WGIN pathology
Exploiting *T. monococcum L.* as a source of novel disease resistance traits, genes and variant alleles

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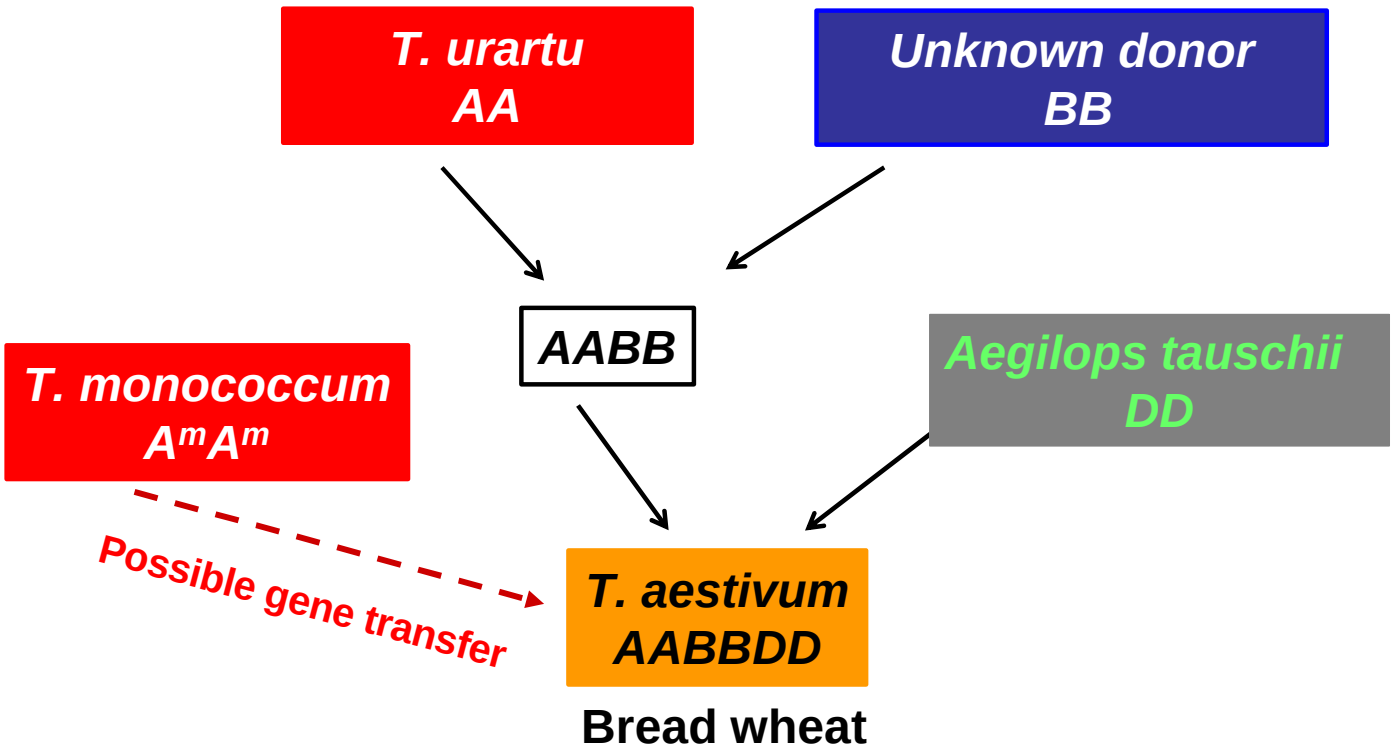
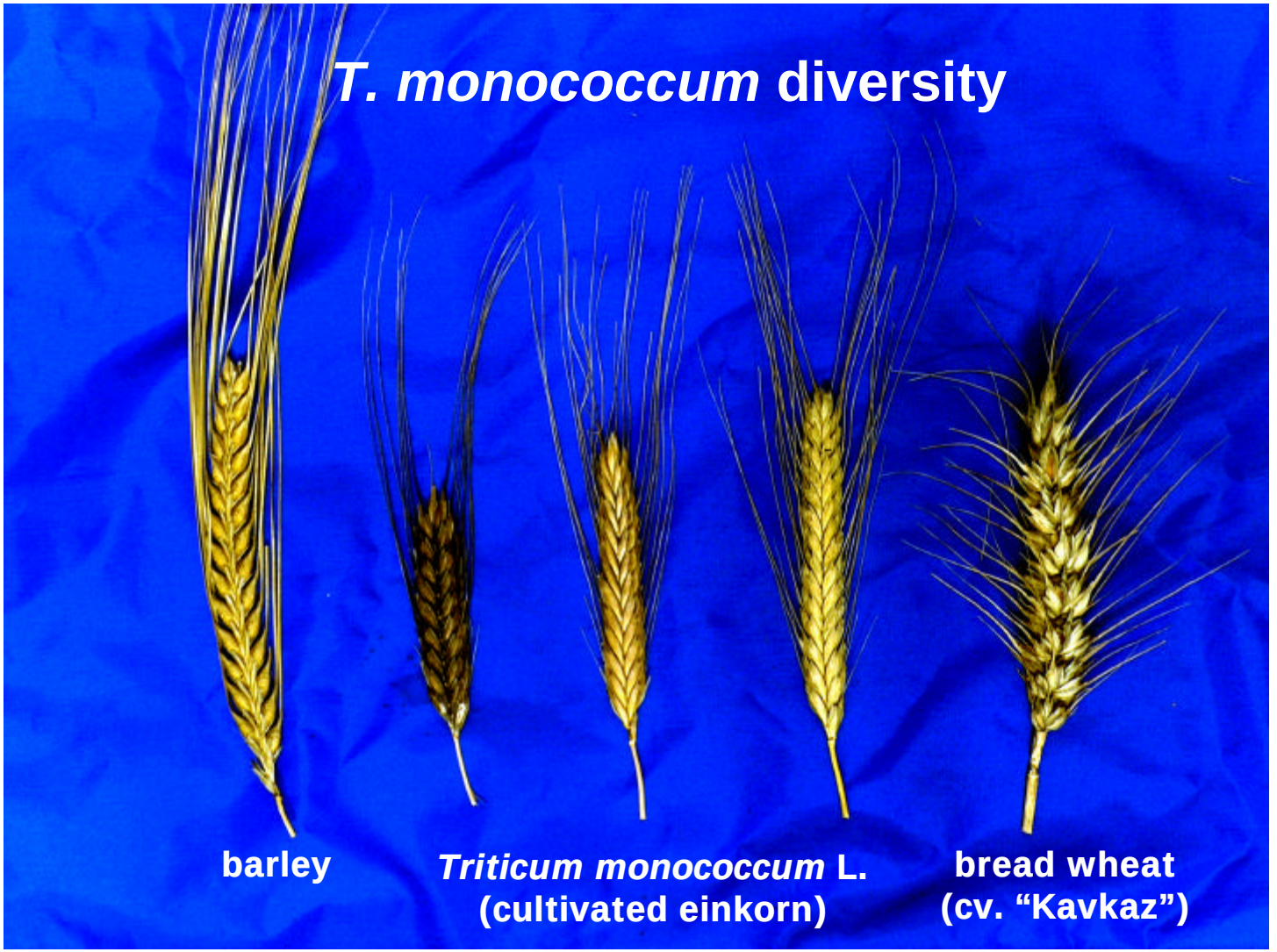
ROTHAMSTED RESEARCH

22nd November 2005

T. monococcum (A^mA^m)




T. monococcum diversity
barley
Triticum monococcum L.
(cultivated einkorn)
bread wheat
(cv. “Kavkaz”)

RRes *Tm* collection

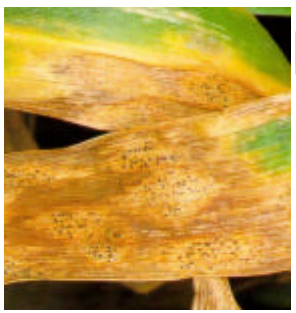
contains both accessions* and pure lines

Item	Numbers
Total number	124 (Vavilov* +SGC)
Origin of countries and regions	54
Original collection time	Since 1904
Spring habitat	93
Winter habitat	31
Accession with BAC library	1
Transformable accessions	2
Accession with EMS population	1

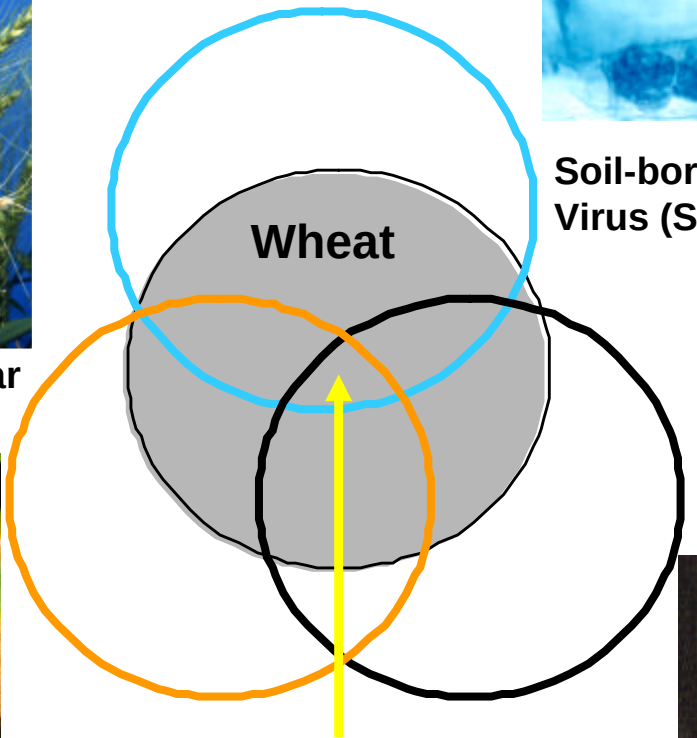
139 (IPK) arrived + 72 CIMMYT lines ordered

