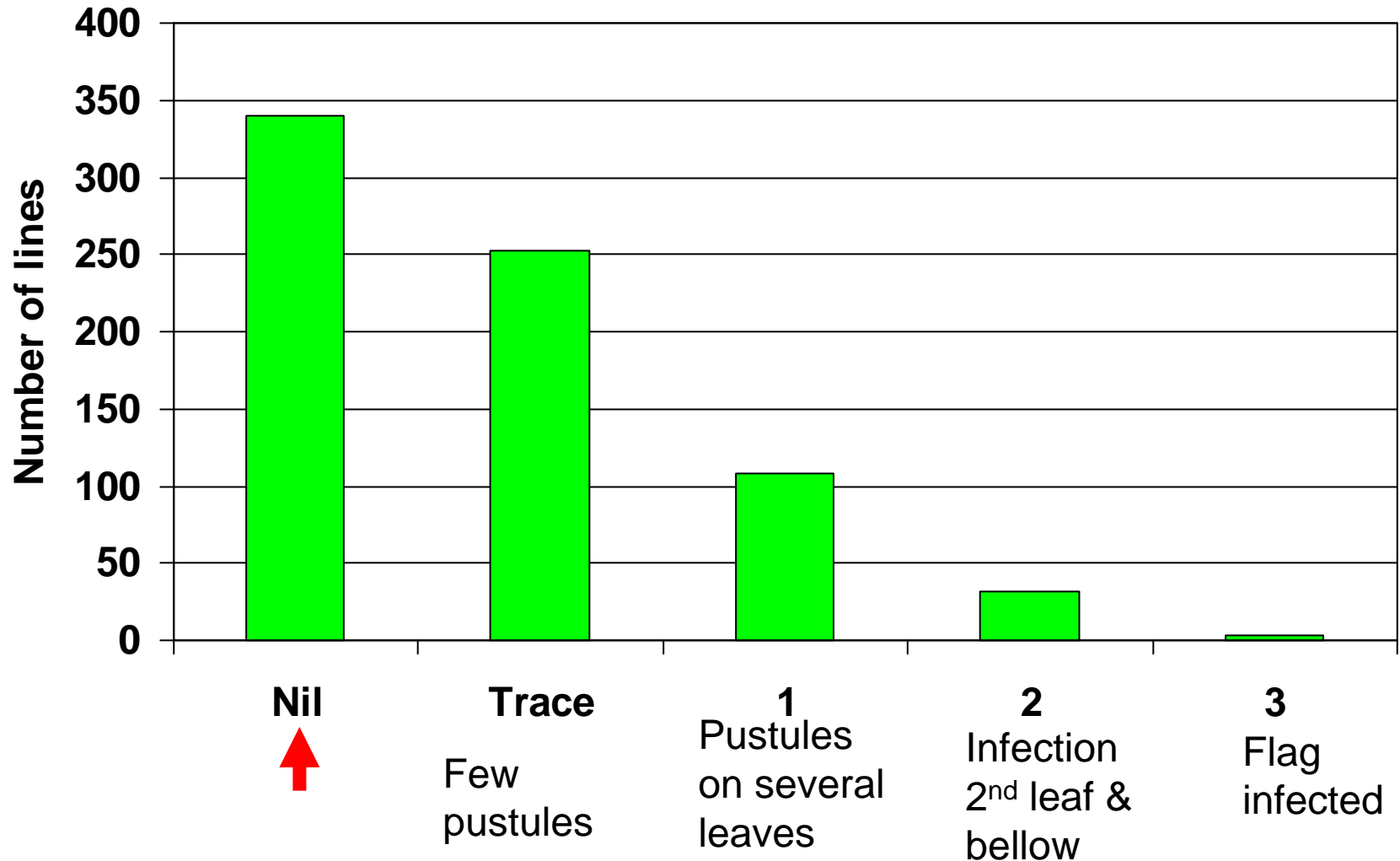


septoria tritici blotch

