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New Breeding Tools Impact Canadian Farmer Fields

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Canada

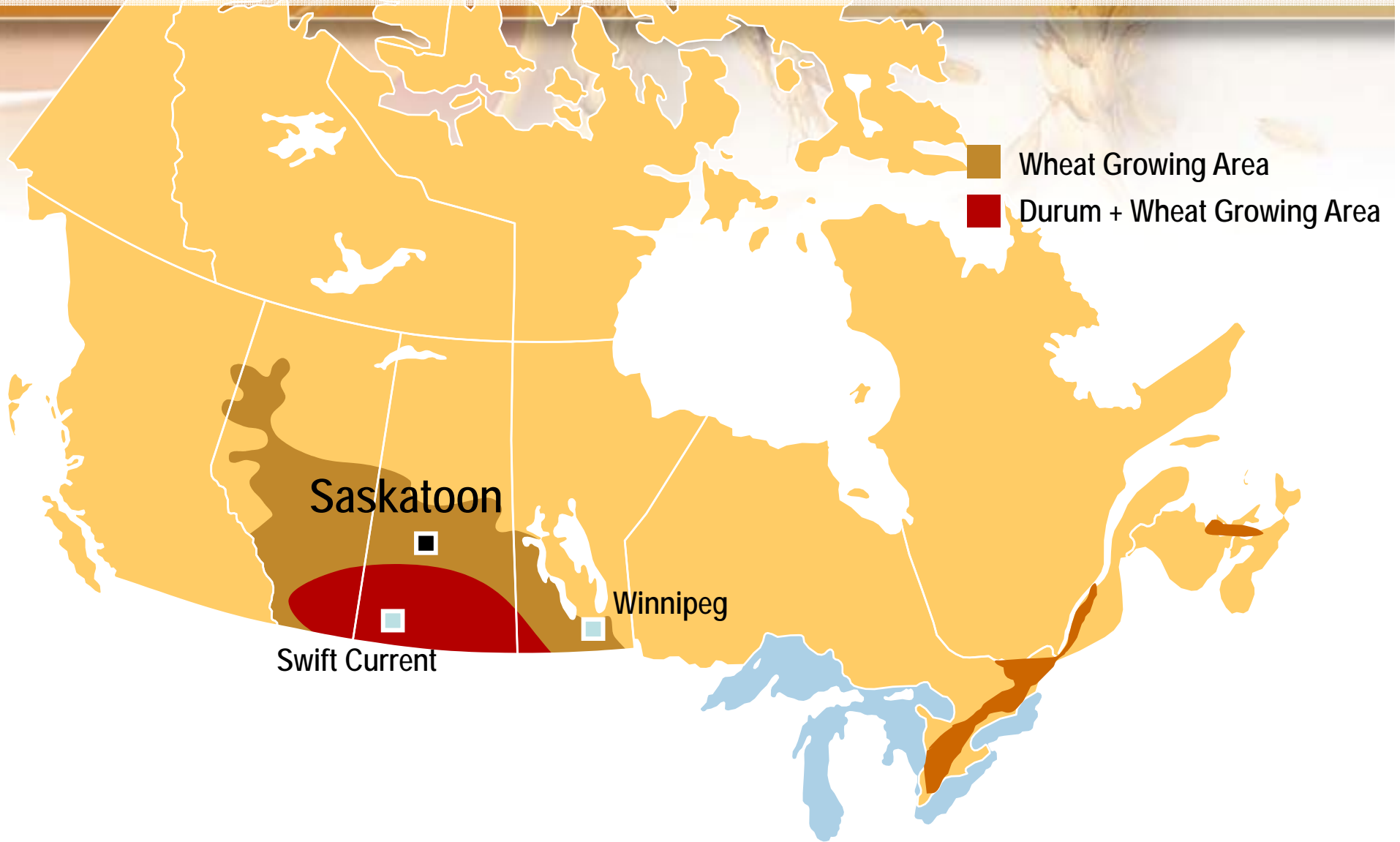
Outline

- Market classes of wheat: production size and value
- Mechanism to release cultivars for production
- Specifications for new cultivars
- Doubled haploid (DH) cultivars by market class and impact
- Marker Assisted Breeding (MAB)
- Combined MAB and DH technology
- Next steps