To identify the common molecular themes conferring resistance to multiple pathogens

***Fusarium* – ear / stem base**



***Mycosphaerella graminicola* – Leaf blotch**



Soil-borne cereal mosaic Virus (SBCMV)/*Polymyxa*

Eyespot stem base

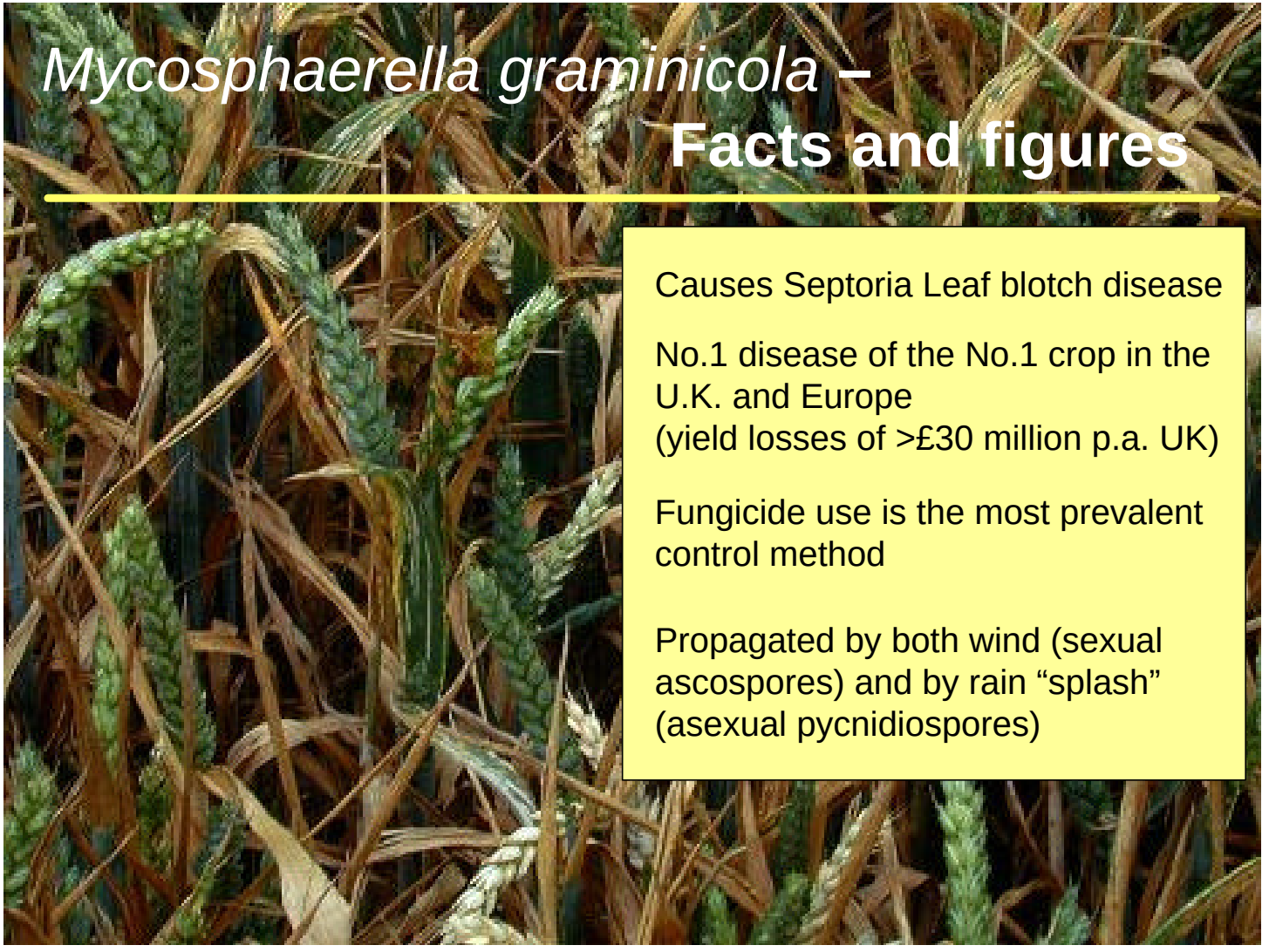
Take-all roots

T. monococcum pathology research activities

Screen the core collection with a range of important UK pathogens (and pests)

Septoria leaf blotch	Field (n)	Glasshouse
Eyespot	Field (a)	Glasshouse
Take-all	Field (n/a)	
Soil-borne viruses		qGlasshouse
Polymyxa graminis vector		qGlasshouse
Fusarium ear blight	Field (a)	
Yellow Rust (JIC)	Field (a)	
Ergot (RRes)	Field (n)	
Sawfly (RRes)	Field (n)	

Blue – completed, n/a – natural / artificial inoculum, q - quarantine



Mycosphaerella graminicola – Facts and figures

Causes Septoria Leaf blotch disease

No.1 disease of the No.1 crop in the U.K. and Europe
(yield losses of >£30 million p.a. UK)

Fungicide use is the most prevalent control method

Propagated by both wind (sexual ascospores) and by rain “splash” (asexual pycnidiospores)

Septoria leaf blotch - Previously published *Tm* Data

Two previous reports on *M. graminicola* - *T. monococcum* interactions

Both studies were conducted in controlled environment

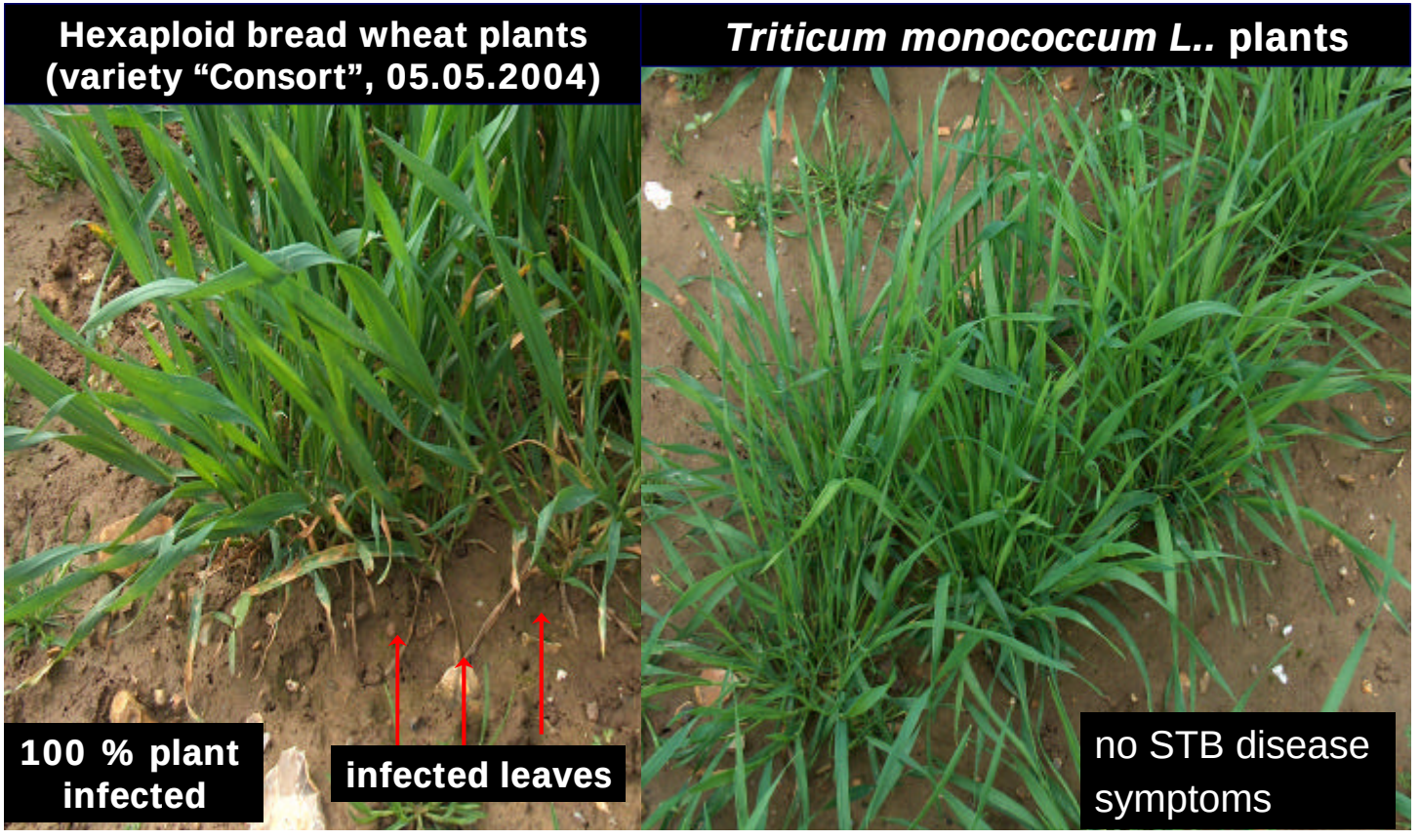
1. **Yechilevich-Auster et al., 1983: Phytopathology**

   Screened 22 lines with 7 isolates. Only 2 lines were susceptible and to just 1 of the 7 isolates. The virulent isolates was from *T. durum*

2. **McKendry et al., 1994: Plant Genetic Resources**

   Screened 13 lines with 14 isolates (bulked)
   ALL lines were susceptible, assessed for necrosis NOT pycnidia

Field resistance to *Septoria tritici* (STB)