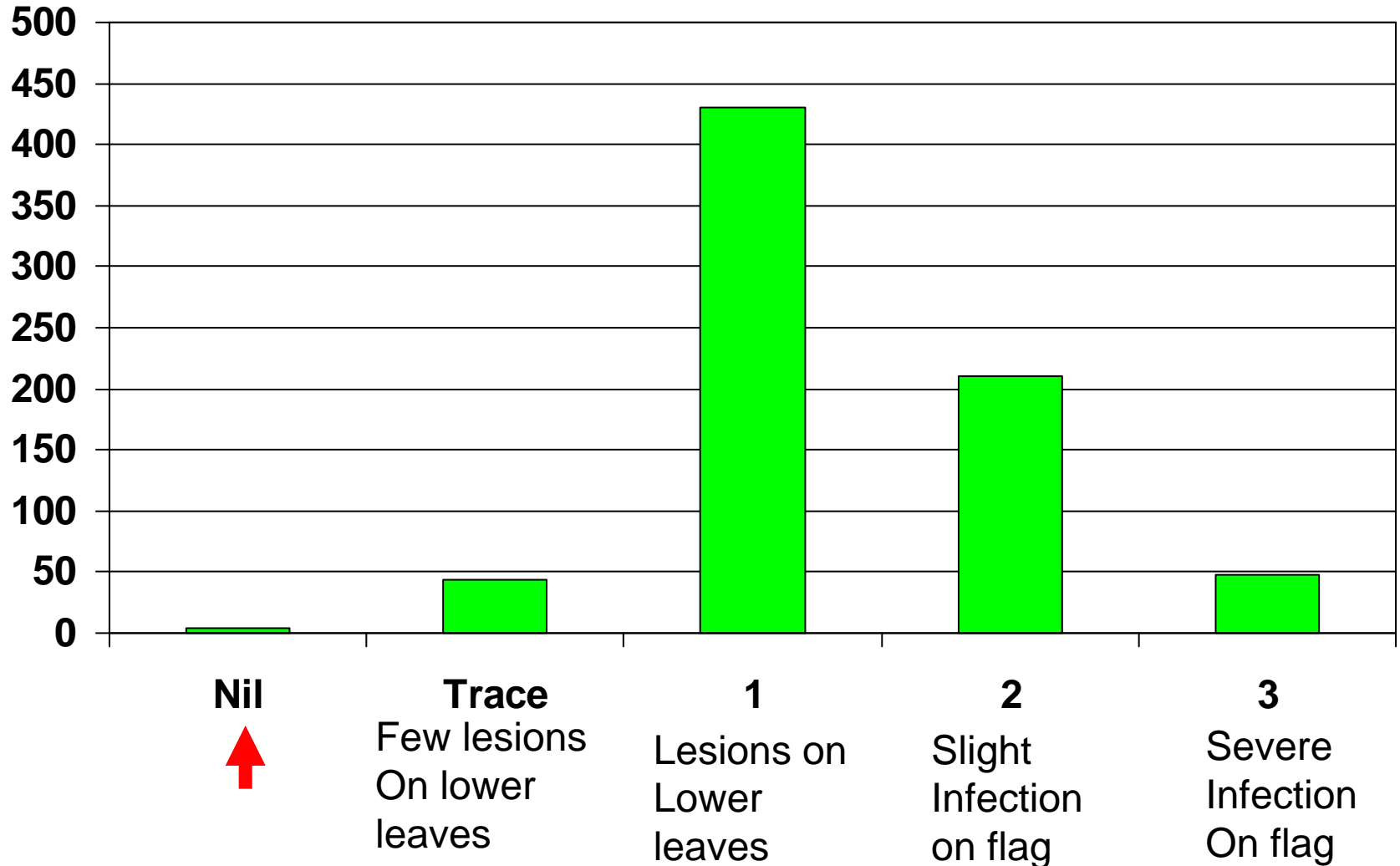
Yellow Rust on flag leaf – percentage area of leaf affected



