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Recent Progress in Breeding for FHB Resistance in Canadian Barley

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Canada

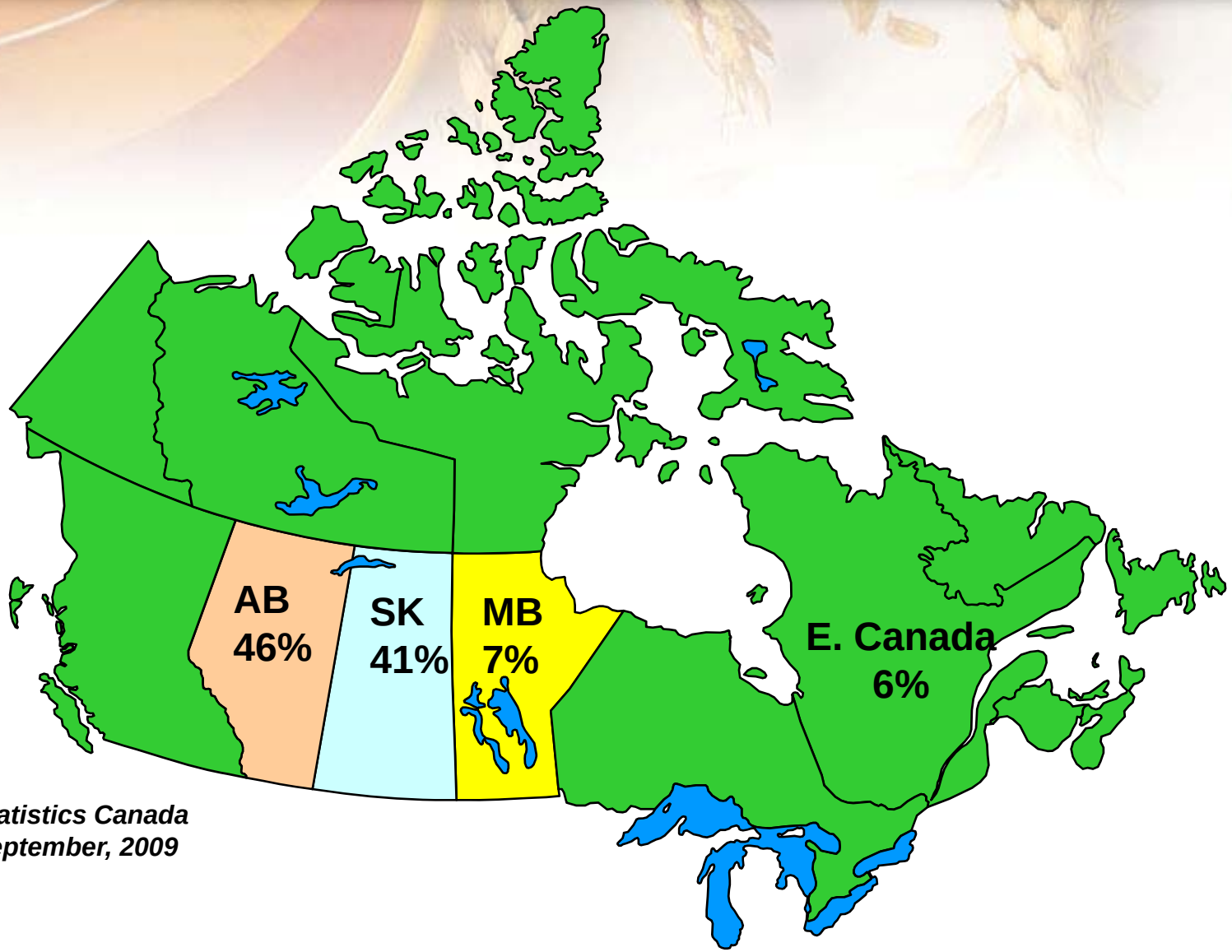
Introduction

- Background – barley in Canada
- Progress to Date – registered cultivars
- On-going Progress
- Modified FHB Project – use of NIR
- Funding