Septoria leaf blotch field experiments

- **Two winter and one spring sown experiment (n = 28)**

No Septoria symptoms on *Tm* vis 100% infected hexaploid

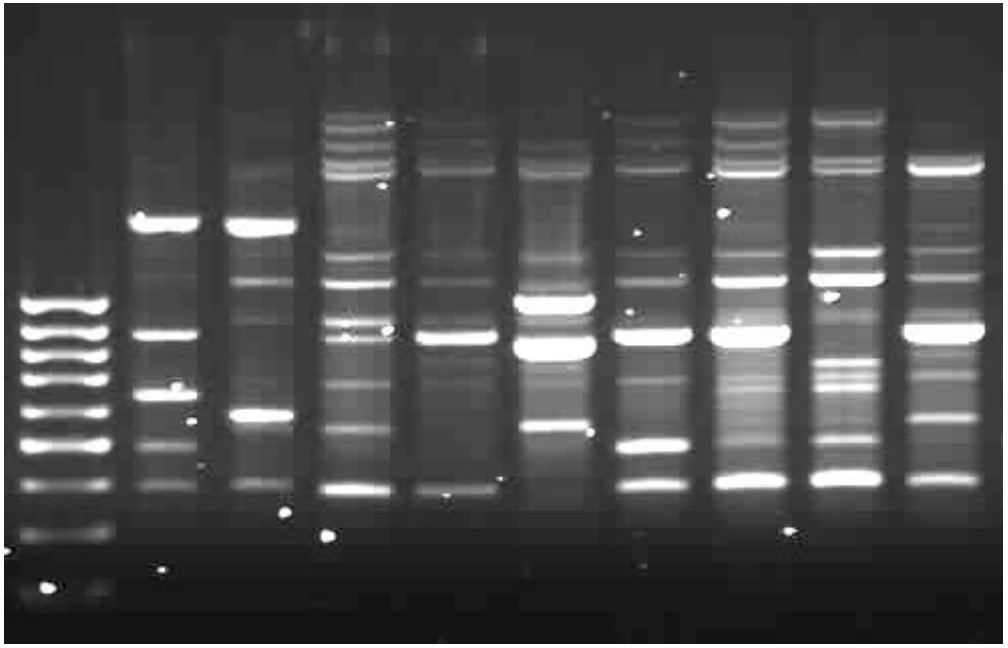
Five Septoria isolates recovered from a total of two *T. monococcum* plots (Feb 2004) – these infect hexaploid wheat under glasshouse conditions

All 5 isolates also carried the variant allele confer resistance to strobulurin fungicide

- **Obtained the differential isolate set from Gert Kema, NL**

Used as a mixed inoculum in glasshouse tests on
***T. monococcum* accessions and**
***T. aestivum* cv Riband (susceptible)**

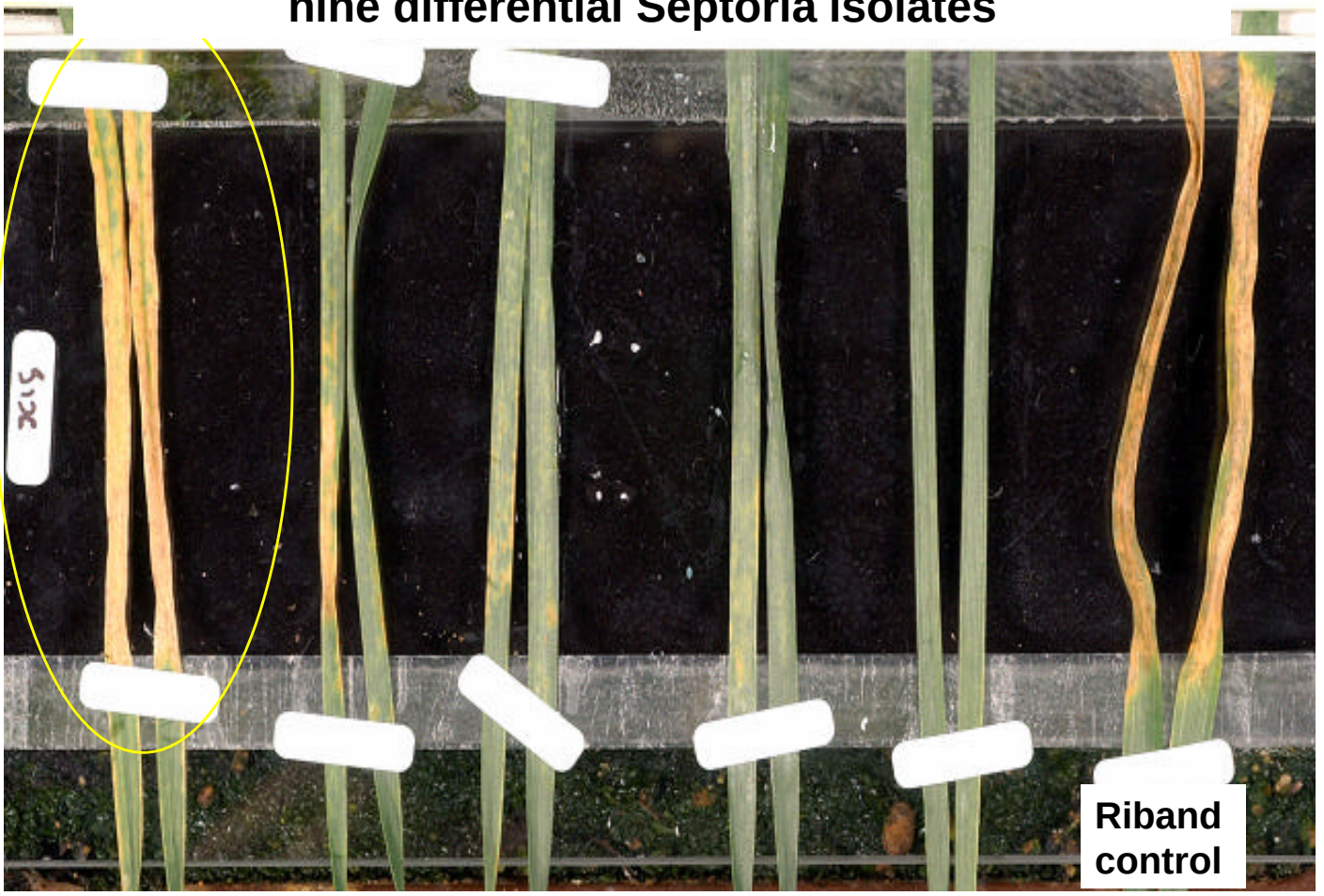
Nine differential *Septoria* isolates distinguished by RAPD6



Lad	St01 (Ur)	St02 (Et)	St03 (Nd)	St04 (Nd)	St05 (Pt)	St06 (Nd)	St07 (Mx)	St08 (Nd)	St09 (*TD*)

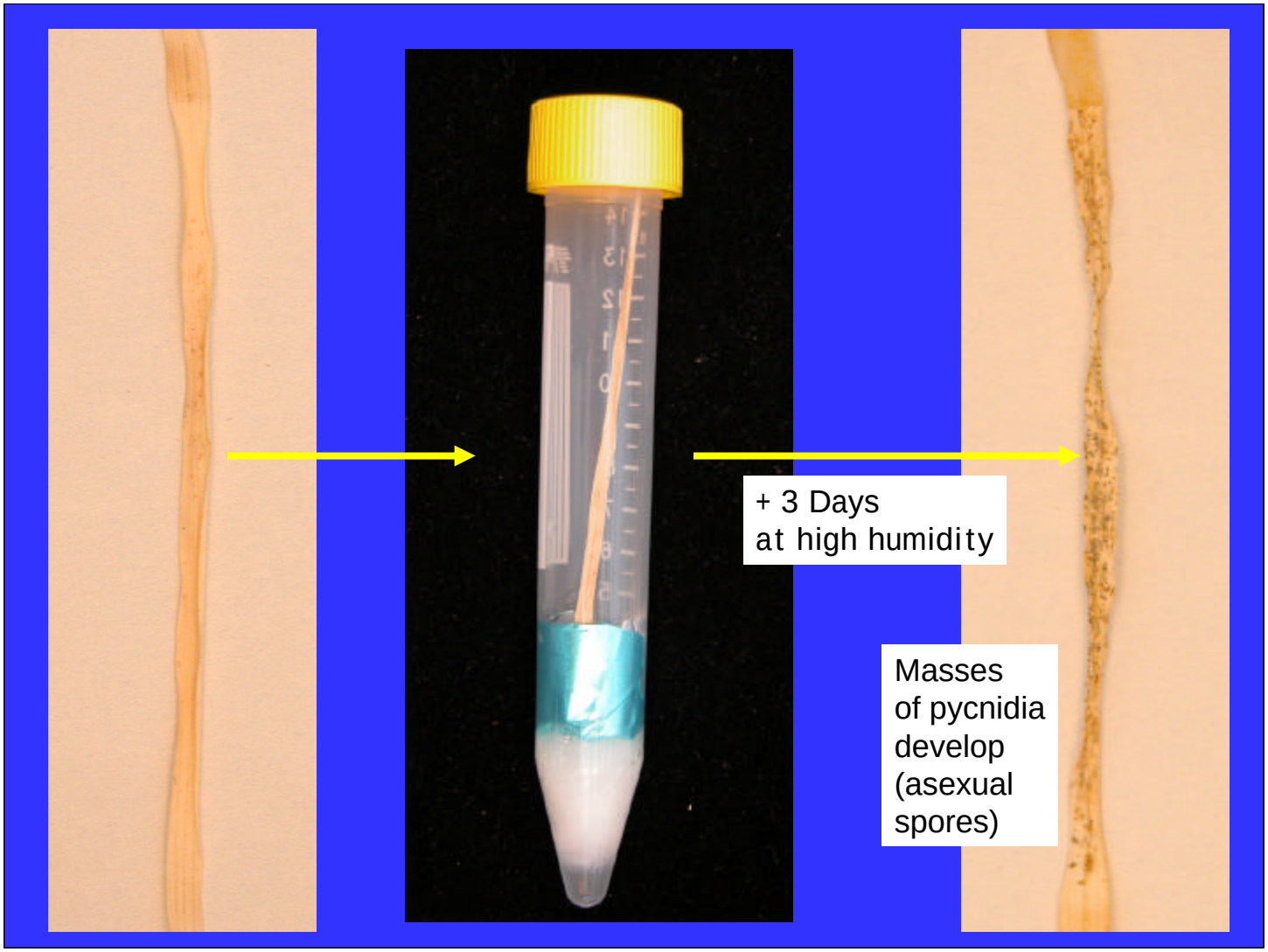
Isolates from Gert Kema

Each *T. monococcum* accession inoculated with the nine differential Septoria isolates



