Disease, cytogenetic and molecular marker screening of perennial wheat germplasm

Phil Larkin
CSIRO Plant Industry, Canberra

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Potential disease problems with PW

Some concern that perennial wheat would:

- Have greater disease problems than annual wheat
- Pose a disease spreading risk to annual wheat

Assessment of risks regarding rust diseases

- Dr Harbans Bariana, University of Sydney

Potential problems

- Seasonal carry over of pathogen populations
- Higher pathogen population causing higher rates of mutation

Mitigating factors and solutions

- Long season wheat has not resulted in unmanagable rust problems
- Strategic deployment of combinations of resistance genes
- Regular monitoring during off season
- Commitment to release only rust resistant genotypes

Stem rust

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Viruses

Would PW extend green bridges between seasons to accentuate virus infection?

BYDV/CYDV

- Aphid vector

WSMV

- Wheat curl mite vector

Mitigating factor:

- PW does senesce above ground

Would living root system be source of inoculum for regrowth?

Wheat streak mosaic virus

Barley yellow dwarf virus

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Cobbitty results

WSU lines

L.elongatum derivatives

Le/Ta/Ta

No WSMV resistance

	Stripe rust	Leaf rust	Stem rust
227a+b	1	2	7
228a	1	2	5
228b	1	2	4
229a	1	2	5
229b	1	2	5
230a	1	2	6
230b	1	2	6
231a	1	2	4
231b	1	2	3
232a+b	1	2	3
233a	1	2	9
233b	1	2	6
234a	1	2	9
234b	1	2	6
235a	2	2	6
235b	2	2	8

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Cobbitty results

WSU lines

L.elongatum derivatives

Le/Ta/Ta

No WSMV resistance

	Stripe rust	Leaf rust	Stem rust
236a	2,9	2	5
236b	8	2	5
237b	3,6	2	9
238a	1	2	9
238b	3	2	9
239a	2	2,7	9
239b	1	2	8
240a	1	2	8
240b	1	3	9
241b	1	2	8
242a	2,4	3	9
242b	1	2	5
243a	1	2	8
243b	1	2	9
244b	2	3	6
245a	1	6	9
245b	1	7	9

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Cobbitty results

WSU lines

L.elongatum derivatives

Le/Ta/Ta

No WSMV resistance

	Stripe rust	Leaf rust	Stem rust
246a	1	2	8
246b	1	2	5
247a	1	2	4
247b	1	2	5
248a	3	3	*
248b	6	4	8
249b	1	2	3
250a	1	2	5
251a	1	2	5
251b	1	2	6
252a	1	2	9
252b	1	2	9
253a	1	6	9
254a	1	4	9
254b	1	6	9
255a	1	2	9
255b	8	*	8

	Stripe rust	Leaf rust	Leaf rust (2)	Stem rust	WSMV
257a	2	*		3	R
257b	2	*		3	
258a	2,8	2	6	8	R
258b	2	3	6	9	
259a	2	3	6	9	R
260a	3	3	6	6	R
260b	3	3	6	7	
261b	2	*	4	6	R
262a	2	2	3	9	R
263a+b	3	6	6	8	
264a	4	2		9	R
264b	4	2		9	
266a	1	2		2	S
266b	1	2		7	
267a	1	2		4	S
267b	1	2		4	
268a	1	2	3	8	R
268b	1	2		4	

	Stripe rust	Leaf rust	Stem rust	WSMV
269b	7	*	3	S
270a	1	2	7	R
270b	1	2	8	
271a	1	2	8	R
271b	1	2	9	
272a	1	2	7	S
273b	1	6	8	S
274a	1	2	9	
274b	1	3	7	R
276a	3	2	9	
280b	3	3	4	
281b	2	2	7	
282a	2	2	8	
285b	5	2	8	S
286a	2	2	8	R
286b	1	2	8	
288a	*	*	*	
291b	2	2	7	
292a	3,8	2	4	
292b	1	2	8	S

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Disease summary to date

- WSU accessions
  - 50 *L.elongatum* derivatives, Le/Ta//Ta
  - 36 very resistant to stripe and leaf rust
  - 3 very resistant to all three rusts
  - None resistant to Wheat streak mosaic virus
- TLI accessions
  - 38 *Th.intermedium* derivatives, Tc/Ti//Ta, Ta/Ti//Ta, or Tc/Ti
  - 26 very resistant to stripe and leaf rust
  - 3 very resistant to all three rusts
  - 12/19 very resistant to Wheat streak mosaic virus

