Canada *in the* Big Picture

Updated for 2004 Wheat Breeding Report

Inside:

- Today's world of wheat breeding
- Key trends and issues
- Breeding highlights
- Class-by-class updates

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New updates for 2004: This *Wheat Breeding Report* was originally produced in 2003, with technical review assistance from the wheat development experts listed on the back page. Variety lists and other key information have been updated for 2004, with technical review assistance from appropriate sources. Sections that include updated information are highlighted with the UPDATED symbol.

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Canadian wheat breeding *in the* Big Picture

International trade and marketing. Global business. The future of Prairie growers. Wheat breeding is ground zero in the chain crucial to the success of Canada's wheat industry and the producers within it.

For many in the wheat industry, discussions of the future inevitably turn to the latest debates on economics, marketing and policy. But when it comes to wheat as a product – one that ultimately provides the foundation for producer livelihoods and the industry's success – the world of wheat breeding research is perhaps the best crystal ball.

Breeding developments in the past were relatively slow and predictable, but today they are unquestionably a major driving force.

Farmer needs, consumer demands, market competition and social issues all funnel into the strategies of wheat breeders charged with developing the wheat varieties that will anchor Canada's success in the future.

The new varieties they develop today will fill Prairie fields over the next decade. How they stand up to major pests such as Fusarium Head Blight (FHB) and wheat midge, how they compete with new wheats from Australia and the U.S. and how they meet the increasingly sophisticated requirements of new markets will all directly impact producers' pocketbooks and the success of the industry.

In many ways, wheat breeding represents a quiet revolution in the impact of science on the industry – one that's growing increasingly louder. Breeding developments in the past were relatively slow and predictable, representing incremental improvements, but today they are unquestionably a major driving force.

Take the advances of the past decade alone. Yield potential is up 10 to 20 percent. Varieties carry multiple resistance to major diseases and pests. Western Canada has broadened and strengthened its portfolio of classes with high-quality wheats tailored to market niches around the globe. Advances in breeding have caused flip-flops in the leadership positions of Canada and its competitors in many key markets, and at the same time have opened new opportunities.

Meanwhile, the major issues surrounding wheat development – from who will control crop genetics to the role of biotechnology – have landed squarely at the centre of public debate, with fundamental implications for the future of food production, both as a business and as a necessity of life.

For farmers, what happens in wheat breeding carries added weight as a major investment. Since 1993/94, wheat growers in Western Canada have invested $3 million annually in wheat breeding programs in Western Canada through the Wheat Check-off Fund administered by Western Grains Research Foundation. This funding has doubled wheat breeding activity in the region and supports many of the new wheat varieties now emerging from the breeding pipeline – varieties that will be showcased in many of next summer's plot tours. The Check-off Fund is just one example of farmers taking a major role in wheat research worldwide.

This special *Meristem Land and Science Wheat Breeding Report* is a perspective on today's world of wheat breeding in Western Canada. It is produced for everyone from farmers and industry to consumers and the general public. The Report looks at key trends and issues, the role of farmers in research funding, the big developments in breeding and new varieties on the way, along with a short course on wheat breeding and the variety registration system.

Western Grains Research Foundation

Sponsored by Western Grains Research Foundation, in the interest of informed producer investors in wheat and barley breeding research. Visit the Foundation Web site, **www.westerngrains.com**, throughout the year for extensive, updated information on wheat and barley breeding progress.

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The Breeding Network

More activity, more players and a strong role for farmers.

Every year brings new faces and ideas to the world of wheat breeding. In Western Canada, public research institutions remain the dominant breeding programs, but private programs have risen greatly in prominence and are making a substantial mark.

Public programs hold strong

A look at Canadian Wheat Board variety surveys in recent years shows the University of Saskatchewan's Crop Development Centre and Agriculture and Agri-Food Canada institutions holding strong as the major developers of Western Canada's wheat varieties. Judging by what's in the pipeline, farmers can expect continued strength from these programs in the future, along with greater contributions from young programs such as the University of Manitoba and the University of Alberta. For years, Saskatchewan Wheat Pool ran the only major private breeding program in the region, which produced significant varieties. However, this program was shut down several years ago, with early generation populations phased into the University of Saskatchewan Crop Development Centre program.

The multinationals have arrived

The first major Canadian wheat breeding program run by a private multinational company arrived in 2000, with Monsanto Canada Inc.'s crop development centre, which focuses on using biotechnology to transfer genes into improved wheat varieties. The facility is a partnership between Monsanto, the Province of Manitoba and the University of Manitoba. Monsanto has collaborated with Agriculture and Agri-Food Canada's Cereal Research Centre on campus to develop a wheat variety with built-in tolerance to its Roundup herbicide.

Boost in private breeding

Companies such as Agricore United, AgriPro Wheat and World Wide Wheat are running breeding programs specifically aimed at Western Canada, which illustrates the major boost in private breeding over the past five years. In fact, the most recent CWB survey shows major acreage gains by privately-developed varieties. This trend is expected to continue. For example, one very promising wheat line currently in the breeding pipeline – expected to become a major acreage leader in the next several years – was developed by Agricore United/Proven Seed.