Appearance of macroscopic symptoms (mixed inoculum)

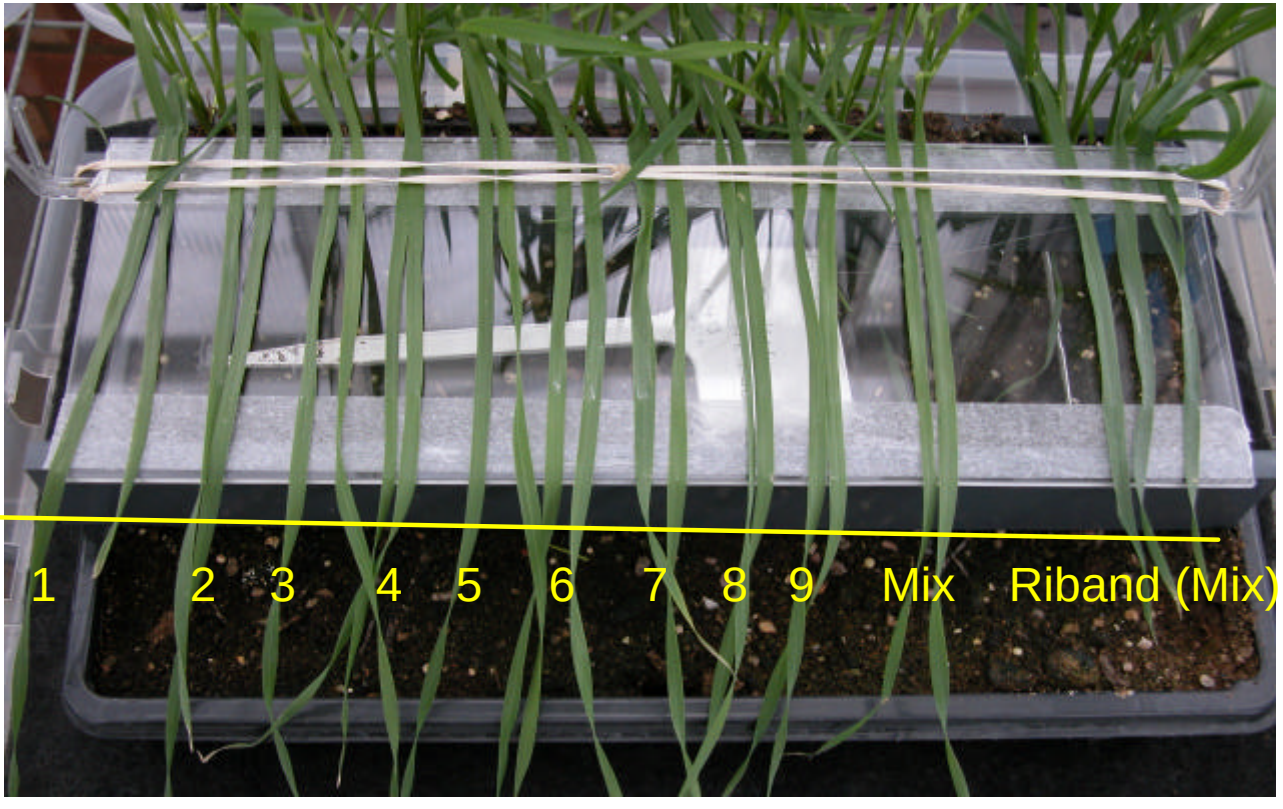
	13 Days	15 Days	20 Days	23 Days	27 Days	29 Days	33 Days	37 Days	41 Days
	7th Dec	9th Dec	14th Dec	17th Dec	21st Dec	23rd	27th Dec	31st Dec	4th Jan
MDR 24	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Nec / Yel	Dead
MDR 243	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Yel	Dead
MDR 35	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Yel /Nec	Dead
MDR 31	NIL	NIL	NIL / Yel	Nil / Nec	Nil / Nec	Nil / Nec	FL/ Nec	Yel/ Nec	Dead
MDR 245	NIL	NIL	NIL / VLF	NIL / VLF	NIL / VLF	NIL / LFL	Fl / FL	Nec /Yel	Dead
MDR 303	NIL	NIL	NIL	FL	FL	FL	FL / Yel	Nec	Dead
MDR 308	NIL	NIL	NIL	FL	FL	FL	Yel	Nec	Dead
MDR 2	NIL	NIL	LF	Yel / FL	Yel / FL	Yel / FL	Yel / FL	Yel / FL	Dead
MDR 230	NIL	NIL	LFL / NIL	FL / NIL	FL / NIL	FL / NIL	Yel / FL	Nec / Yel	Dead
MDR 252	NIL	NIL	LF	FL	FL	FL	FL	Nec	Dead
MDR 259	NIL	NIL	LF	FL	FL	FL	FL	Nec	Dead
MDR 30	NIL	NIL	LF	FL	FL	FL	FL	Yel	Dead
MDR 218	NIL	NIL	LF	FL	FL	FL	Yel / FL	Nec	Dead
MDR 50	NIL	NIL	MF / LF	FL	FL	FL	FL / Yel	Nec	Dead
MDR 41	NIL	NIL	Yel / L FL	Yel / FL	Yel / FL	Yel / FL	Yel / FL	Nec / Yel	Dead
MDR 36	NIL	NIL	LF / Yel	FL / Yel	FL / Yel	FL / Yel	FL / Yel	Yel /Nec	Dead
MDR 46	NIL	NIL	Yel / FL	Nec /FL	Nec /FL	Nec /FL	Nec /Yel	Nec	Dead
MDR 25	NIL	NIL	LF	Yel	Yel	Yel	Yel	Nec	Dead
MDR 26	NIL	NIL	LF	Yel	Yel	Yel	Yel	Nec	Dead
MDR 39	NIL	NIL	LF	Yel	Yel	Yel	Yel	Yel	Dead
MDR 33	NIL	NIL	Yel / LF	Nec / Yel	Nec / Yel	Nec / Yel	Nec	Nec	Dead
MDR 27	NIL	NIL	LF	Yel	Yel	Yel	Yel	Nec / P.Sym	Dead
MDR 49	NIL	NIL	MF	FL / Yel HS	Fl / Yel (HS)	Fl / Yel (HS)	Fl / Yel (HS)	Yel / Nec	Dead
MDR 45	NIL	NIL	FL / Yel	Nec	Nec	Nec	Nec	Nec	Dead
MDR 1	NIL	NIL	LF	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Dead
MDR 28	NIL	NIL	LY	Yel	Yel	Yel	Yel	Nec	Dead
MDR 235	NIL	NIL	Yel	Yel	Yel	Yel	Yel	Nec	Dead
MDR 48	NIL	NIL	Yel P.Sym	Yel (HS)	Yel (HS)	Yel (HS)	Nec (HS)	Nec (HS)	Dead
MDR 29	NIL	NIL	Yel / Nec	Nec	Nec	Nec	Nec	Nec	Dead
MDR 234	NIL	NIL	L Yel / Nec	Nec HS	Nec HS	Nec HS	Nec HS	Nec HS	Dead
MDR 44	NIL	NIL	Nec	Nec	Nec	Nec	Nec	Nec	Dead
MDR 40	NIL	NIL	Yel (Hs) / LF	Yel (HS) / FL	Yel (HS) / FL	Yel (HS) / FL	Yel (HS) / Yel	Nec (HS) /Nec	Dead
MDR 34	NIL	NIL	Nec P.Sym	Nec	Nec	Nec	Nec	Nec	Dead
MDR 37	NIL	NIL	Nec P.Sym	Nec	Nec	Nec	Nec	Nec	Dead
MDR 38	NIL	NIL	Nec P.Sym	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Dead
MDR 258	NIL	NIL	Nec P.Sym	Nec (P.Sym)	Nec (P.Sym)	Nec (P.Sym)	Nec (P.Sym)	Nec (P.Sym)	Dead
MDR 43	Fl	Fl	Yel / M FL	Nec / FL	Nec / FL	Nec / FL	Nec / Yel	Nec	Dead
MDR 32	Fl	Fl	Yel (BL)	Nec	Nec	Nec	Nec	Nec	Dead
MDR 42	Fl	Fl	Nec	Nec	Nec	Nec	Nec	Nec	Dead
MDR 47	Fl	Fl	Nec (P.Sym)	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Dead
MDR 242	Yl	Yl	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Dead
Riband	Yl	Sym	Sym	Sym	Sym	Sym	Sym	Sym	Sym


+ 3 Days
at high humidity
Masses
of pycnidia
develop
(asexual
spores)