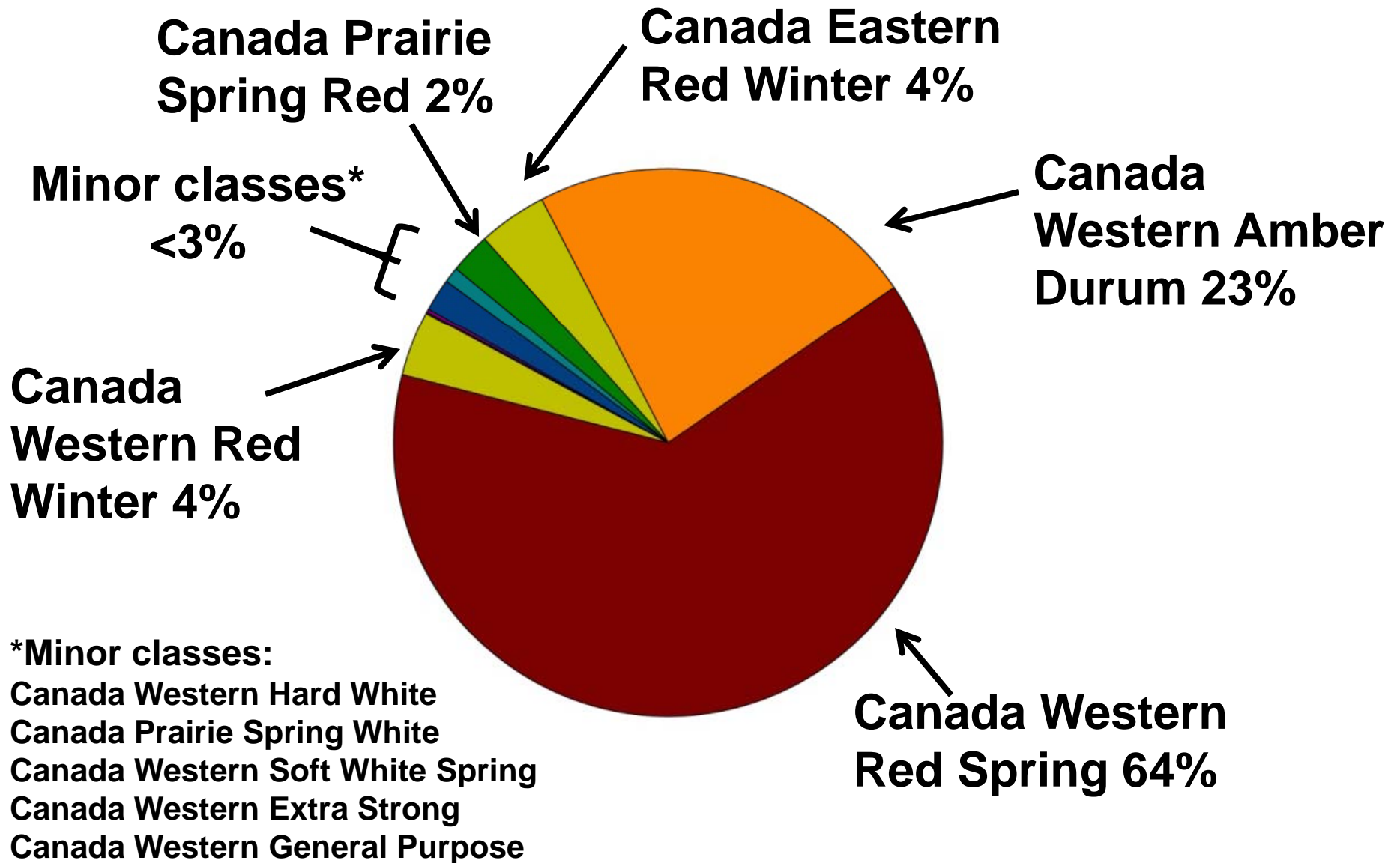
Canada in the World

- Canada produces about 4% (25.8mmt) of the global wheat supply (646mmt)
- Canada accounts for about 15% of global wheat trade
- Canada produces about 12% (4.5mmt) of the global durum wheat supply (37.1mmt)
- Canada accounts for about 50% of global durum wheat trade.