U.S. programs looking north

More foreign breeding programs are also targeting registration of their varieties in Western Canada. Most notable in recent years has been North Dakota State University, which partnered with Canterra Seeds in a failed attempt to get its Fusarium-resistant Alsen variety registered in Canada. Other U.S. programs, such as the University of Minnesota, Western Plant Breeders of Montana, AgriPro Wheat and World Wide Wheat, are paying more attention to the potential north of the border. Scattered programs from as far as Europe and Australia have also shown interest, though no varieties of significance have been registered.

Steady rise in non-public funding

The funding picture shows far more private impact in breeding. This shift began in the mid-1980s, when declining public funding for wheat breeding threatened the viability of the public system, driving an effort to attract more outside funding. This trend has risen steadily and the result today is much greater outside funding support in public wheat breeding, by everyone from farmers to private industry.

Farmers emerge as big funding players

By far the biggest funding partners in public wheat breeding are western wheat producers, who began supporting the breeding effort through the Wheat Check-off Fund started in the 1993/94 crop year. Farmer funding now accounts for approximately 25 percent of the operating budget of the key public programs, This farmer funding has resulted in double the breeding activity.

Swell in private funding

Along with Saskatchewan Wheat Pool, companies such as Agricore United, AgriPro Wheat and World Wide Wheat are funding wheat breeding in Western Canada, as are a growing number of organizations. Ducks Unlimited, which is supporting winter wheat breeding, and hog producers, who are supporting feed wheat breeding, illustrate the diversity of the new industry players in funding.

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The Growing role *of* Farmers

Producer investment has revitalized wheat breeding in Western Canada – part of a growing trend around the world. New breeding agreements will set the stage for the next generation.

Producers re-energize wheat breeding in Western Canada

Farmers have emerged as big funding players in wheat breeding throughout the world, and Western Canada is no exception. The region's major farmer-funded effort has doubled breeding activity and given producers significant equity in the genetics of their crop.

Wheat producers in Western Canada support research through the Wheat Check-off Fund, administered by the farmer funded and directed Western Grains Research Foundation. This Check-off funding - over $3 million allocated annually - has made a dramatic impact on breeding programs. By building on the substantial public investment already in place, wheat breeding activity has more than doubled across the region. Because the Check-off qualifies as industry funding, it is eligible for programs such as the federal Matching Investment Initiative, which essentially doubles the farmer investment by supporting complementary research on a dollar-for-dollar basis. Other key matching funds include those from the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Alberta Agricultural Research Institute (AARI). Over 80 percent of Check-off funding is matched annually, drawing roughly an additional $3 million for research.

The Wheat Check-off Fund is set at $0.20/tonne, deducted only from Canadian Wheat Board final payments to producers. Farmers have the option to participate and currently over 90 percent of producers support the Check-off. A new development means a tax credit is available to producers for the portion of their annual Check-off investment that goes to research.

Investment pays dividends, builds equity

The major return on farmers' investment is only now churning out of the breeding pipeline, since breeding a new cereal variety and bringing it to market takes roughly seven to 12 years. But clear breeding improvements have already emerged.

- Higher yields – 10 to 20 percent greater than a decade ago
- Stronger, multiple disease and pest resistance
- Specialized agronomics for a wide range of soil and climate zones
- Potential new classes of hard white wheat and extra-strong durum
- Higher and more tailored quality for a range of markets in all wheat classes
- Ongoing progress toward Fusarium Head Blight resistance
- Many other advances, which are detailed in the breeding overview section of this report

The Check-off Fund investment has also given farmers significant equity in wheat genetics and a say in breeding direction. The strongest signal of this are the plant breeding royalties that have started to stream back to the Foundation, based on a percentage of royalties breeding programs receive on sales of farmer-funded varieties. The Foundation is re-investing these funds into the originating breeding research programs.

Breeding agreements set stage for new progress

While the strongest breeding progress supported by the Wheat Check-off Fund is only beginning to surface, the next generation of farmer-funding is fast approaching. Check-off funds are currently allocated based on 10-year agreements with breeding institutions that outline breeding targets and other funding details. These agreements are set to expire at the end of 2004 and preparations are underway to develop new agreements to begin in 2005. (For full, updated information on Western Grains Research Foundation, the Wheat Check-off Fund and farmer-funded breeding progress, visit **www.westerngrains.com**.)

Global farmer-funding programs raise the bar

The scale of farmer funding rises on the world stage. Canada's competitors, such as Australia, the United States and the European

Union, all have extensive public wheat breeding efforts supported by farmers, and several are significantly out-funding Canada.

Australia leads the pack. Approximately 50,000 Australian grain growers support research through a mandatory levy on wheat, barley, canola and other crops. This system was initiated by growers and is co-ordinated by the Grains Research and Development Corporation (GRDC). The Australian government matches producer investment to a set ceiling. Australian farmers are now contributing more than the federal government, and royalties from research the GRDC has helped fund are beginning to positively affect GRDC finances. This means the GRDC has now surpassed the $100 million mark in its budget, with the vast majority of those funds directed toward research.