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Disease and amphiploids

Amphiploid	Stripe rust	Leaf rust	Stem rust	WSMV	BYDV
TAF 46	1	2	4		R
CS-LE	1	3	9		S
B84-994	1	5	9	R	S
CA657 (ABV)	1	5	2	S	S
OK7211542	1	2	3	R	R
Otrastajuscaja 38	3	2	8	R	R
Summer 1	1	2	2	R	R
Zhong 1	2	2	2,5	R	R
Zhong 2	3	2	3	R	R
Zhong 4	1	2	4	R	R
Zhong 5	1	2	4	R	R

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Argentine *Megawheats*

	Stripe rust	Leaf rust	Stem rust
MW0117	1	2	2
MW0177	1	2	2
MW0400	1	2	2
MW0865	1	2	2
MW3162	1	4	7
MW3162 E	1	2	2
MW2444	2	2	2
MW0846	1	2	2
MW0863	1	2	3
MW0157	2,4	2	2
MW0419	3	2	2
Wedgetail	3	2	2
Naparoo	1	2	5

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Disease conclusions

- The presence of resistance can not yet be formally linked to the alien chromosomes
  - WSMV and BYDV resistance very likely from alien chromosomes
- ***L.elongatum*** possible source of stripe rust and leaf rust resistance
  - Stem rust resistance rarer
- ***Th. intermedium*** possible source of stripe rust, leaf rust, WSMV and BYDV resistance
  - Stem rust resistance rarer
- ***Th. ponticum*** possible source of stripe rust, leaf rust, WSMV and BYDV resistance

Perennial grass donors can be source of robust resistance to many diseases.

This makes sense ecologically

However much research yet to be done ….e.g. ….

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Threats from root and crown diseases

A Preliminary assessment by Dr Gordon Murray (retired NSW I&I)

Take-all

Disease	Pathogen	Threat to PW
Take-all	*Gaeumannomyces graminis* var. *tritici*	No worse than for wheat
Crown rot	*Fusarium* spp.	Species need study
Rhizoctonia root rot	*Rhizoctonia solani* groups	Depend on sowing
Common root rot	*Cochliobolus sativus*	Increase on trash?
Cereal Cyst nematode	*Heterodera avenae*	Could increase
Root lesion nematode	*Pratylenchus* spp.	Could increase
Eyespot	*Tapesia yallundae*	Increase on trash?
Pythium root rot	*Pythium* spp.	Locally important
Others		Monitor

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Cytogenetics

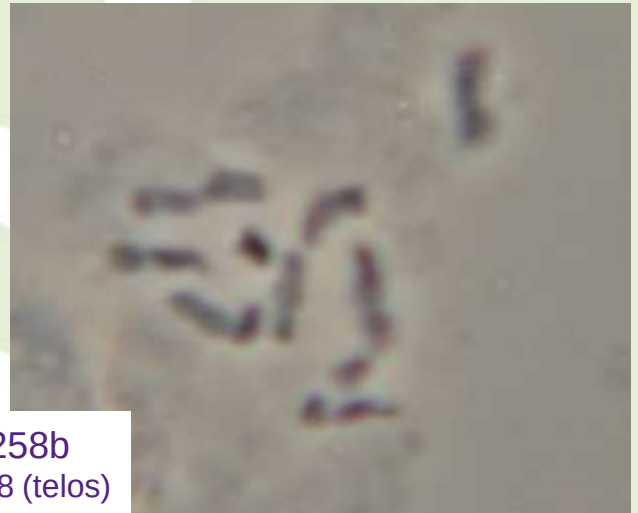
147544b
2n=56

147236a
2n=56

147233a
2n=48

147272a
2n=56

147258b
2n=48 (telos)