Wheat Growing Regions of Canada



Market Classes Production and Approximate Value



Procedure to Release a Cultivar

- Specifications of agronomic performance, resistance to diseases and insects, and possess appropriate end-use suitability of a market class.
- Experimental lines are compared to “registered” check cultivars.
- Experimental line must meet “merit” criteria relative to check cultivars each of three consecutive years which is determined by a committee of experts.
- Cultivar is registered by the Canadian Food Inspection Agency.
- Market rights awarded to a seed company.

Specifications for a New Cultivar

- Value for cultivation
- Performance attributes
- Resistance to biotic stresses:
 - Diseases: Fusarium head blight, leaf and stem rust, bunt, loose smut, leaf spots
 - Insects: sawfly, midge
- Resistance to abiotic stresses:
 - Seedbed, pH, nutrient deficiency, nutrient toxicity
 - Water deficit, excess water
 - High temperature stress, Low temperature stress
 - Preharvest sprouting

Attributes of Market Classes and End-Products

Market Class	Products	Protein		Kernel
		Quantity	Quality	Hardness
CWRS 13.5, CWHW 13.5	blending, bread, noodles	high	strong	hard
CWRS 12.5, CWHW 12.5	bread, noodles	medium	strong	hard
CWRS 11.5, CWHW 11.5	bread, noodles	medium	medium	hard
CWRW, CPS_red, CPS_white	French, Brazilian, Arabic breads, steamed buns, chapaties, "filler" wheat	medium	medium	medium
CWES	frozen dough, "carrier"	medium	extra strong	hard
CWSWS	confectionary	low	weak	soft
CWAD	pasta,	medium	strong	hard
CWRW, CPS_red, CPS_white	French, Brazilian, Arabic breads, steamed buns, chapaties, "filler" wheat	medium	medium	medium
CWES	frozen dough, "carrier"	medium	extra strong	hard
CWSWS	confectionary	low	weak	soft
CWAD	pasta, couscos	medium	strong	hard

Doubled Haploid Technology and Cultivars

- DH methods have been integrated into cultivar development programs for about 20 years
- Since 1997, 25 DH cultivars registered in 7 market classes
- 23 DH cultivars developed by maize pollination of wheat ovules
 - (Knox et al. 2000 Plant Breeding 112:289-298) .
- Two cultivars developed by anther culture
 - (Orshinsky and Sadasivaiah 1994 Plant Science 102:99-107)
- Currently all Canadian DH programs use maize pollination and dicamba

Canada Western Red Spring Market Class

- 64% of total area planted to wheat
- Renowned for milling, rheological and functional properties
- Quality parameters are exceptionally stringent
- Traded internationally at highest average price of hexaploid wheat

Canada Western Red Spring Market Class

- McKenzie (1997) first doubled haploid cultivar in Canada, anther culture
- 12.7% more grain than highest yielding check and similar protein concentration
- *Lr21*, resistance to all North American races of leaf rust
- 9% was maximum area planted
- Parent of 5 of 43 CWRS cultivars released since 1997

Canada Western Red Spring Market Class

- Superb DH (2001) higher grain yield, maximum area seeded 19%, parent in 5 new CWRS cultivars, all DH's

Canada Western Red Spring Market Class

- Lillian DH (2003) resistance to wheat stem sawfly
- Higher grain yield
- *Gpc-B1/Yr36, Lr34/Yr18,*
- Most widely grown CWRS cultivar 2007 to 2009.
- **First widely grown cv to deploy *Gpc-B1*

Comparison of Lillian with *Gpc_B1* to highest yielding check (Mean 31 trials 3yr)

Cultivar	Yield Kg ha⁻¹	% check	Grain Protein %	Maturity (days)	Density Kg hL⁻¹	Seed size (mg)
Lillian	3594	102.4	14.9	101.5	79.5	33.9
AC Barrie	3509		14.6	101.2	80.6	34.2

DePauw et al. (2005) Can. J. Plant Sci. 85: 397 - 401.