Britain sets tone for Europe. The major grain-producing nations of Europe support research through check-off style systems. A leading example is Britain, where the British Society of Plant Breeders administers a direct farmer check-off on cereal varieties at the seed cleaning level. Farmers pay a royalty rate per tonne on certified and farm-saved seed and the money goes directly to research. British producers contribute roughly $46 million annually to breeding programs for various crops, with the majority going to cereals research.

U.S. keeps pace. American farmers are using check-offs to fund market development work and research they view as a critical component of staying competitive and providing customer demands. Growers in key grain states support breeding and other initiatives through several farmer check-offs on wheat, including those in North Dakota, Montana, Colorado and Kansas.

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Key issues *in* wheat development

A snapshot of what's shaping the big-picture agenda.

Who will breed and who will pay?

Traditionally, wheat breeding has not been lucrative enough to attract much private interest. But this is changing significantly with the new potential opened up by biotechnology and a greater awareness of intellectual property rights. Both have increased the potential return on investment in wheat breeding programs, which is likely to continue attracting new players in breeding and funding. While no major shifts are expected in the short-term, the rapid evolutions of science, agriculture and business leave the long-term possibilities wide open. One thing is certain – those involved on both the breeding and funding side will have a major say in setting the agenda for the future of the crop.

With major issues such as genetic ownership rapidly approaching, a major benefit for farmers is the equity stake gained through the direct funding of research. This position gives them significant leverage in determining how genetic material and varieties developed by farmer-funded programs are managed.

Changes to the variety registration system

The Canadian Food Inspection Agency (CFIA) is almost finished its large-scale review of Canada's variety registration system, and is preparing to move forward as early as late 2004 with a proposal for significant restructuring. The process had been slated for earlier completion, but was placed on hold to await the completion of a broad, industry-driven Seed Sector Review.

The variety registration review, which has included an extensive stakeholder consultation process, has been ongoing since the fall of 1998. Over the intermediate period, stakeholder views have evolved, as have CFIA proposals in response to those views. The CFIA's most recent regulatory proposal, issued in 2002, is available on the CFIA Web site, **www.inspection.gc.ca**.

For wheat stakeholders, the heart of debate surrounding this review had been a recommendation in CFIA's original proposal to remove agronomic merit as a requirement for variety registration of key crops such as wheat and barley. However, under the latest 2002 draft proposal, a new "Schedule A" crop category was created to uphold merit assessment for agronomics as a requirement for western wheat and barley varieties.

While the CFIA has yet to develop a final proposal to move forward with, it has identified a number of key areas of consensus. The include the need to: maintain merit and/or performance testing requirements, where needed; maintain a capability to deal with consumer confidence, especially in health

and safety issues; increase the flexibility and responsiveness of the existing rule making process; and strengthen existing consultative structures.

Further information on the future of wheat variety registration is available at **www.meristem.com**, in the *Meristem Land and Science 2004 PRRCG Report*. The Report is delivered out of the Prairie Registration Recommending for Grain (PRRCG) annual meeting.

Genetic ownership

Few issues are more understandably emotional than genetic ownership, particularly when what is "owned" is a life form or food source. Wheat has remained on the fray of the debates around genetic ownership; the spotlight has focused on more biotech-oriented crops and broader realms such as human medicine, but the same issues are fast approaching.

Can crop life be patented? Who should control access? Where is the line drawn on equity and ownership in genetics? What's the threat to innovation? These questions and countless others will be addressed over the next decade, and will have wide-ranging implications.

In wheat, two trends have led to an increasing focus on the ownership of genetics. The first is the progression of intellectual property rights, which makes genetics and plant breeding in general more lucrative. The second is the advancement of biotechnology, which allows researchers to identify and potentially patent novel genes and genetic techniques. As a result, there's concern among many in the wheat breeding community that access to germplasm – the genetic raw material of breeding programs – will become more limited. This is expected to further increase as crop genetics become more lucrative and competition intensifies. Ultimately, patents and other forms of ownership may lead to a new playing field where sharing is still common, but done in a more controlled business environment, where the focus shifts to healthy competition and partnerships that would stimulate access, innovation and protect the public good.

The GMO debate

The debate surrounding genetically modified organisms (GMOs) is complex, and how this issue evolves will undoubtedly affect the wheat industry and farmer incomes. For scientists and many others in the industry, a major source of frustration is the potential for this issue to be hijacked by non-science-based decision-making. It's a classic battle of science vs. emotion, fact vs. misinformation and the struggle of science to find direction amid the backdrop of diverse political, business and social interests.