Barley Production in Canada

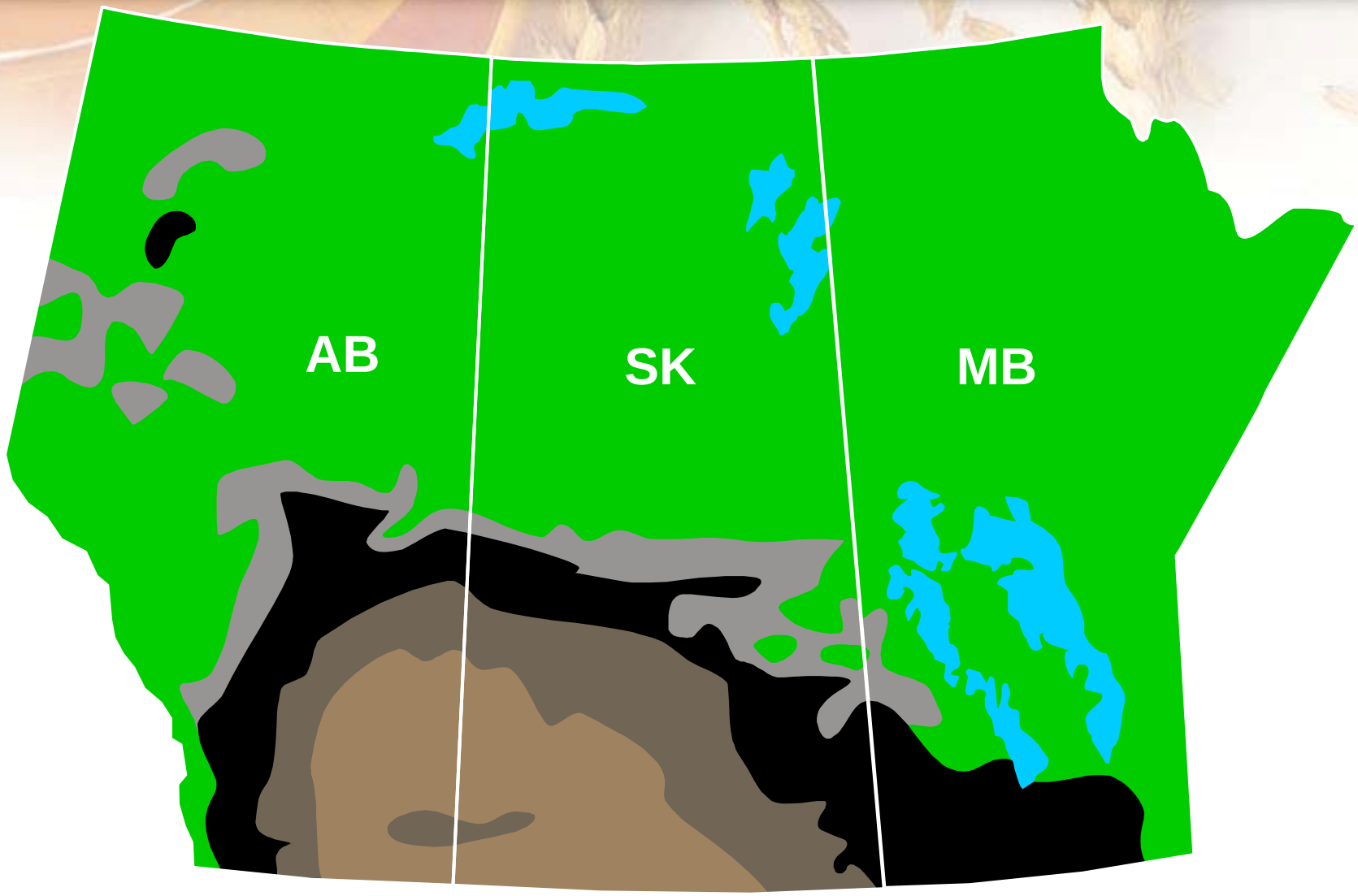
- Barley ranks third in acreage in Canada
- Grown on average of 10.1 million acres from 2004 to 2008
- Acreage down to 8.7 million in 2009
- 90 - 95% of acreage in western Canada
- FHB a problem in eastern Canada, Manitoba and eastern Saskatchewan