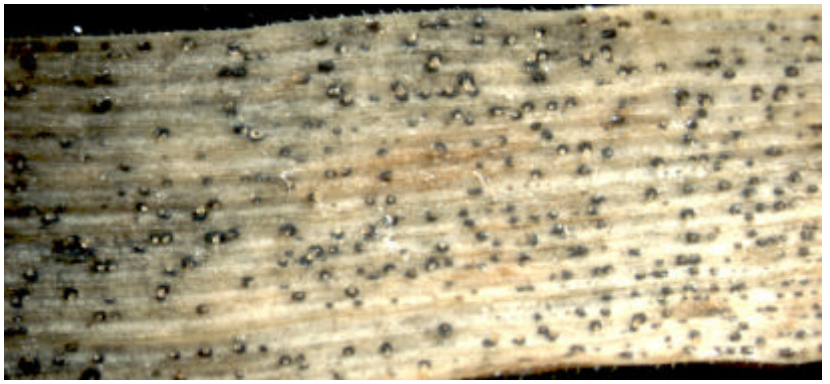
Glasshouse mixed inoculation: mimicking the field situation

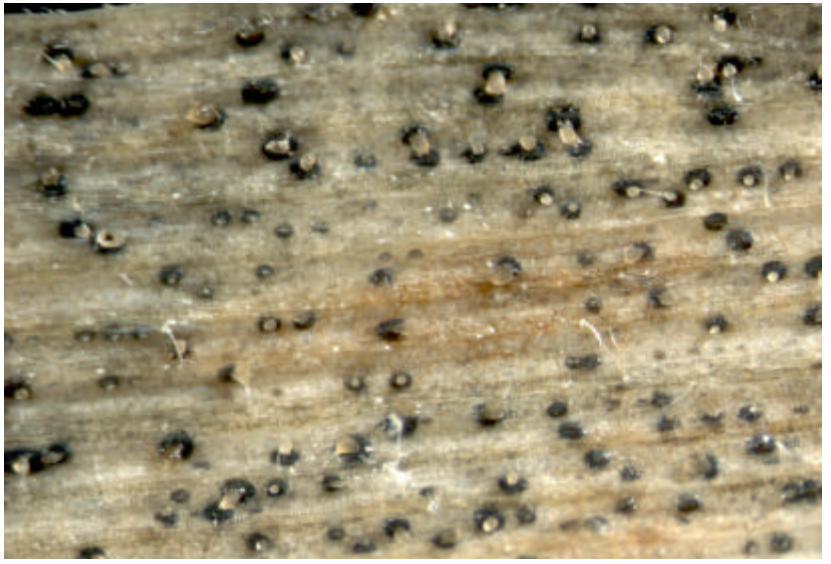
	15 Days	20 Days	23 Days	29 Days	33 Days	37 Days	41 Days	Sporulation
	9th Dec	14th Dec	17th Dec	23rd	27th Dec	31st Dec	4th Jan	
MDR 24	NIL	NIL	NIL	NIL	NIL	Nec / Yel	Dead	+
MDR 243	NIL	NIL	NIL	NIL	NIL	Yel	Dead	0
MDR 35	NIL	NIL	NIL	NIL	NIL	Yel /Nec	Dead	0
MDR 31	NIL	NIL / Yel	Nil / Nec	Nil / Nec	FL/ Nec	Yel/ Nec	Dead	+
MDR 303	NIL	NIL	FL	FL	FL / Yel	Nec	Dead	+
MDR 308	NIL	NIL	FL	FL	Yel	Nec	Dead	+
MDR 2	NIL	LF	Yel / FL	Yel / FL	Yel / FL	Yel / FL	Dead	+
MDR 50	NIL	MF / LF	FL	FL	FL / Yel	Nec	Dead	+
MDR 46	NIL	Yel / FL	Nec /FL	Nec /FL	Nec /Yel	Nec	Dead	0
MDR 25	NIL	LF	Yel	Yel	Yel	Nec	Dead	+
MDR 45	NIL	FL / Yel	Nec	Nec	Nec	Nec	Dead	0
MDR 1	NIL	LF	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Dead	+
MDR 40	NIL	Yel (Hs) / LF	Yel (HS) / F	Yel (HS) / FL	Yel (HS) / Yel	Nec (HS) /Ne	Dead	0
MDR 34	NIL	Nec P.Sym	Nec	Nec	Nec	Nec	Dead	0
MDR 37	NIL	Nec P.Sym	Nec	Nec	Nec	Nec	Dead	0
MDR 38	NIL	Nec P.Sym	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Dead	+
MDR 258	NIL	Nec P.Sym	Nec (P.Sym)	Nec (P.Sym)	Nec (P.Sym)	Nec (P.Sym)	Dead	0
MDR 47	Fl	Nec (P.Sym)	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Dead	ND
MDR 242	Yl	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Nec (HS)	Dead	+
Riband	Sym	Sym	Sym	Sym	Sym	Sym	Sym	+

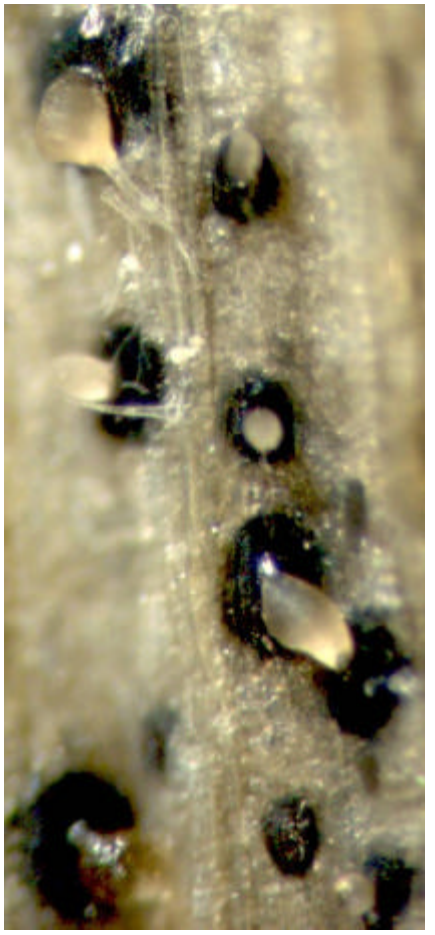
Resistance to individual isolates

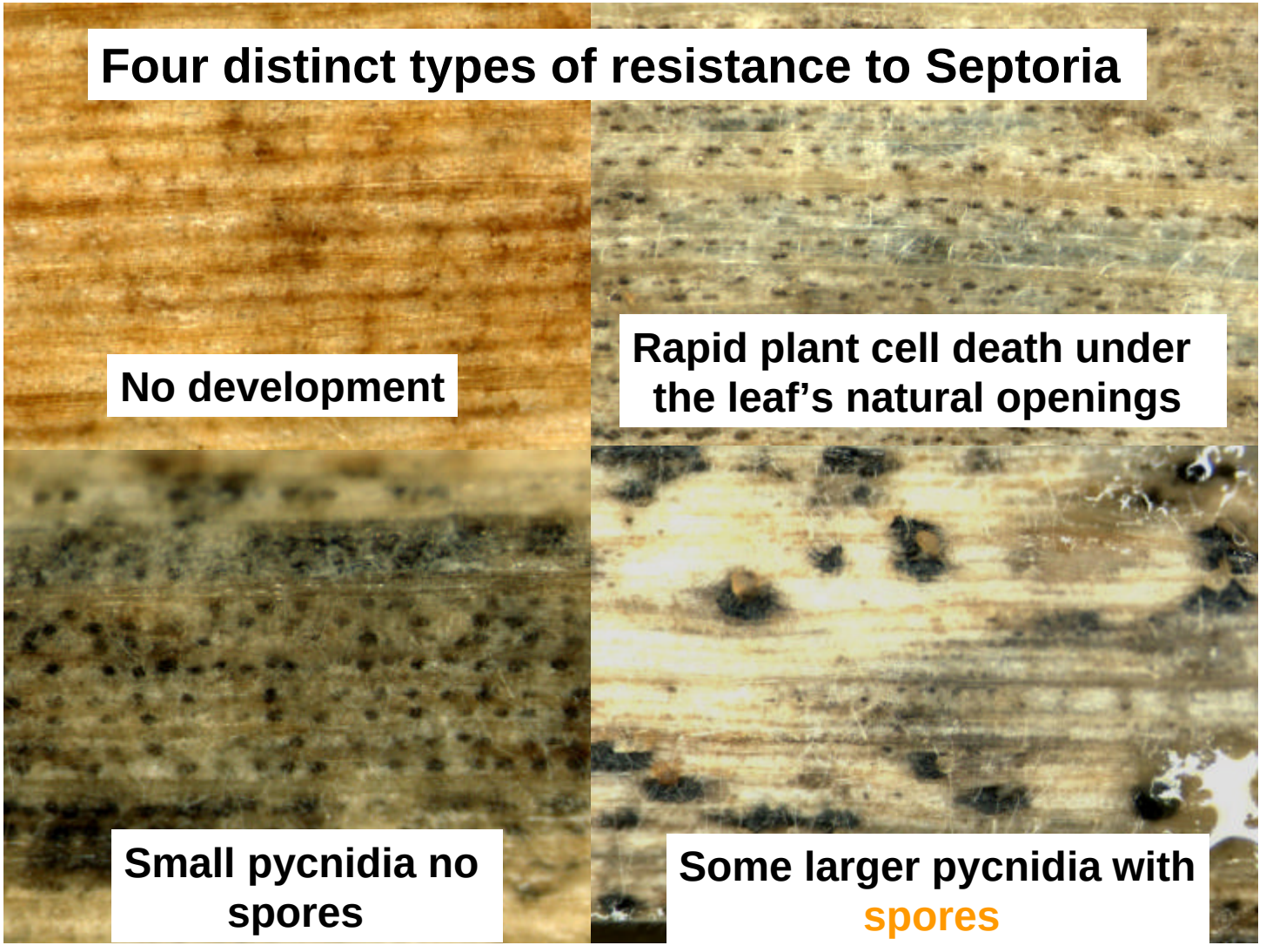


Sporulation: Riband mixed inoculation





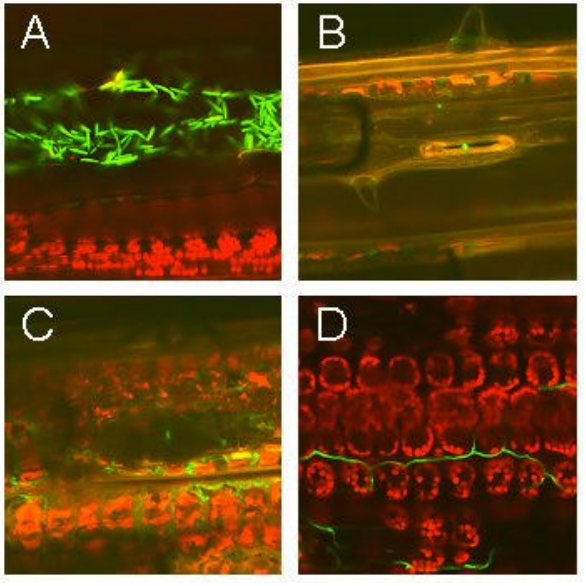



Four distinct types of resistance to Septoria
No development
Rapid plant cell death under the leaf's natural openings
Small pycnidia no spores
Some larger pycnidia with spores

Where next ?