The definition of a "GMO" is itself hotly debated, and the rhetoric on both sides of the pro and anti-GMO forces makes it difficult for the public and the countless interest groups within it, to make informed decisions. For many wheat breeding institutions, the bottom line for GMOs is market acceptance – it simply doesn't make sense to introduce a GMO wheat unless it makes good business sense and won't unduly risk markets for conventional wheat. As a result, much of the future for GMO wheat hinges on the evolution of public opinion both at home and abroad.

At the same time, it's impossible to ignore the tremendous potential in GMO crops, and this is what the wheat research community is cautiously exploring. The most advanced GMO wheat line is Monsanto Canada Inc.'s Roundup Ready wheat, currently in advanced pre-registration testing. Researchers are also exploring other opportunities. Still, factors external to breeding are likely to decide whether and when any products from these efforts become commercially available.

For the industry, the obstacles include practical ones such as pressure on the handling system to segregate GMO varieties. Pressing questions include what degree of purity will be required and who will pay the cost of segregation. On the consumer front, the public perception of GMOs may improve as benefits emerge that are more related to health and nutrition.

Pressure on Canada's grain handling system

The steady drumbeat toward diversification and class-or-variety-specific markets bodes well for Canada's market success, offering a wide portfolio and the flexibility to meet tailored customer demands. But it also poses major challenges for the grain handling system.

With seven wheat classes and counting, additional specialized varieties and markets, and the prospect of GMO wheat, the requirements for efficient, quality-guaranteed handling are rising dramatically.

Enter the next generation of wheat quality assurance. Canada's quality assurance system for wheat has long relied on Kernel Visual Distinguishability (KVD) as a segregation tool. Different classes of wheat are bred to have features that make them distinguishable by the human eye, providing the basis by which different classes of wheat are kept separate in the grain handling system. But increasingly, relying on KVD as a segregation tool is proving inadequate to uphold the system's integrity and to meet a broader array of farmer and market demands.

Under a segregation system based on KVD alone, visually indistinguishable, non-registered varieties of wheat have potential to compromise the Canadian quality assurance system if they are misrepresented. This can cause significant financial losses for grain handling companies and marketers, which can

work its way back to producers. KVD also limits the ability of plant breeders to rapidly incorporate improved disease resistance, agronomic and quality characteristics into new wheat varieties, and it can impede the handling of non-milling wheats, such as high yielding feed varieties or wheat used for industrial purposes such as ethanol production.

Several players in the industry have worked to develop a more sophisticated alternative to the current KVD system. In one major recent effort, the Canadian Grain Commission (CGC) developed and sought broad feedback on a proposal to use a Variety Eligibility Declarations (VED) system, to segregate grain in the handling system. The CGC concluded that the benefits to producers and other industry stakeholders were not sufficient at this time to go forward with a government mandated VED system, but it would encourage the use of declarations in commercial transactions.

To continue progress on the issue, the CGC is now developing a new Wheat Quality Assurance Strategy, which involves several key elements: new technology for variety identification, increased variety monitoring and wheat class restructuring. More detail on this is available on the CGC Web site, **www.grainscanada.gc.ca**.

Grappling with Fusarium

Fusarium Head Blight (FHB) attacks all major grain crops, including wheat, barley, corn and oats. Damage appears in the form of sterile florets and poorly filled seed, resulting in lower grain yield and quality. Fusarium produces mycotoxins - of most concern, deoxynivalenol (DON) - which renders infected grain unfit for livestock consumption and other end uses.

With little in the way of control options, overall losses to Fusarium in Canada have ranged from $50 to $300 million annually since the early 1990s.

In wheat, the complexity of the disease and the lack of resistance sources has made for slow progress on the research front, but researchers have made important gains. There are a growing number of examples of wheat varieties with incrementally higher levels of Fusarium resistance, which, after years of breeding work, are now beginning to become available to farmers.

Breeding progress is made difficult in part due to the constraints of incorporating resistance traits from poorly adapted material, within the bounds of Western Canada's stringent quality requirements. For the future, molecular breeding and other innovative approaches promise stronger multi-gene resistance to both Fusarium and its mycotoxins.

Further information on FHB progress in wheat is available at **www.westerngrains.com,** in the February 2004 edition of the WGRF *Industry Report* newsletter. The newsletter features an overview of the 3rd Canadian Workshop on Fusarium Head Blight – Canada's major scientific session aimed at finding FHB solutions.

Seed Sector Review

Canada's seed sector is undergoing a major review and strategic planning process, expected to wrap up in summer 2004.

The review is a broad assessment of the Canadian seed sector and Canada's seed regulatory environment in the global context. It was initiated based on a submission put forward by the Canadian Seed Growers Association (CSGA), the Canadian Seed Institute (CSI), the Grain Growers of Canada (GGC) and the Canadian Seed Trade Association (CSTA).

Among the review's more specific purposes is a goal to generate consensus on challenges facing the sector and on options for facilitating constructive change, with a key area of focus being the regulatory framework and related systems. The review aims to develop recommendations for the structure of the CFIA's regulatory scheme and for priorities for regulatory change.