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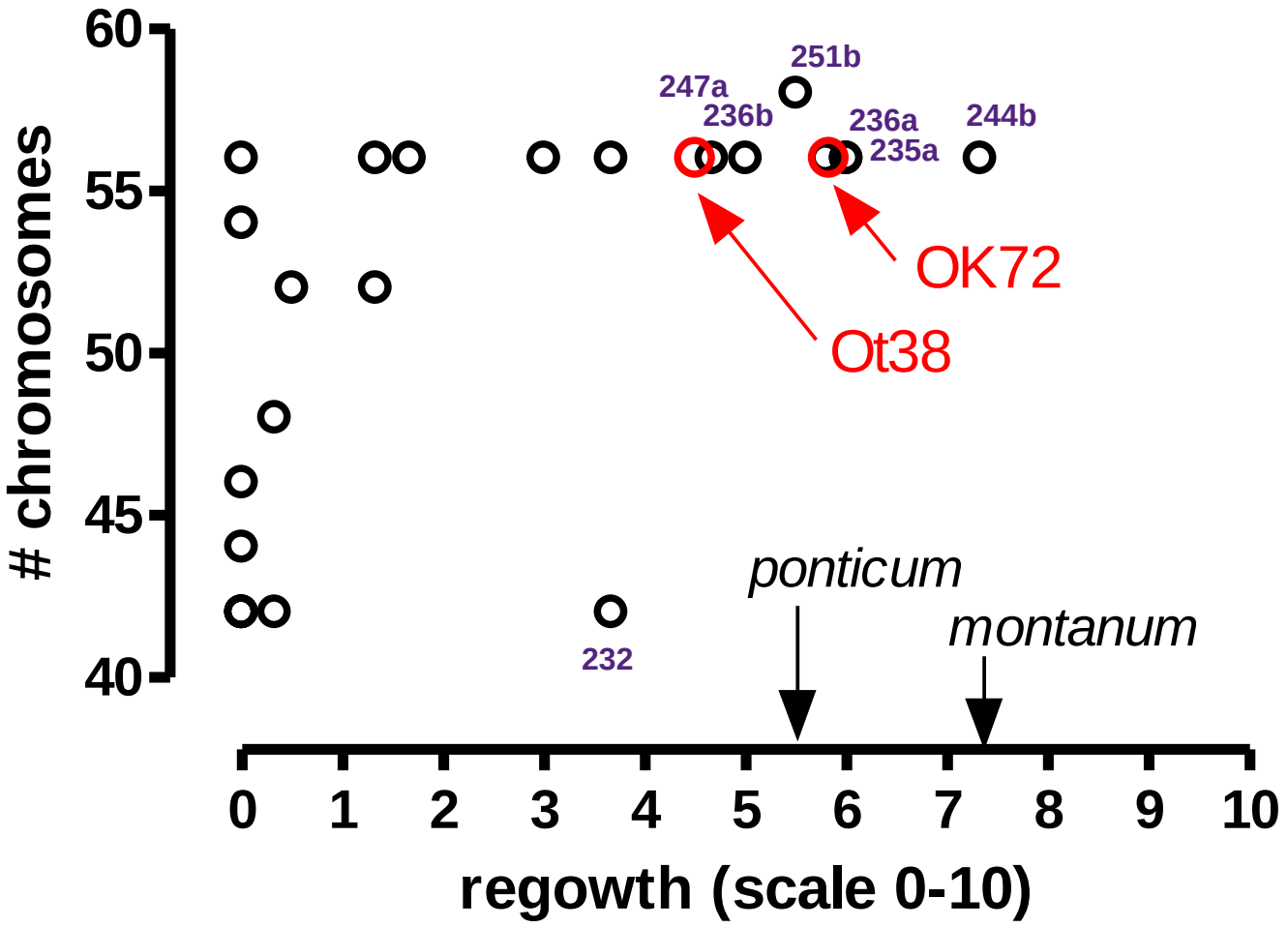
WSU lines regrowth & chromosomes

Cowra and/or Woodstock, Sep2010



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WSU lines – chromosomes and regrowth
preliminary conclusions

Le/Ta//Ta
2n=56

- Full *elongatum* genome (E) required for perenniality
  AABBDDEE 2n=56; true amphiploids
- Potential exception 147232 (2n=42) needs further examination
  - Limited pedigree information suggests AABBEE is unlikely
- Some 56 chromosome lines not showing good perenniality
  - Why not?
  - Possible effect of different *elongatum* donors
  - Potentially extra wheat chromosomes substituting for *elongatum* chromosomes