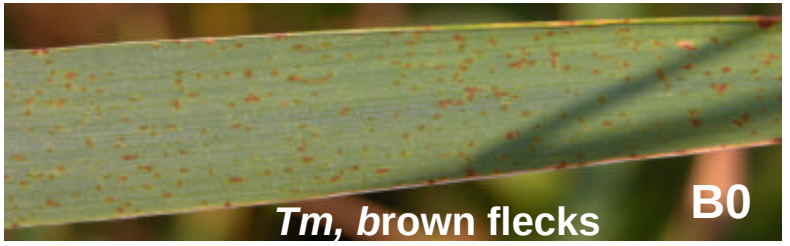
- **Attempt to introgress the Stb pycnidia resistance phenotype into *T. aestivum* and test for functionality**

- **Investigate the resistance mechanism**



Green Fluorescent Protein expressing *Septoria* isolates and UV microscopy

Yellow rust resistance (JIC field trial)



Lesley Boyd

Yellow rust resistance – Summary

Non-host and high resistance phenotypes only

Lines	Symptoms
15	0 - small necrotic flecks (5 with leaf tip necrosis)
5	B0 – brown flecks, typical non-host resistance
11	n0 – slightly larger necrotic flecks
2	nn0 – large flecks

No sporulation

Eyespot pot experiment

Oculimacula yallundae (W-type)

MDR lines	Infection Score	s.d.	Classification
Cappelle Infected	1.8	1.8	R
MDR285	4.3	2.1	R
MDR002	4.5	2.4	R
MDR028	6.0	2.9	R
MDR308 (DV92)	6.0	3.6	R
MDR303	6.7	2.5	M
MDR047	6.7	3.7	M
MDR024	7.1	1.7	
MDR032	7.2	2.5	
MDR029	7.3	3.6	
MDR026	7.5	2.5	
MDR040	7.5	3.4	
MDR033	7.6	1.6	
MDR043	7.6	3.6	
MDR042	7.7	1.8	
MDR036	7.8	5.1	
MDR027	7.9	2.7	
MDR030	8.4	2.6	
Hereward infected	8.5	1.4	
MDR046	8.9	1.8	
MDR050	9.3	1.7	
MDR049	9.3	2.5	
MDR035	9.4	1.9	
MDR037	9.6	1.1	
MDR001	10.1	1.2	
MDR031	10.2	1.7	
MDR244	10.3	2.7	
MDR044	10.5	1.2	
MDR034	10.9	1.2	

Oculimacula acuformis (R-type)

MDR lines	Infection score	sd	Classification
MDR033	5.1	2.3	R
Cappelle infected	5.8	1.5	
MDR002	6.0	1.0	R
MDR285	6.2	1.9	R
MDR047	6.3	3.4	M
MDR024	6.7	2.0	M
MDR032	6.8	1.0	M
MDR027	7.5	1.4	S
MDR026	7.6	1.5	S
MDR028	7.9	1.1	
MDR029	8.2	2.8	
MDR046	8.3	2.7	
MDR303	8.3	1.7	
MDR030	8.4	3.1	
MDR050	8.6	2.6	
MDR040	8.6	3.1	
MDR308(DV92)	8.7	2.5	
Hereward infected	8.7	1.4	
MDR043	8.8	1.8	
MDR001	9.0	2.0	
MDR035	9.1	1.9	
MDR042	9.1	2.0	
MDR036	9.5	0.4	
MDR244	9.8	1.3	
MDR031	9.9	1.2	
MDR034	10.2	1.5	
MDR049	10.3	1.5	
MDR044	10.4	1.9	
MDR037	11.4	0.5	

Field work 2005

- **Assessed for *Septoria*, ergot (n), eyespot (a)…. and take-all (a)**

Richard Gutteridge

Kim Oldham (BSPP)
Marcin Szynkiewicz
(Polish funds)

Ergot (natural infection at RRes)

prevailing wind

Treatment 6
no fungicide

Broadbalk
historic
Wheat exp
started 1843

Tm
Septoria
trial

High ergot disease incidence on both *T. monococcum* and black grass

Ergot assessment *Tm* accessions (0 - 5 scale)

MDR	Mean	sd	MDR	Mean	sd
MDR-2	0.0	0.0	MDR-235	0.7	0.6
MDR-24	0.0	0.0	MDR-25	1.0	0.0
MDR-27	0.0	0.0	MDR-31	1.0	0.0
MDR-32	0.0	0.0	MDR-50	1.0	0.0
MDR-44	0.0	0.0	MDR-33	2.0	1.0
MDR-46	0.0	0.0	MDR-29	2.3	0.6
MDR-259	0.0	0.0	MDR-303	2.3	1.5
MDR-243	0.0	0.0	MDR-258	2.3	0.6
MDR-40	0.3	0.6	MDR-245	2.3	1.2
MDR-41	0.3	0.6	MDR-242	2.3	1.2
MDR-42	0.3	0.6	MDR-37	2.7	0.6
MDR-45	0.3	0.6	MDR-36	3.0	1.0
MDR-47	0.3	0.6	MDR-43	3.3	0.6
MDR-48	0.3	0.6	MDR-218	3.7	0.6
MDR-49	0.3	0.6	MDR-234	3.7	0.6
MDR-252	0.3	0.6	MDR-39	4.0	0.0
MDR-26	0.7	0.6	MDR-230	4.0	1.0
MDR-28	0.7	0.6	MDR-1	4.3	1.2
MDR-34	0.7	0.6	MDR-30	4.3	0.6
MDR-38	0.7	0.6	MDR-35	4.7	0.6
MDR-308	0.7	0.6			

Score 0-5
0; 0% 1: <20%; 2: 21-40%; 3: 41-60%; 4: 61-80; 5: >80%

Method

1 plot / accession

3 independent measurements / plot

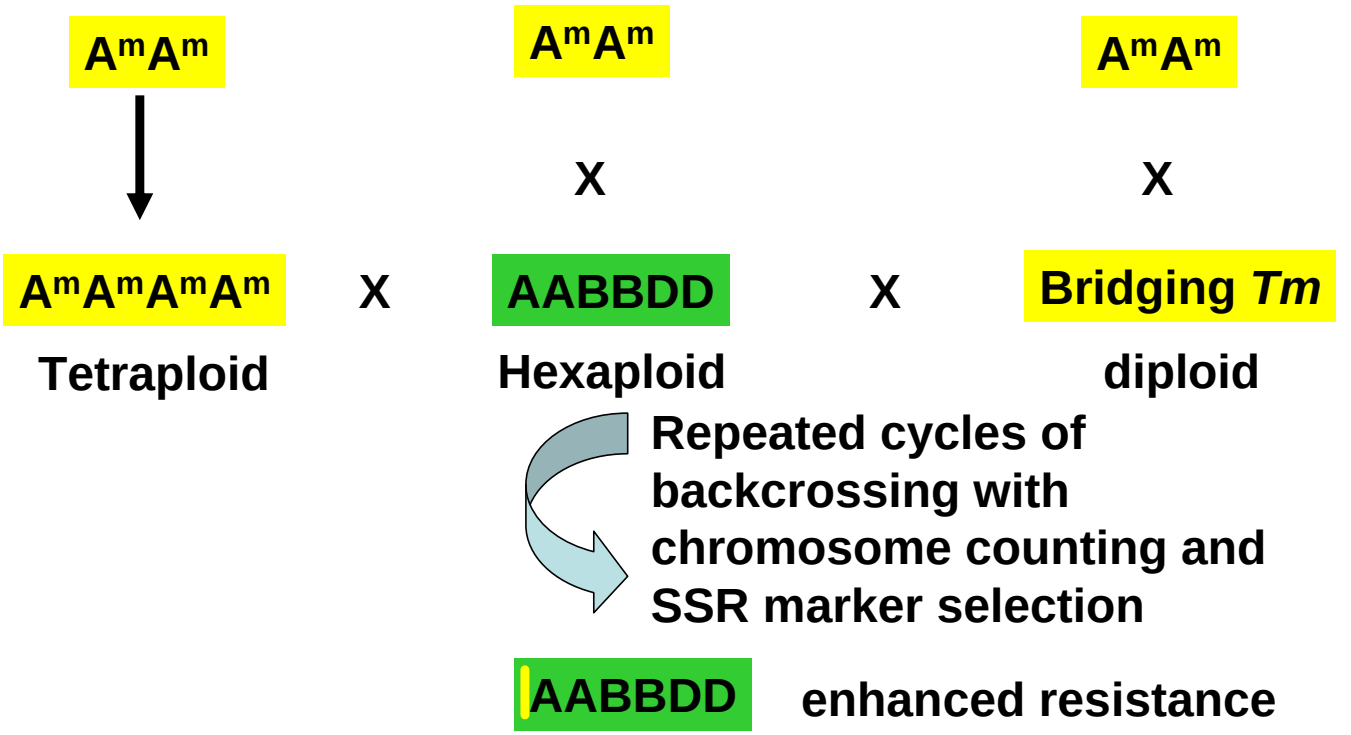
Overall summary of *Tm* pathology results