It's been about 20 years since the seed program of CFIA was thoroughly reviewed. Since that time, pressures on the program have evolved significantly with changes to the industry environment. Along with new players in the system, there are important changes in science and technology, in the operations and demands of markets and in the expectations of consumers.

Key result areas identified it as essential to the future of the seed industry include: regulatory flexibility and timeliness; positive environment for science and innovation; profitability of the sector; and consumer acceptance and confidence. A top priority for addressing these concerns is improving the sector's capacity to respond rapidly to new innovations and market signals.

Further information the Seed Sector Review is available at **www.meristem.com**, in the *Meristem Land and Science 2004 PRRCG Report,* and at the Seed Sector Review Web site, **www.seedsectorreview.com**.

Plants with novel traits (PNTs)

The genetically-modified organism (GMO) issue has spawned a second three-letter acronym that is rapidly becoming just as infamous in the Canadian crop research community. Plants with Novel Traits, or "PNTs," is the term coined in new federal regulations governing the registration of new plant varieties.

The regulations are partly in response to the controversy over GMO crops. Rather than focus on the method used to introduce traits, which is how GMOs are defined, Canada has chosen to focus on the actual traits expressed. Under this broad definition, PNTs may include everything from plants produced by mutagenesis or recombinant DNA techniques, to those produced by conventional breeding.

Once labelled a PNT, plant lines are subject to more intensive tests, such as those falling under the auspices of Health Canada and the Food and Drugs Act. This raises concerns in the barley community that lines bred conventionally may be subject to PNT testing, which could add cost, stifle innovation and give the plants a stigma associated with GMOs. Overall, a chief concern is that Canada has chosen a unique path that is out of step with how others are approaching the issue worldwide - a position some argue places Canada at a competitive disadvantage.

The players

The major wheat breeding programs in Western Canada (in random order)

University of Saskatchewan Crop Development Centre, Saskatoon (U of S)
Breeding programs include Canada Western Red Spring, Canada Western Extra Strong, Canada Western Hard White, Canada Western Amber Durum, Canada Prairie Spring, Canada Western Red Winter, feed and specialty wheats. Programs concentrate on varieties for growing regions in Saskatchewan, with a special emphasis on northern regions.

Agriculture and Agri-Food Canada (AAFC)
The AAFC wheat breeding network includes several major research institutions across the Prairie.

Semiarid Prairie Agricultural Research Centre, Swift Current. Breeding programs include Canada Western Red Spring, Canada Western Amber Durum, Canada Prairie Spring, Canada Western Hard White and Canada Western Extra Strong. Programs focus on varieties for the semi-arid (warmer and drier) region of the Prairies.

Cereal Research Centre, Winnipeg.
Breeding programs include Canada Western Red Spring, Canada Prairie Spring, Canada Western Extra Strong, Canada Western Hard White and "ultra-high-yielding" feed wheat. Researchers focus on varieties for the eastern prairie, which means a heavy emphasis on resistance to plant diseases and lodging, and varieties for the northern prairie, which requires early maturity and good maintenance of quality in the field.

Lethbridge Research Centre. Breeding programs include Canada Western Red Winter, Canada Western Soft White Spring and Canada Western Hard White. The winter wheat program has a regional mandate, while the soft white program concentrates on the crop's traditional growing area in irrigated southern Alberta. The objective of the new Canada Western Hard White wheat program is to develop cultivars with end-use quality similar to that of CWRS, with high-yield potential and built-in genetic resistance to diseases.

University of Manitoba, Winnipeg
University of Manitoba breeding programs include Canada Western Red Winter, Canada Western Red Spring and Canada Western Extra Strong. Programs focus on the transfer of tan spot resistance and the development of Fusarium Head Blight-resistant germplasm.

Agricore United and AgriPro Wheat
The largest private wheat breeding program in Western Canada is a joint venture between Agricore United and AgriPro Wheat, which began in 1988. This effort, based largely in Rosebank, Manitoba, targets Canada Western Red Winter and Canada Prairie Spring varieties. U.S.-based AgriPro Wheat has bred wheat for the past 30 years, and claims the largest private wheat germplasm collection in North America.

Monsanto Canada Inc., Winnipeg
The wheat breeding program at Monsanto's crop development centre focuses on using biotechnology to transfer genes into improved wheat varieties. Monsanto has worked with Agriculture and Agri-Food Canada's Cereal Research Centre to develop a potential wheat variety with built-in tolerance to Monsanto's Roundup herbicide.

University of Alberta, Edmonton
The cereal research program concentrates on finding desirable genes for specific traits beneficial to Parkland zone wheat crops. Wheat producers in this zone are challenged by a shorter growing season and cooler temperatures, and often have greater precipitation than most wheat growing areas of the Prairies. Key emphases are early maturity and strong straw.

Alberta Agriculture, Food and Rural Development, Lacombe
The breeding program focuses on winter wheat and adaptation to the northern prairies, particularly the Central Parkland and Peace River regions of Alberta. Key emphases are cold tolerance, straw strength and resistance to powdery mildew.

UPDATED

The road *beyond* Avonlea

New varieties with stronger gluten will raise the bar on Canada's signature durum class.