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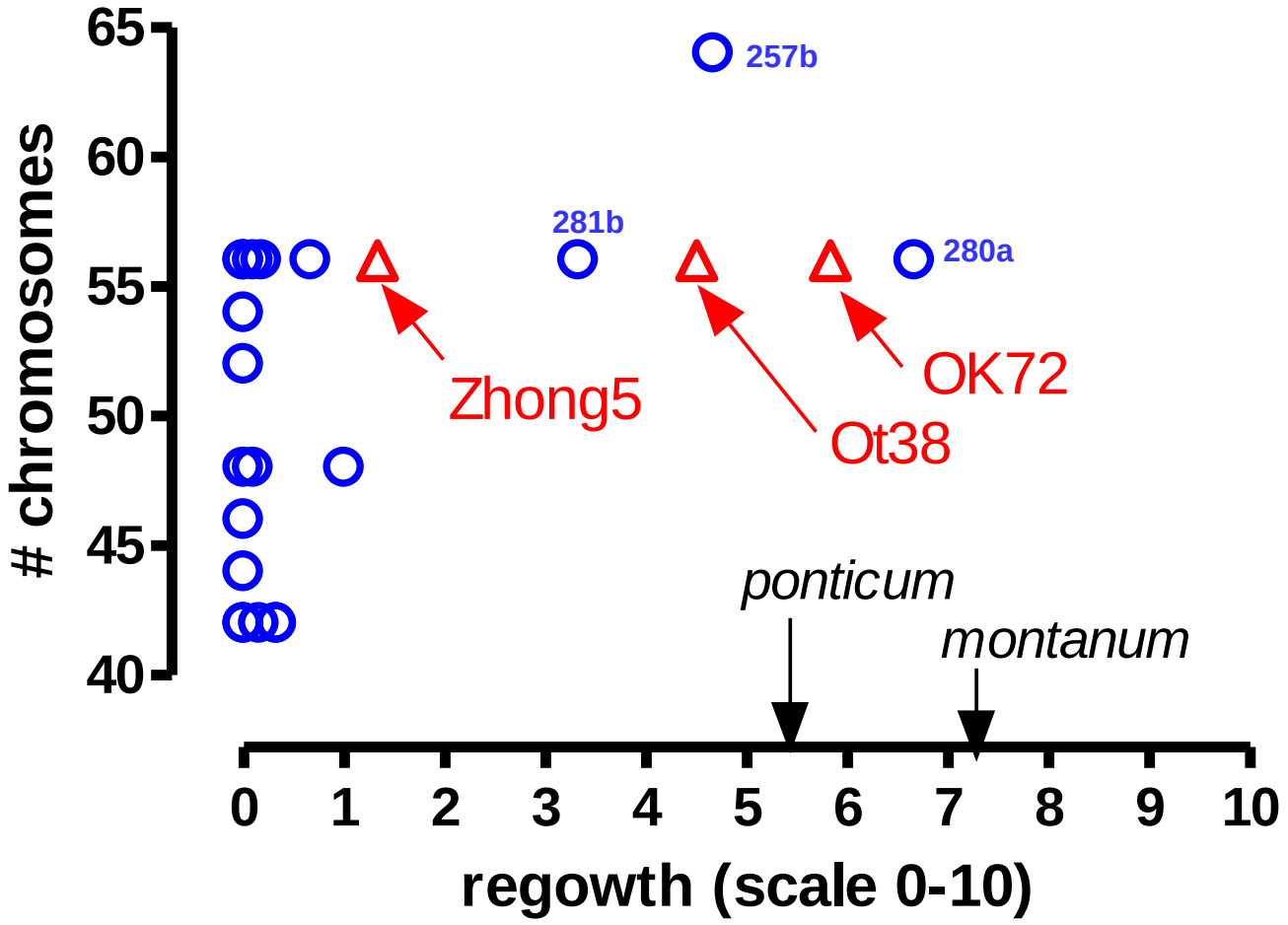
TLI lines regrowth & chromosomes

Cowra and/or Woodstock, Sep2010



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TLI lines – chromosomes and regrowth
preliminary conclusions

- Only octoploids (2n=56) could be perennial, AABBDDXX
  - But not all octoploids were perennial
  - Since *Th.intermedium* is a hexaploid (JJJ^sJ^sSS), the extra genome can be a synthetic mix of JJ^sS (call X)…..
  - Apparently some synthetic *intermedium* genomes (X) are adequate for perenniality and some not

- Examples:
  - 147280 and 147281 (2n=56) were as perennial as mountain rye or tall wheatgrass – not yet tested at Woodstock
  - 147271 and 147274 (2n=56) not perennial (also Woodstock)

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Cytogenetics: preliminary conclusions

OK7211542

- Prospect for perenniality from each of three donor sources:
  - *elongatum* (2x)
  - *intermedium* (6x)
  - *ponticum* (10x)
- Potential perennial grains selections e.g.:
  - 147235a (2n=56)
  - 147251b (2n=56-58)
  - 147257a (2n=60-66)
  - 147280a (2n=56)
  - 147281a (2n=56)
  - OK7211542 (triple rust, double virus resistant)
- Even if we found a line adapted to target regions, a release needs an ongoing, feasible breeding strategy…… my next talk