Pathogen/Vector	Susceptible	Intermediate	Resistant	Total screened
Polymyxa graminis*	**122**		**2**	**124**
SBCMV	**93**		**31**	**124**
Mycosphaerella graminicola			**29****	**29**
Fusarium graminearum/ F. culmorum	**26**		**2**	**28**
Oculimacula yallundae	**23**	**2**	**4**	**29**
Oculimacula acuformis	**23**	**3**	**3**	**29**

***Vector for *SBCMV*.**

****Four *Tm* accessions displayed lesion formation with immature pycnidia briefly in February 2004 just prior to leaf senescence.**

Three approaches to introgress novel resistance from *A*^{m} into bread wheat



EU Framework 6 – Integrated Project 2005 – 2010

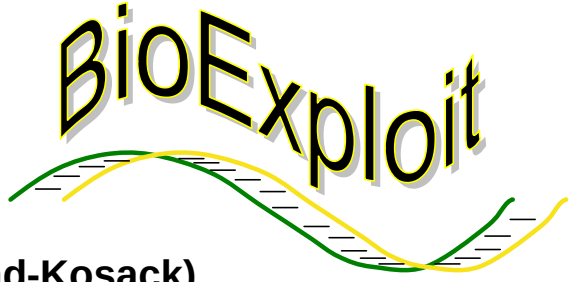
Exploitation of natural plant diversity for the pesticide - free production of food

Focus: Wheat, barley, potato and tomato
Fungal and Oomycete pathogens

14 industrial / SME partners and 29 academic partners

14 European countries + Mexico

6 UK partners



Rothamsted Research
Novel Fusarium Screens (Kim Hammond-Kosack)
Stable wheat transformation to determine gene function (Huw Jones)

Knowledge dissemination and the transfer / exploitation of results

John Innes Centre
Adaptation of the *Septoria tritici* fungus to wheat crops
Including genetics of virulence, costs of virulence and distribution of virulent genotypes (James Brown)

Markers for rust resistance (Lesley Boyd)
Mildew resistance (Chris Ridout)

6 UK partners

Sainsbury Laboratory

Resistance to Potato Late Blight (Jonathan Jones)
Novel resistance gene specificities (David Baulcombe)

NIAB

Screening for resistance to yellow rust
YR pathotypes, cost of virulence, induced resistance
(Rosemary Bayles)
Techniques for evaluation of potato blight resistance
(Jane Thomas)

6 UK partners

Scottish Crops Research Institute
Resistance to Potato Late Blight
Novel resistance gene specificities (Paul Birch and Glenn Bryan)

Manage knowledge on marker-assisted selection and genetic engineering of plant resistance
Improvements to the integrated database GERMINATE on genotype, phenotype and passport data (David Marshall and Robbie Waugh)

GERMINATE currently covers potato, barley, wheat (and Brassica) (Univ Dundee, SCRI, JIC and WUR) aims to provide specific disease resistance genotype / phenotype descriptors

University of Dundee
Develop and apply high-throughput molecular markers linked to resistance to wheat rusts and potato late blight for marker-assisted breeding (Andy Flavell)

ACKNOWLEDGEMENTS

Diploid wheat
Hai-Chun Jing
Dmitry Kornyukhin*
Kostya Kanyuka
Prof Mitrofanova*
*** The Vavilov Institute**

Septoria leaf blotch
Darren Lovell
Jason Rudd
John Keon
Kim Oldham

Ergot and Take-all
Richard Gutteridge
Kim Oldham
Marcin Szynkiewicz

Fusarium ear blight
Arsalan Daudi
Jon West
Richard Gutteridge

Cereal Virus – *Polymyxa*
Kostya Kanyuka
Dmitry Kornyukhin*
Rebecca Lyons

Eyespot
Kerry Maguire
Maria Eckert

Sawfly
BCH Division, RRes

ROTHAMSTED RESEARCH

bbsrc biotechnology and biological sciences research council

defra

Wheat Genetic Improvement Network

www.WGIN.org.uk

BSPP

BHP

T. monococcum accessions from The Vavilov Institute

Note: Each accession is a land-race NOT a pure line

	Sort Number MDR	VIR nomber	Variety	Origin Country	Year
1	MDR 24	K-105	flavescens, hornemannii	Chechen-Ingushetia	1904
2	MDR 25	K-8365	flavescens, macedonicum	Crimea, Ukraine	1923
3	MDR 26	K-8555	macedonicum, symphaeropolitanum	Crimea, Ukraine	1923
4	MDR 27	K-18105	macedonicum	Azerbaijan	1927
5	MDR 28	K-20399	flavescens	Germany	1927
6	MDR 29	K-20491	flavescens	Spain	1927
7	MDR 30	K-20589	monococcum	Spain	1927
8	MDR 31	K-20994	vulgare, macedonicum	Turkey	1927
9	MDR 32	K-21308	vulgare	Italy	1927
10	MDR 33	K-23032	vulgare	Yugoslavia	1928
11	MDR 34	K-23653	hornemannii	Armenia	1928
12	MDR 35	K-25968	vulgare	Austria	1930
13	MDR 36	K-29603	flavescens, monococcum	Czechoslovakia	1932
14	MDR 37	K-30086	macedonicum	Armenia	1934
15	MDR 38	K-30090	monococcum	Armenia	1934
16	MDR 39	K-31683	hornemannii	Georgia	1934
17	MDR 40	K-38079	macedonicum	Bulgaria	1940
18	MDR 41	K-39417	nigricultum, flavescens	Albania	1950
19	MDR 42	K-39471	macedonicum	Balkans region	1950
20	MDR 43	K-39722	vulgare	Greece	1950
21	MDR 44	K-45024	hornemannii	Turkey	1965
22	MDR 45	K-45927	vulgare	Denmark	1970
23	MDR 46	K-46748	macedonicum, vulgare	Romania	1970
24	MDR 47	K-46752	macedonicum	Hungary	1970

Take – all disease causes patches with poor wheat growth

Major problem in continuous wheat culture especially 2nd and 3rd wheat's

T. monococcum – Take-all artifical inoculation Exp

10 reps using two different artificial inoculation methods

- **take-all infected grain spread over the plots**
- **infected soil brought from a high incidence site**

Controls, Bobwhite Paragon (Spring sown)

Yellow rust resistance – details

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,					MDR 302-1	n0,
MDR 307-1	0,					MDR 302-2	n0,
MDR 307-2	0,					MDR 306-1	n0,
DV92	0,					MDR 306-2	n0,
						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						

B0, -brown fleck, typical non-host responses

0, -small necrotic flecks

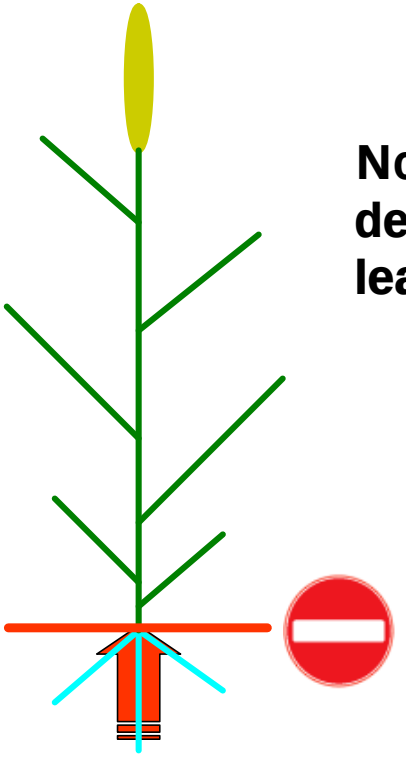
n0, -slightly larger necrotic flecks

nn0, -larger fleckes

LTN, leaf tip necrosis

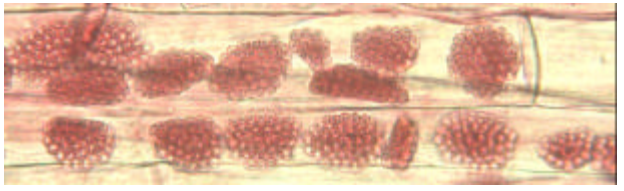
Resistant hexaploid wheat genotypes ‘Cadenza’, ‘Claire’, ‘Charger’

Roots still become infected with *Polymyxa* and virus but SBCMV particles do not spread into aerial tissues



No virus detected in leaf tissue

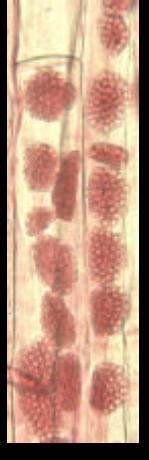
***Polymyxa graminis* - SBCMV**



Infected roots

Wheat –SBCMV interaction

- Furovirus, transmitted by *Polymyxa graminis*
- Symptoms include yellow leaf streaks, dwarfing
- Yield losses of up to 50%



Overall summary of *Tm* pathology results for the five selected accession for crossing

Accession	*Polymyxa*	*SBCMV*	*Fusarium*	*Septoria*	Eyespot
MDR002				0	R
MDR040		R	M	0	M
MDR043				R	
MDR044			M	R	
MDR308		R	ND	R	R