Canadian durum breeders are boosting gluten strength in conventional durum varieties to make the grain more attractive to pasta makers. The first variety registered in this mould is DT712, which marketers and breeders alike are touting as a worthy successor to Kyle and AC Avonlea.

The world market for conventional amber durums in the stream of DT712 and AC Avonlea is expected to hold steady over the next several years, says Graham Worden, Senior Manager of Technical Services with Canadian Wheat Board (CWB) market development. The current market calls for about 4.2 million tonnes, and that's expected to increase to about 4.6 million tonnes by 2007. "I don't see the conventional market suddenly jumping to six million tonnes or dropping to two million tonnes," says Worden. "It will remain fairly steady."

Improved conventional varieties such as DT712 are expected to solidify Canada's market share over this period, says Worden. "DT712 is an excellent variety for Canadian farmers with good yield and a good agronomic package, and it has improved quality which will appeal to our customers. It should have just an excellent fit with everyone."

Yet-to-be-named DT712 represents the future of conventional Canadian durum, says breeder Dr. John Clarke.

Strength key to future of class

From a class and market perspective, the higher gluten strength of DT712 is the variety's key feature, he says.The variety is representative of where Canadian marketers and breeders have envisioned taking the conventional durum class in recent years.

Along with higher gluten strength than AC Avonlea, the variety features highly desirable lower cadmium content, seven percent higher yield, similar high protein, slightly higher test weight and a similar disease profile. It is well adapted across the Prairies.

"This variety marks a new chapter in durum breeding in Western Canada," says Dr. John Clarke, durum breeder at AAFC Swift Current and developer of DT712.

Low cadmium breakthrough

Along with strength, another key characteristic of DT712 is low cadmium uptake, says Clarke. The variety is the first in a series of durum cultivars on the way that combine this trait with high yield and a solid agronomic and quality package. Low cadmium varieties are targeted to meet an expected move toward lower international standards on cadmium levels. The new standards will assure pasta manufacturers and consumers that products made from Canadian durum are healthy and safe.

"We've now selected for the low cadmium trait in DT712 and in the most promising new lines of durum now in co-op trials, so we're confident the low cadmium hurdle has been crossed," says Clarke. "Our efforts will now focus on further agronomic and quality improvements in the next generation of varieties."

UPDATED

The fight against Fusarium

The battle has proven long and difficult, but researchers are making steady progress.

What happens when you cross a wheat variety from Canada with one from Brazil?

Dr. Gavin Humphreys holds up a photo that shows the answer – a muddle of uneven stands, peppered with tall, downy cultivars that look completely foreign to the uniform golden wheat that normally fills Prairie fields.

It's no joke for eastern Prairie farmers, whose hopes for wheat with resistance to Fusarium Head Blight (FHB) rest largely on exotic wheat sources. The unwanted characteristics are what Humphreys calls "linkage drag," the weaknesses that are inevitably brought in when breeders make crosses between adapted Canadian wheats and exotic varieties.

For the AAFC Winnipeg wheat breeder, the photo illustrates the biggest hurdle researchers face in trying to develop Fusarium-resistant varieties. Since the only identified sources of genetic resistance are found in obscure wheats from places such as China and, more recently, Brazil and Mexico, breeders must grapple with the difficulties of getting that resistance into lines with acceptable quality and agronomic characteristics for Canada.

It's been a tough battle, says Humphreys, but new advances in genetic sources, breeding methods and screening are steadily overcoming those obstacles.

Resistant varieties on the way

The 2004 Prairie Registration Recommending Committee for Grain (PRRCG) meeting saw the emergence of a new CWRS wheat line, BW297, which represents a significant gain in FHB resistance for Canadian wheat. The PRRCG recommended the line for Canadian registration and the Canadian Food Inspection Agency is expected to approve this recommendation later in 2004 or in early 2005.

While not as resistant as the American variety Alsen, BW297 features greater resistance than AC Barrie, which is acknowledged to have highest resistance among current Canadian varieties. The Agricore United/Proven Seed line has been hailed as an excellent overall variety candidate that combined valuable FHB resistance for farmers with top market quality characteristics.

Other wheat varieties with incremental improvements in FHB resistance are expected over the next several years, and all Prairie breeding programs have further CWRS lines with improved FHB resistance in early generation testing.

Different class challenges

Among other wheat classes, durum has proven one of the spring wheats most susceptible to the disease, and no sources of resistance have been found in a durum genetic background. But breeders are turning to innovative breeding techniques to bring in resistance from spring wheat sources.

Winter wheat has managed to avoid the disease in eight of the past nine years, but the potential for major epidemics has breeders laying the groundwork for resistant varieties.

The next wave of resistant varieties will be easier to develop, says Humphreys. After years of breeding with exotic sources, there is now enough Fusarium resistance in North American source material to provide a pool for developing new lines. These newer lines are becoming the preferred sources of resistance because they carry fewer of the agronomic and quality detriments of the exotic sources and less adapted lines.