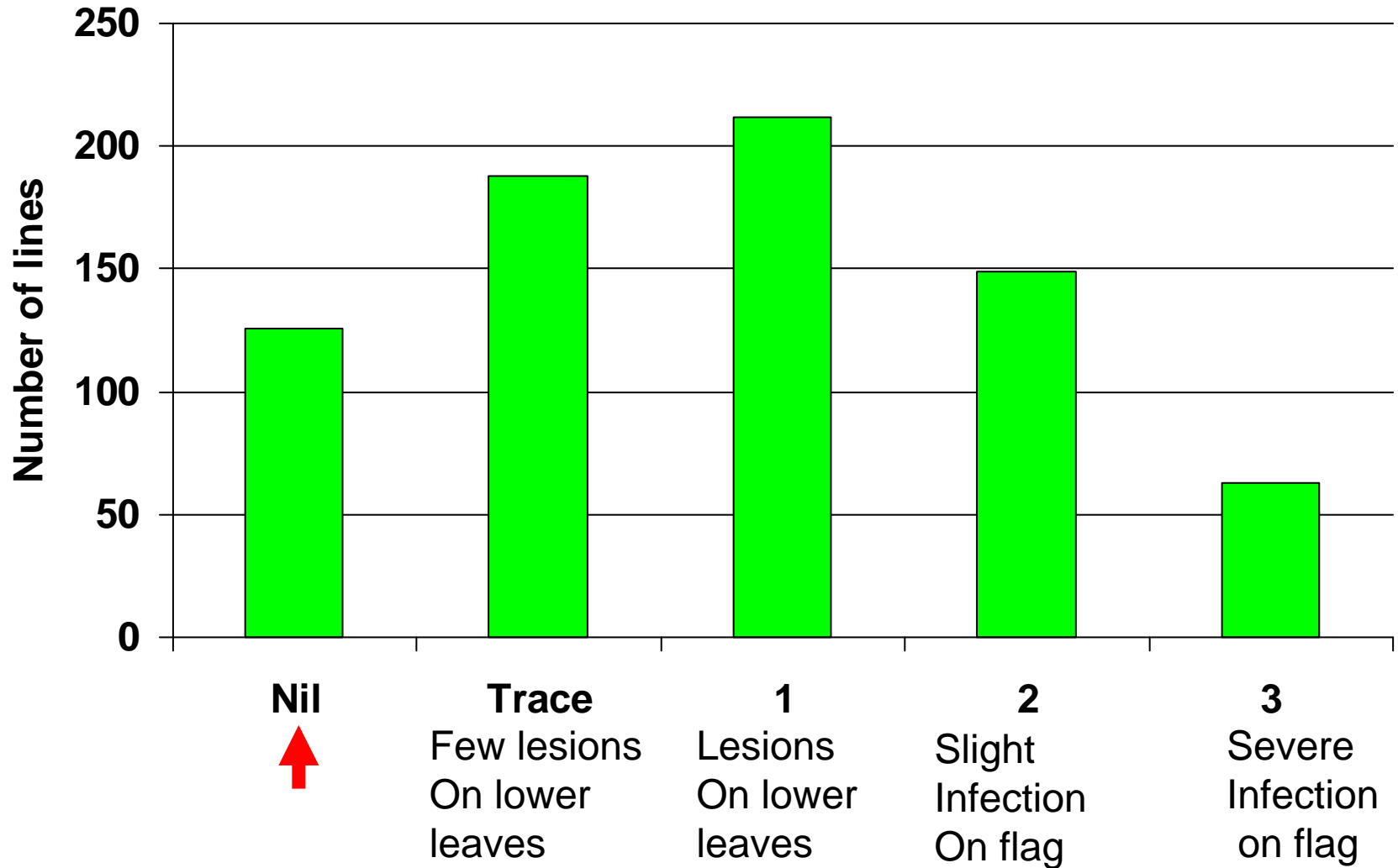
Brown Rust Infection score



Septoria Infection score



Mildew Score



Take-all



Conclusions

- The diploid wheat *T. monococcum* confers resistance to major wheat diseases in UK
- The Watkins Wheat Collection contains varieties (land races) with good resistance
- These resources may be useful for future breeding programmes

Acknowledgements

RRes (PPM)

Kim Hammond-Kosack
Richard Gutteridge
Michael Hammond-Kosack

RRes Farm team

JIC/Sainsbury Lab

Lesley Boyd
Simon Orford
Simon Griffiths
John Snape

The Vavilov Institute

Dmitry Korniyukhin
Olga Mitrofanova