147235a

147257a

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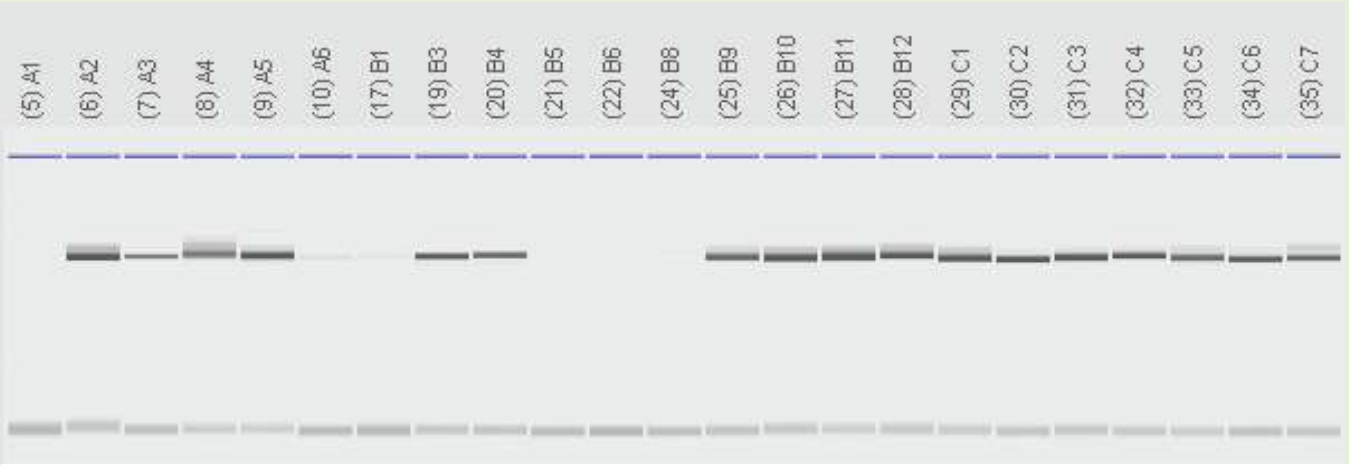
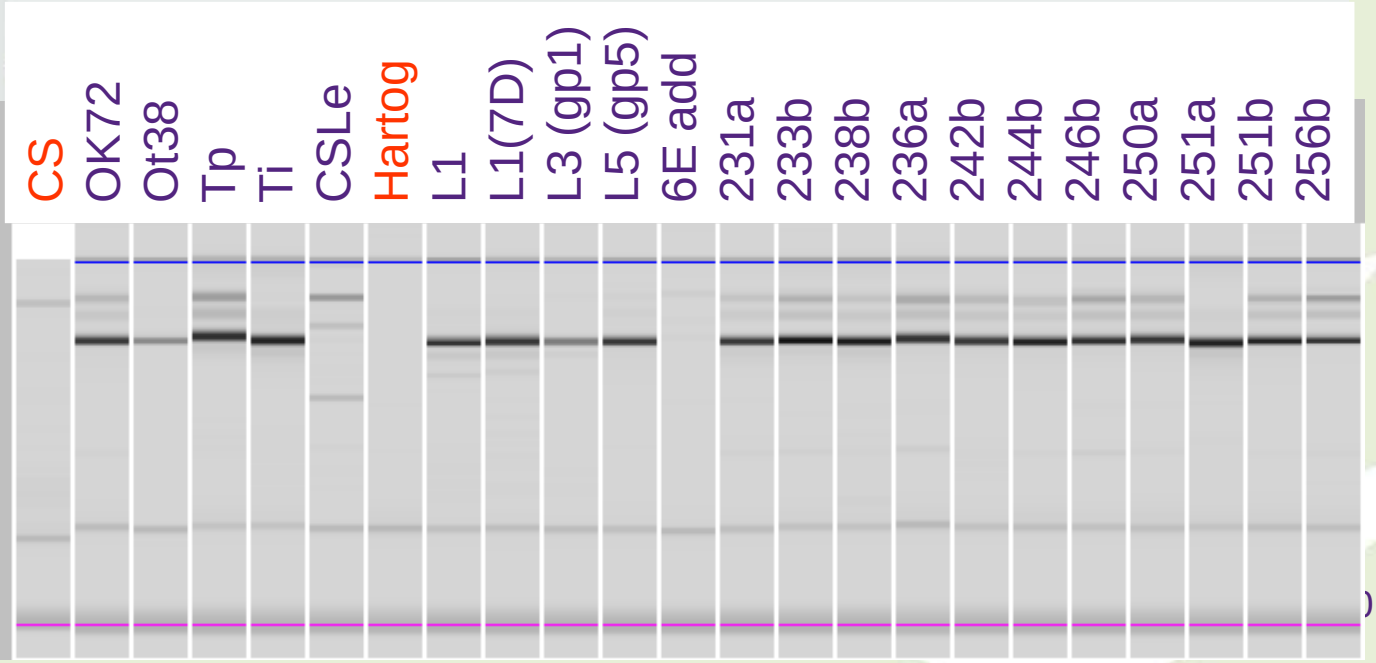
Molecular markers