In Western Canada, researchers have established Fusarium-screening nurseries at Portage la Prairie, Winnipeg, Carmen and Minto, Man., and private research firms have also shown interest. Efforts such as this, along with continued national and worldwide collaboration, will help Canada overcome its most formidable cereal disease threat.

Further information on FHB progress in wheat is available at **www.westerngrains.com**, in the February 2004 edition of the WGRF *Industry Report* newsletter. The newsletter features an overview of the 3rd Canadian Workshop on Fusarium Head Blight – Canada's major scientific session aimed at finding FHB solutions.

UPDATED

Cutting down the wheat stem sawfly

This old wheat pest has returned with a vengeance. New solid-stemmed varieties will keep it out of wheat fields.

Wheat biologist Brian Beres remembers the first time he witnessed the devastation of the wheat stem sawfly. There was no sign of damage, no hint of the pest. Then the wind blew.

"We went out to this field in Southern Alberta. The producer was gearing up to go in and combine at the beginning of the week, when a severe windstorm hit over the weekend and toppled everything that was cut or girdled by sawflies. It was quite a sight – his whole field was about 90 percent cut."

That was five years ago, in a relatively isolated case, says the AAFC Lethbridge scientist. But in the past couple of years, producers have seen the high-water mark in a rising tide of sawfly damage across the Prairies. Estimates have put the level of sawfly-toppled wheat at 30 to 50 percent in at-risk areas throughout the heart of wheat country. The increasing damage and lack of control options has spurred a beefed-up research effort.

The focus of this effort is to develop solid-stemmed wheat varieties, says Dr. Ron DePauw of AAFC Swift Current. "Female sawflies insert their eggs into the hollow stem of the wheat plant, and the damage is caused by the larvae that feed inside the stem. By developing wheat with higher stem solidness, we can prevent the sawfly from inserting its eggs which reduces the chance of larval survival."

Solid stems reduce cutting

Already an important variety developed by DePauw's team, AC Abbey, is widely available to producers. "AC Abbey is not immune, but it helps reduce the sawfly population," says DePauw. Though this variety does not have a high degree of stem solidness, it has enough resistance to significantly reduce sawfly damage by over 75 percent compared to hollow-stemmed wheat.

A drawback is that AC Abbey produces up to 0.8 percent lower protein than newer hollow-stemmed wheat such as AC Barrie. Older solid-stemmed varieties such as AC Eatonia are also available, but carry a large yield penalty. "Traditionally, the solid-stemmed wheats have not yielded as well as the hollow-stemmed wheats – so there's an economic disadvantage to producers," says DePauw.

The researchers plan to overcome those obstacles. Several potential successors to AC Abbey are in development, with higher sawfly resistance and a better quality package. One of the first of these, the CWRS variety Lillian, was developed by AAFC Swift Current and registered in 2003. Already, it has been touted as a successor to AC Abbey as the sawfly-resistant wheat of choice. Its key advantage is higher protein potential than AC Abbey, with respectable yield and similar maturity to checks.

Multidisciplinary approach

For the future, Prairie researchers are pursuing a multidisciplinary team approach that covers all the major components needed to develop strategies to reduce sawfly damage over the long-term.

Along with agronomic and breeding components, a key aspect researchers are looking at is the effects of specific cultivars on sawfly population dynamics, in relation to weather and overwintering survival. "We have established that solid stem varieties produce smaller larvae and fewer females," says Dr. Hector Carcamo of AAFC Lethbridge. "We also know that there is less cutting in solid stems. The solid-stemmed varieties not only reduce the cutting in year one, but the population is further reduced over the following year, through reduced winter survivalship of the larvae and the reduced fertility of the females."

Another question researchers hope to answer is how far the sawfly moves, says Carcamo. "This will help us get a better idea of the potential for trap cropping, while supporting other risk assessment and control strategies."

Further information on sawfly resistance progress is available at **www.westerngrains.com**, in the July 2003 edition of the WGRF *Industry Report* newsletter titled "Farmer dollars cut down the wheat stem sawfly."

UPDATED

New wheat class *fits like* a white glove

Canadian breeders have developed the first varieties of the new Canada Western Hard White wheat class, which aims to preserve the same high quality of traditional hard red wheat while adding the higher flour extract, preferred colour and sweeter taste of white wheat.

Prairie farmers used to growing standard CWRS wheat should find a new wheat class known as Canada Western Hard White wheat (CWHW) fits their operations like a white glove, while at the same expanding Canada's portfolio for key markets.

"The quality characteristics and agronomics of hard white are basically the same as hard red wheat," says Dr. Gavin Humphreys, wheat breeder with AAFC Winnipeg. "In fact it is hard red spring wheat without the red pigmentation."

The main advantages of this type are higher flour extract for processors and a colour and slightly sweeter taste preferred by key markets, particularly Asia, he says. In many Asian countries where noodles are popular, white wheat is normally preferred because bran contamination (speckiness) is less evident, relative to red wheat. Where high extraction flours are used, white wheat can produce flours that are lighter in colour.