Summary DH in Canada Western Red Spring Market Class

- Since 1997, 10 of 43 CWRS cultivars are DH
- 10 of 25 DH cultivars are CWRS
- Past 4 yrs >30% of CWRS acreage seeded to DH cvs
- Doubled haploid technology accelerated introduction of new traits:
 - CDC Abound resistance to imidazolinone herbicide
 - Carberry and Waskada improved resistance to Fusarium head blight
 - Shaw resistance to midge
 - Parents of 3 recently registered CWRS cultivars were DH's from germplasm development projects

Doubled Haploid Cultivars in Other Market Classes

- Canada Western Hard White Spring
- White seed with quality similar to CWRS and has preharvest sprouting resistance
- Entirely based on DH's cultivars:
 - Snowbird (2000),
 - Kanata (2000),
 - Snowstar (2006)

Doubled Haploid Cultivars in Other Market Classes

- Canada Western Soft White Spring
- Confectionary products
- AC Andrew (2001) anther culture, 15% higher yield than highest yielding check, plus improved resistance to Leaf rust, Stem rust, powdery mildew
- Grown on >95% of CWSWS area 2007-09

Doubled Haploid Cultivars in Other Market Classes

- Canada Western Extra Strong (CWES)
- Very strong gluten, frozen dough products, “carrier” of weaker gluten flour
- Burnside (2004) equal yield, 0.9 units more protein, 2 days earlier maturity
- Grown on 36% of seeded CWES area in 2009

Doubled Haploid Cultivars in Other Market Classes

- Canada Western Red Winter Wheat
- W434 (2010) grain yield equal to highest yielding check, plus higher protein, earlier maturity, shorter stronger straw, improved resistance to leaf rust, stem rust, common bunt, powdery mildew

Doubled Haploid Cultivars in Other Market Classes

- Canada Western General Purpose: intended as feedstock for livestock and ethanol sectors
- First DH registered in 2008 and 4 of 5 cultivars registered since then are DH

Doubled Haploid Cultivars in Other Market Classes

- Canada Western Amber Durum (pasta, couscous)
- DT801 (2010), first doubled haploid durum in world?
- 2.7% more yield than highest yielding check, higher grain protein, more desirable yellow pigment, reduced cadmium uptake, improved resistance to fusarium head blight

Marker Assisted Breeding

- Number of useful traits closely linked to molecular markers has increased
- DNA- based marker technologies have improved in cost effectiveness, repeatability, ease of use, and through put
- Now routinely use in wheat cultivar development
- Combined with doubled haploid technology
- F1 generation used to make haploids
- Markers applied to haploids prior to doubling

Cultivars developed by MAB

Market Class	Name	Year of Release	DNA marker for gene and trait
CWRS	Lillian	2003	<i>Gpc-B1/Yr36</i>, protein
CWRS	Somerset	2004	<i>Gpc-B1</i>, protein
CWRS	Goodeve	2007	<i>Sm1</i>, midge resistance
CWES	Burnside	2004	<i>Gpc-B1</i>, protein
CWES	Glencross	2008	<i>Gpc-B1</i>, and <i>Sm1</i>
CWAD	Brigade	2008	<i>Cdu1</i>, cadmium uptake
CWAD	Verona	2008	<i>Cdu1</i>, cadmium uptake

Impact of Traits Selected by MAB

- *Gpc-B1/Yr36* (Pro \$15m + Yld \$48 = \$63m)
- *Sm1* (Yld \$19m + Grade Protection \$21m = \$40m)
- *Cdu1* (market access)
- *Lr21, Lr34, Lr22a* (maintained in cultivars)
- *Fhb1, fhb2, fhb5A* etc

Current and Future

- *5QTL's FHB, Lr21, Lr34, Sm1*
- Continual marker validation activity
- **Whole genome selection MAB**
- Somers et al. (2005) Theoretical Applied Genetics. 111: 1623 - 1631.
- **ICIS data management tool**



Conclusions

- Doubled Haploid technology
- Cultivars, traits, rate of genetic progress, adoption
- High value to farmers
- Marker Assisted Breeding
- Cultivars, traits, rate of genetic progress, adoption
- High value to farmers
- Future: Integration of MAB, DH technology, ICIS

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