2009 Barley Acreage in Canada*



*Statistics Canada
September, 2009

Soil Zones in Western Canada



2009 Canadian Wheat Board Barley Variety Survey

CLASS	ACREAGE (%)
Two-row Malting	55.1
Six-row Malting	9.9
Feed (2-row & 6-row)	34.8
Hulless	0.2

2009 CWB Barley Variety Survey

Two-Row Malting Variety	Acreage (%)
AC Metcalfe	60.2
CDC Copeland	24.9
CDC Kendall	7.0
Newdale	5.5

Varieties Selected for Domestic Use and Export*

Class	Domestic Use for Malt (%)	Malting Barley for Export (%)
Two-row malting	90	82
Six-row malting	10	18 *(USA)*

5-yr average from Canadian Malting Barley Technical Centre (2004).

FHB Project

- Initiated FHB project in western Canada in 2000
- New funding arrangement every 3 years
- We are now in our 10th year
- Project evolved considerably over the years
  - modified significantly in 2009

Collaborators 2009

- W. Legge, M. Therrien, J. Tucker – BRC, Brandon
- A. Tekauz – CRC, Winnipeg
- M. Savard (B. Blackwell), A. Choo – ECORC, Ottawa
- R. Martin – CLRC, Charlottetown
- K. Turkington – AAFC Lacombe
- B. Rossnagel, D. Voth, T. Zatorski – CDC, U. of Sask., Saskatoon
- J. Helm, P. Juskiw, J. Nyachiro, K. Xi, J. Zantinge – AARD, FCDC, Lacombe

Previous Project

- Large FHB nursery at Brandon with 17,280-row capacity for initial screening & further evaluation of promising lines
- Most promising lines identified at Brandon were evaluated in several smaller nurseries across Canada
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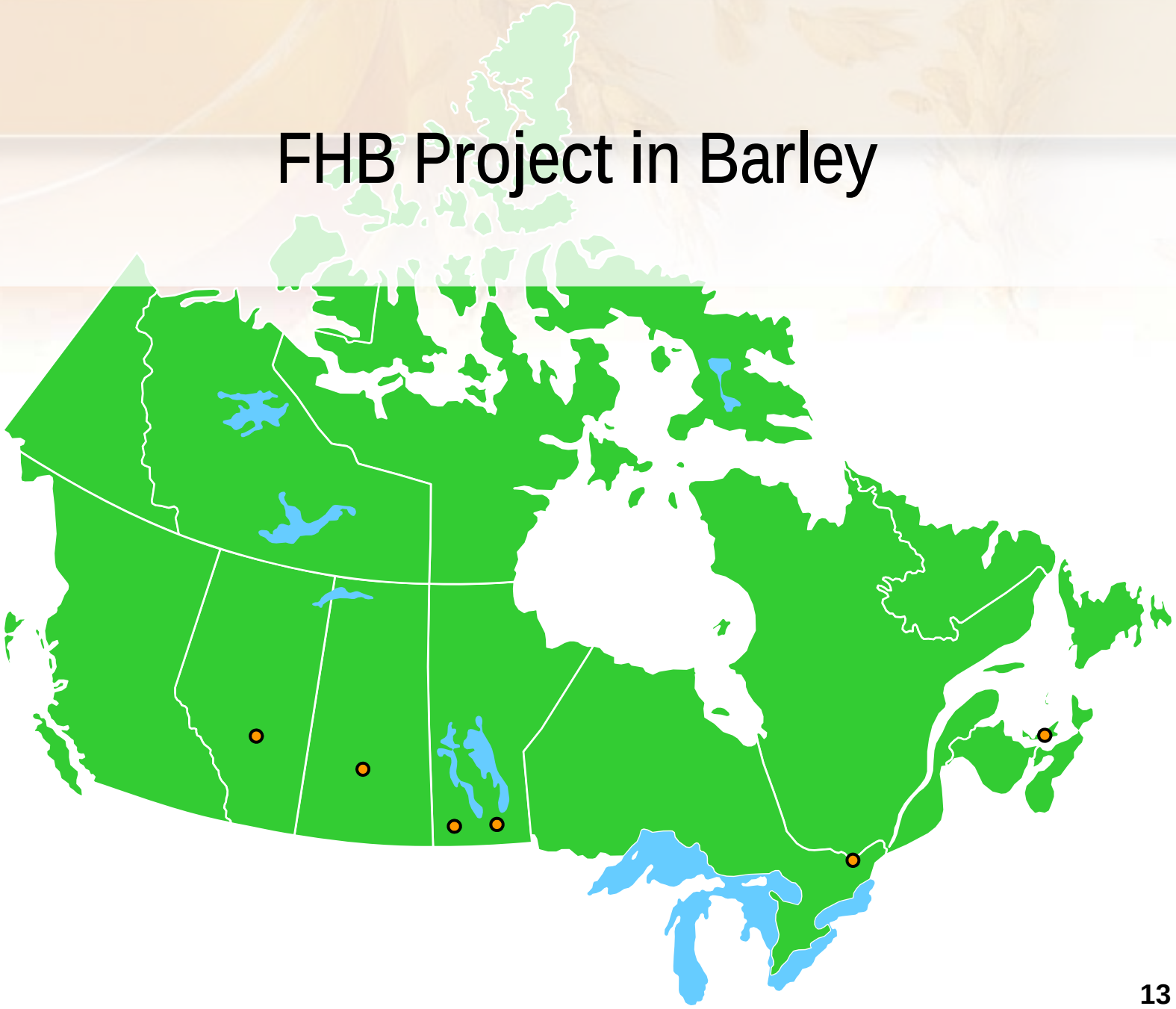
	Rows
– Portage la Prairie, MB	1,500
– ECORC, Ottawa, ON	1,000
– Charlottetown, PE	1,000