work in progress …..

TIREP



3P3/3P4



	BQ170567	TIREP	2P1-2P2	3P3-3P4	SCM04	Qi	WS2	WS9	BYAgi	
	gp2	R gp2,4,7	R	R	gp2	gp4	gp4	gp4	gp7	2n=
CS										42
Hartog										42
Tp	**2~**	**1**	**2**	**1,2**	**1**		**1**	**1**	**1**	70
OK72	**2**	**1**	**2f**	**2f**	**1**					56
Ti	**1,2**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	42
Ot38	**1**	**1**		**1**	**1**				**1f**	56
Sebasta Blue (4EL translocation)					**1**					42
TAi27	**1**	**1**		**1**	**1**				**1**	44
Zhong1		**1**		**1**	**1**	**1**	**1**	**1**	**1**	56
Zhong5	**1**	**1**		**1**	**1**				**1**	56
Yi4214 (gp2 sub)	**1**	**1**		**1**	**1**					42
CA739 (4DL.4Ai2S)		**1**			**1**	**1**		**1**		42
YW642 (7Slong)		**1**		**1**					**1**	42
L1 (gp7 add)		**1**		**1**	**1**				**1**	44
L1(7D) sub		**1**		**1**	**1**				**1**	42
L3 (gp1 add)				**1**						44
L5 (gp5 add)				**1**	**1**					44
L7 (gp6 add)				**1**	**1**					44

	BQ170567	TIREP	2P1-2P2	3P3-3P4	SCM04	Qi	WS2	WS9	BYAgi	
	gp2	R gp2,7	R	R	gp2	gp4	gp4	gp4	gp7	2n=
CS										42
Hartog										42
CS-Le	2		2	2						56
6E add										44
231a	2	1		1, 2f	1					
233b	2	1	2	1, 2f	1					56
236a	2	1	2	1, 2f	1		1	1		56
238b	2	1	2	1, 2f	1					
242b	2	1	2f	1, 2f	1					56
244b	2	1	2f	1, 2f	1					56
246b	2	1	2f	1, 2f	1					
250a	2	1	2f	1, 2f	1					56
251a	F	1	2f	1	1					56
251b	2	1	2f	1, 2f	1					58
256b	2	1	2f	1, 2f	1					

	BQ170567	TIREP	2P1-2P2	3P3-3P4	SCM04	Qi	WS2	WS9	BYAgi	
	gp2	R gp2,7	R	R	gp2	gp4	gp4	gp4	gp7	2n=
CS										42
Hartog										42
Ti	1,2	1	2	1	1	1	1	1	1	42
257b	F	1		1	1		1	1		66
258a							1	1		
258b	2	1	2f	1, 2f	1					48
259a	2	1			1		1	1	1	42
261b	2	1			1		1	1	1	42
264a		1			1		1	1		
267b			2f	2						
268a								1		48
274b								1		
276b	1	1	2f	1	1				1	
281a		1	2	1	1				1	56
286a		1		1	1					
286b		1		1	1					56

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Conclusions thus far…

- Perennial Triticeae donors have proved useful sources of resistance to foliar fungal diseases and viruses
- Root and crown diseases require attention
  - May even be responsible for failure to regrow
  - Yet can anticipate that the donors will be good sources of resistance
- *elongatum* (2x), *intermedium* (6x), and *ponticum* (10x) can all donate perenniality to wheat
  - require a whole extra genome
  - Envisage the new perennial grain crop will be an amphiploid
- Molecular markers will be useful to confirm and track the inheritance of the alien chromosomes in a breeding program