Susceptible
Intermediate

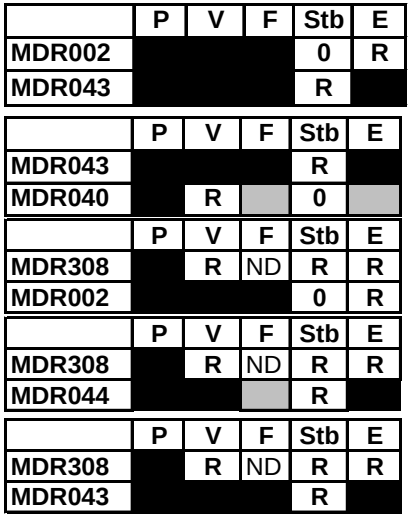
R Resistant
ND: No data

Status of F_1 *Tm* plants

Female	Male	F_1 seed	All plants in flower
MDR002	MDR043	22	6
MDR043	MDR040	38	6
DV92 (MDR 308)	MDR002	18	3
DV92 (MDR 308)	MDR044	1	1
DV92 (MDR 308)	MDR043	43*	3

* probably all are F_1s but protein profiles of the two parents are nearly identical

Barcode of disease scores



Selection of DV92 (MDR 308) for mutagenesis

Disease scores

Accession	*Polymyxa*	*SBCMV*	*Fusarium*	*Septoria*	Eyespot
MDR308	[redacted]	R	ND	R	R

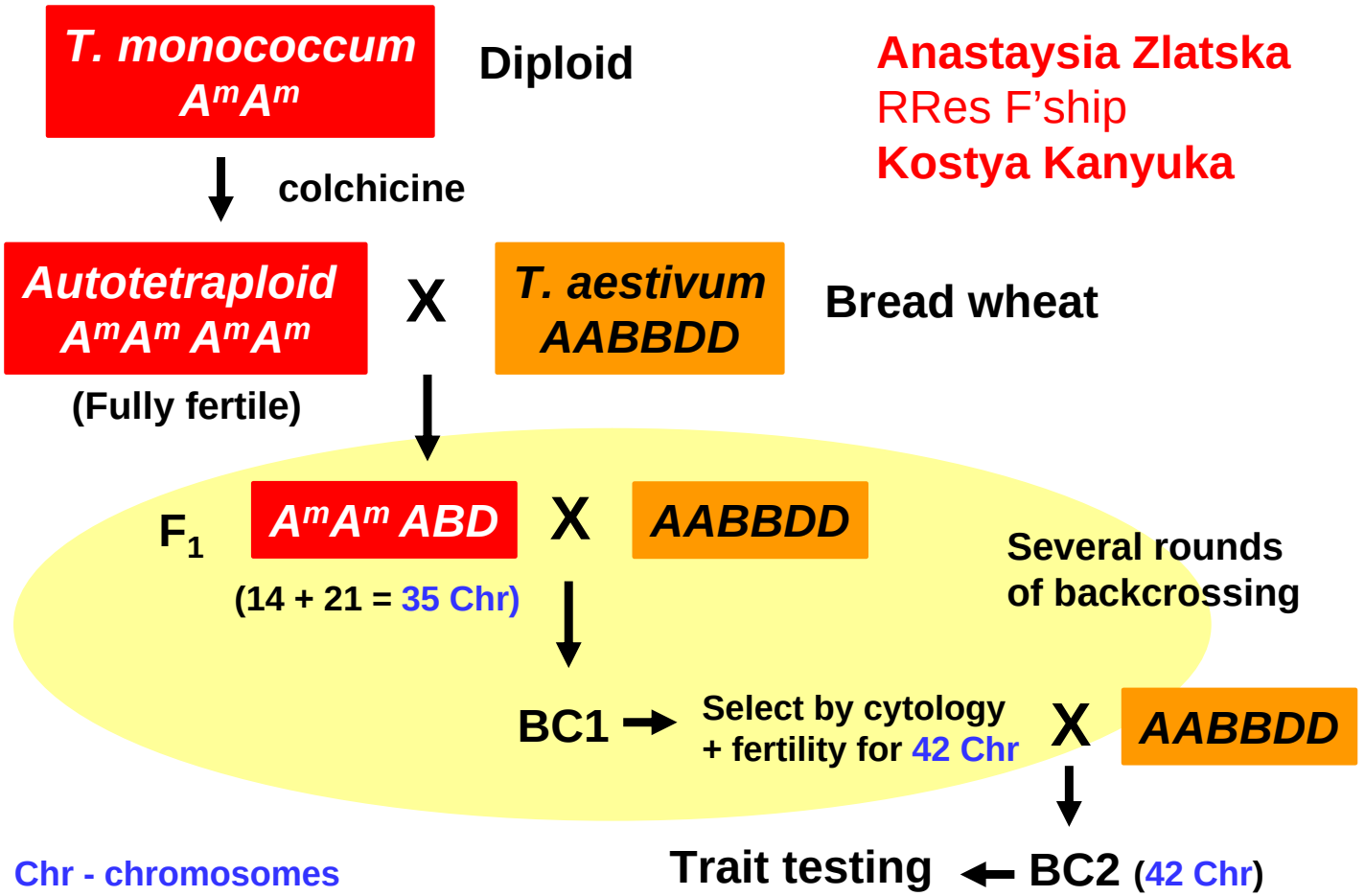
Mutagenesis test (200 seeds / treatment) Oct 05

0.3, 0.4 and 0.5% EMS in phosphate buffer
(2 h at 4C, 2 h 20C, and rinsed with water overnight)

Advice from Dubcovsky, July 2005

1st Population = 3,000

Our preferred introgression strategy

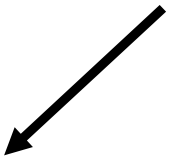


Anastaysia Zlatska
RRes F'ship
Kostya Kanyuka

Our 2nd integration strategy use of a bridging species

***Tm* accession (PI 355520)** **X** ***Tm* accession of interest**

Bridging species



F_1 **X** ***T. aestivum***

n = 14 **n = 42**

Select for plants with correct chromosome numbers

Cox T S; Harrell L G; Chen P; Gill B S (1991). Reproductive-behavior of hexaploid diploid wheat hybrids. *Plant Breeding* **107, 105-118**

ACKNOWLEDGEMENTS

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bbsrc biotechnology and biological sciences research council

defra

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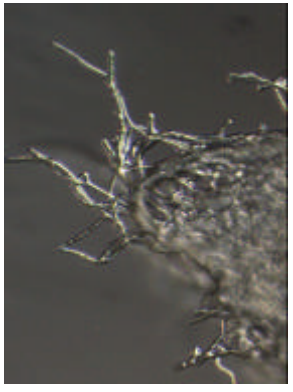
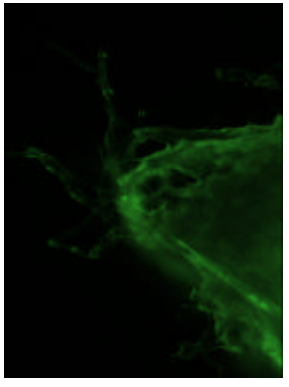
BHP

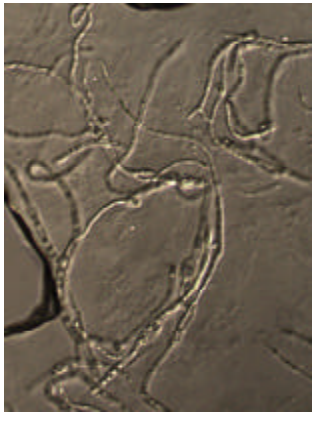
Macerated agar plate
Filter paper method

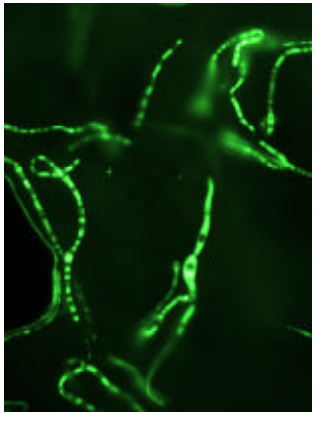




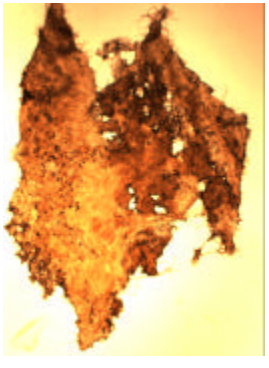
***O. acuformis* 185 sGFP**

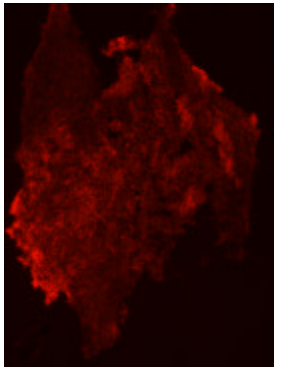
Spores
Agar overlay





***O. yallundae* 22-433 sGFP**





***O. yallundae* 22-432 dsRed**

Main results from two successful exps

Spores or macerated mycelium - OK

Overlay appears to give more transformants

Growth rates Tfns same as WT (22 C)

sGFP and dsRed Tfns for each species

Transformed new species – *T. acuformis*

Association genetics in diploid wheat

- **Link specific gene allele variants to susceptibility or resistance lines**
- **Fifty *T. monococcum* lines phenotyped**

Lines	*SBCMV*	*Mycosphaerella graminicola*	*Tapesia yallundae*	*Fusarium culmorum/ F. graminearum*
MDR0001	R	R	M	M
MDR0303	R	R	R	-
MDR0040	R	R	S	M
MDR0033	S	R	R	M
MDR0034	S	R	R	M
MDR0036	S	R	R	M
MDR0042	S	R	R	M
MDR0047	S	R	R	M
MDR0028	S	R	S	S
MDR0037	S	R	S	S
MDR0049	S	R	S	S
MDR0025	S	R	S	S
MDR0002	S	R*	R	S
MDR0030	S	R*	S	M
MDR0050	R	R*	M	-
MDR0308	R	-	M	-

Plus Take-all
Yellow rust (2005)