Previous Project – DON Analysis

- DON analysis conducted by ELISA at ECORC – 6,000 samples per year.
- Additional 3,000 samples analyzed by modified ELISA technique in a commercial lab each year.
- Visual FHB symptom ratings (0-5 scale) were used to reduce the number of entries to fit into our DON testing quota and our sample processing capabilities at Brandon (about 8,000 rows per year).

FHB Project in Barley



CDC Mindon Two-row Feed Barley

- First new cultivar to be released as a result of the FHB project – registered in 2007.
- Developed by Crop Development Centre, University of Saskatchewan, from existing variation within the breeding program.
- CDC Mindon = TR04378 = SB00106 = TR339/TR251
- Consistently 50 – 60% deoxynivalenol (DON) content of AC Metcalfe at Brandon.
- Replaced CIho4196 as resistant 2-row check in our FHB nurseries in 2005.
- Set DON target to CDC Mindon or lower.

Other Traits of CDC Mindon

- Good disease resistance package for eastern prairies
  - Moderate resistance to spot blotch
  - Poor spot blotch resistance a problem in 2-row cultivars with lower DON
- About 10% lower yielding than popular 2-row feed cultivars like Xena
  - Similar to AC Metcalfe

DON Content of CDC Mindon Repeated Checks

Mean DON (ppm)	Brandon 2005-08	
Entries	FHB *(0-5)*	DON *(N=4)*
AC Metcalfe	2.4	8.6
CDC Mindon	*2.5*	*5.4*
CDC Bold	4.0	16.2
- Vs AC Metcalfe (%)		*63*

Norman (TR05915) Two-row Malting Barley

- Norman, a joint release with the CDC, was registered in 2009
- Selected from CDC Kendall at AAFC Brandon using *in vitro* selection (IVS) by adding *fusarium* mycotoxins to the doubled haploid (DH) system
- Norman has about 25-30% less DON than CDC Kendall
- Generally similar to CDC Kendall in agronomic, disease reaction & malting quality traits

Norman vs. CDC Kendall - DON Content

DON Content as a % CDC Kendall	Brandon 2001-2008	Other Nurseries – 2003-2008		
		Portage*	Ottawa	PEI
Norman	*70*	*91*	*66*	*83*
Number of years	8	4	5	6

* FHB nursery at Portage la Prairie, MB

HB705 Two-row Hulless Barley

- HB705, a hulless cultivar with malting potential, was registered in 2009.
- Selected from CDC Freedom/Rivers cross at AAFC Brandon using IVS.
- HB705 has about 35% lower DON than CDC Freedom (one of the most FHB resistant hulless cultivars available).
- High malt extract combined with low DON content may make HB705 attractive to the malting and brewing industry.

HB705 vs. CDC Freedom - DON Content

DON Content as % CDC Freedom	Brandon 2002-2008	Other Nurseries – 2004-2008		
		Portage*	Ottawa	PEI
HB705	*65*	*70*	*67*	*62*
Number of years	7	3	5	5

* FHB nursery at Portage la Prairie, MB

On-going Breeding Progress

- Most breeding programs in Canada have developed some germplasm (mostly two-row) with moderate resistance to FHB over the past decade.
- Most are now in the second or third breeding cycle.
- Have better parents available for crossing purposes.
- Development of CDC Mindon from existing variation is encouraging.
- Other strategies are also being used to complement and enhance FHB resistance such as incorporating ‘exotic’ resistance sources.

Use of Exotic Resistance Sources at Brandon

- Many ‘exotic’ sources (about 30 since 1996) have been used at Brandon with generally disappointing results.
- Harbin (2-row) /TR253//TR253 has been the best cross so far.
  - 6 advanced breeding lines were entered in the Western Cooperative Two-row Barley Registration Test (WCTBRT).
  - Similar to CDC Mindon with TR04282 having the lowest DON.
  - TR06292 best combination of malting quality and FHB resistance, but poorest agronomic performance.
  - All were dropped but used extensively in crosses.

DON Content of TR04282 - 2000-08

DON Content (% AC Metcalfe)	BRC* *(N=8)*	MB *(N=6)*	ECORC *(N=5)*	PEI *(N=6)*	ALL *(N=25)*
TR04282	48	45	45	103	59

* BRC = Brandon Research Centre; MB = FHB Nurseries at Glenlea & Portage la Prairie, Manitoba; ECORC = Eastern Cereal and Oilseed Research Centre, Ottawa, Ontario; PEI = Charlottetown, Prince Edward Island; ALL = mean over all site years; N = number of site years.

TR08203 Two-row Malting Barley

- TR08203, a DH line from the TR04282/Newdale cross, was entered for a second year in the 2009 WCTBRT and NABSEN.
  - 6% higher yielding than AC Metcalfe with acceptable agronomic and malting quality traits.
  - Good disease resistance package.
  - DON levels between AC Metcalfe and CDC Mindon.

FHB Resistance of TR08203 – 2008 WCTBRT

FHB Nursery	Brandon		Portage la Prairie
Entry	FHB *(0-5)*	DON *(ppm)*	DON *(ppm)*
AC Metcalfe	3.5	23.7	17.1
TR08203	*2.7*	*18.0*	*13.9*
- Vs AC Metcalfe (%)		*76*	*82*

DON Content (ppm) of Breeding Lines - 2007-08

Entry	Pedigree	BRC* *(N=2)*	Other* *(N=6)*
AC Metcalfe		14.5	11.6
TR04282	Harbin/TR253//TR253	7.0	9.2
TR08203	*TR04282/Newdale*	*8.5*	*13.0*
BM0270D-192-0	TR04282/Newdale	9.3	13.8
BMO270DCB-18-0	TR04282/Newdale	7.9	10.5
BM0270D-214-0	TR04282/Newdale	7.9	9.1
BMO270DTB-1-0	TR04282/Newdale	12.1	14.1
BMO362D-40-0	HDE84194-622-1/Newdale	3.6	8.6

* Mean DON content, where BRC = Brandon Research Centre, MB; Other = FHB Nurseries at Portage la Prairie, MB, Ottawa, ON, and Charlottetown, PE; N = number of site years.

DON Content (ppm) of Breeding Lines - 2007-08

Entry	Pedigree	BRC* *(N=2)*	Other* *(N=6)*
AC Metcalfe		14.5	11.6
TR04282	Harbin/TR253//TR253	7.0	9.2
BM0122-360-1	Rivers/Krasnojarskij//Rivers	8.7	13.8
BM0122-272-1	Rivers/Krasnojarskij//Rivers	8.0	10.2
BM0126-42-0	Rivers/Niedzical	12.0	13.9
BM0127-156-1	Rivers/Primus	9.1	10.7
BM0331D-5	Conlon/TR03273	10.2	15.5
BM0331D-294-0	Conlon/TR03273	9.8	11.5

* Mean DON content, where BRC = Brandon Research Centre, MB; Other = FHB Nurseries at Portage la Prairie, MB, Ottawa, ON, and Charlottetown, PE; N = number of site years.

DON Content (ppm) of Breeding Lines - 2008

Entry	Pedigree	BRC* *(N=1)*	Other* *(N=3)*
AC Metcalfe		21.6	11.3
TR04282	Harbin/TR253//TR253	10.1	9.7
BM0358D-32	BM9637-53/TR02271	19.0	7.0
BMO362D-115	HDE84194-622-1/Newdale	15.2	10.4
BMO429D-9	Island/BM9831D-229	12.5	9.2
BMO429D-34	Island/BM9831D-229	20.5	15.0
BM0510D-21	CDC Mindon/Newdale	13.7	9.4

* Mean DON content, where BRC = Brandon Research Centre, MB; Other = FHB Nurseries at Portage la Prairie, MB, Ottawa, ON, and Charlottetown, PE; N = number of sites in 2008.

Previous Project – Problems

- Visual ratings not very reliable in barley and are time-consuming
  - Correlation coefficient between visual ratings and DON content by ELISA < 0.50.
  - Concerns about missing lines like CDC Mindon with average visual symptoms but low DON levels.
  - DON content of paramount importance in barley.
- DON calibrations have been developed for NIRS at CDC, Saskatoon and FCDC, Lacombe
  - Correlation coefficient between NIR DON and ELISA DON about 0.90 at the CDC.

New Approach for Project in 2009

- Visual ratings discontinued in all but key material.
- Replace with a DON pre-screening step using the NIR at the CDC and FCDC for advanced breeding lines.
- Entries with the lowest NIR DON values will be sent to ECORC for DON analysis using the ELISA technique.
  - Screen out about 40-50% of entries at this stage.
- Critical tests and all entries at off-station sites will be sent directly to ECORC.
- ECORC will continue to do about 6,000 samples per year.
- Brandon will continue to handle about 8,000 rows per year including harvest and sample processing.

New Approach to Project in 2009

- Core FHB nursery at Brandon will consist of 8,640 rows for critical tests, initial screening & further evaluation of promising lines with most rows harvested
  - Some of the remaining capacity will be used by the Brandon program to select in populations segregating for FHB resistance as resources allow (visual selection).
- Promising lines will be evaluated further in 3 smaller nurseries
  - Portage la Prairie, MB 1,000
  - ECORC, Ottawa, ON 500
  - Charlottetown, PE 500

Previous Funding Arrangement

- Funding agencies:
  - *Western Grains Research Foundation (WGRF) Barley Check-off*
  - *AAFC Matching Investments Initiative (MII) program*
  - *Agriculture Development Fund (ADF) via CDC*
  - *Canadian Wheat Board (CWB)*
  - *Agri-Food Research and Development Initiative (ARDI)*
  - *Alberta Crop Industry Development Fund (ACIDF)*

Current Funding for New Project in 2009

- Funding agencies:
  - *WGRF Barley Check-off*
  - *ADF via CDC (2 years left)*
  - *New ACIDF funding via FCDC, Lacombe (5 years)*
- Total budget needed about $100,000 per year less than previous project
  - *Still short of the required funding*
  - *Major adjustments may be needed next year*

Conclusions

- Good progress is being made as two-row barley lines with improved FHB resistance are being evaluated in registration trials and released as new cultivars.
- DON content has been reduced by 20-50% relative to check cultivars like AC Metcalfe.
- However, most FHB resistant lines are lower yielding than other new cultivars, and attaining acceptable malting quality will be a challenge.
- Progress has lagged in six-row barley.
- New barley cultivars with improved FHB resistance should be released within the next 5 years.

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