Introducing hard white wheat varieties will help Canada compete with Australia, which grows nothing but white wheats and is the world's leading hard white wheat exporter. The U.S has also shifted heavily into white wheats. The lucrative Japanese market is particularly partial to this hard white wheat, for both noodles and milling.

The bottom line is there's a significant upside and virtually no downside to shifting to white wheat, says Humphreys. When it comes to the CWRS quality type, markets are either neutral on seed colour or prefer white. Major western Canadian wheat breeding programs have typically shifted 20 to 40 percent of their efforts into hard white wheat, which many predict will take over from CWRS as the region's acreage and market leader over the next 10 to 20 years.

"It will take a few generations of Canadian varieties to meet the range of needs for end-use customers and get varieties adapted to the various growing areas of Western Canada," says Humphreys. "But the payoff is very promising"

First varieties hitting the field

Humphreys and colleagues, building on the pioneering work of Fred Townley-Smith, now retired, have developed the first two hard white wheats registered for western Canadian growers – Snowbird and Kanata. Both were first granted interim registration in 2001, to facilitate market testing, and Snowbird is currently produced as a premium priced, identity preserved (IP) crop under contract with the CWB

Snowbird was recommended for full registration approval in 2004 by the Prairie Registration Recommending Committee for Grain, which also recommended Kanata for an additional two years of interim registration. The Canadian Food Inspection Agency is expected to grant approval of these recommendations later this year.

Meanwhile, Humphreys and other wheat breeding colleagues, including Dr. Sadash Sadasivaiah at the AAFC Lethbridge Research Centre and Dr. Pierre Hucl with the University of Saskatchewan's Crop Development Centre, are working on new lines with improved agronomic and quality traits.

Strong market response

Premium world markets are demanding high quality hard white wheat for a range of products such as noodles and steam breads, says Graham Worden, CWB's senior manager of technical services, market development. Interest has also been promising on the domestic front, with Canadian millers showing strong interest in hard white wheat for both blending and solitary use.

Millers can get a higher level of flour extraction from white wheat because the white bran is hidden in the flour, Worden explains. When using hard red wheat, the red pigmentation often has to be removed or bleached first. If left as is, the red bran will leave red flecks in the flour. White wheats can produce products considered better looking and better tasting.

Looking to the future, there are two key goals for hard white wheat, say wheat experts. The first is to continue hammering

down quality targets. While CWRS quality has been the general target, marketers are looking to fine-tune CWHW quality based on customer feedback. The second, and equally important priority, is ongoing breeding progress to hit quality and other key targets. An important goal within this priority is to ensure farmers have a range of well-adapted varieties to choose from, so they can capitalize on white wheat's growing promise.

"The potential benefits are broad and extend to everyone in the supply chain," says Humphreys.

Biotech *adds speed and precision to* wheat breeding

The result is quick response to new challenges and superior varieties for farmers.

The extremes of biotechnology's potential are what make headlines, but for today's wheat breeders the advances in biotechnology simply mean practical tools to make the job of conventional wheat breeding more efficient and effective.

Doubled haploid technique – a short cut to true breeding lines

One of these tools is a technique called doubled haploid regeneration; it allows researchers to develop true breeding lines for field testing in just one generation rather than the roughly eight needed with traditional breeding methods. The technique can reduce the timeline for developing new varieties by as much as two or three years.

"A typical example is the variety AC Superb," says Dr. Stephen Fox, a wheat breeder at AAFC Winnipeg. "The breeder, Dr. Fred Townley-Smith, who developed this variety made his initial crosses in 1993, and with the speed added by the doubled haploid technique, AC Superb was formally registered in 2000 – eight years later. Had the breeder used only conventional techniques, the process might have taken 10 or 12 years."

The time savings can mean huge cost savings to the industry, as it allows faster response to disease epidemics and other challenges, says Fox. "You need only look at the damage that Fusarium causes to appreciate how significant it would be if we could deliver higher levels of Fusarium resistance two years faster."

Molecular markers – DNA fingerprints for rapid trait selection

Another powerful tool is molecular marker technology. Molecular markers are pieces of DNA that repeated analysis shows are closely linked to the presence of genes that control a specific trait, such as resistance to disease or winter hardiness. The advantage is that these markers are much easier to identify than the genes themselves, making them a powerful selection tool for breeders. Markers allow breeders to identify traits in the lab, rather than in time-consuming and costly field trials, and to produce more reliable and consistent results.

"Plant breeders have always been very dependent on environmental conditions to evaluate new lines for resistance to disease or insects," explains Dr. Ron Knox, a cereal biotechnology specialist at AAFC Swift Current. "If environmental conditions don't favour the growth and reproduction of an insect pest or a disease-causing pathogen, it's very difficult to draw any conclusions about resistance. Thanks to techniques such as molecular markers, environment isn't the limiting factor it used to be."

Gene stacking – boosting the power and longevity of key traits

Many common wheat pathogens mutate over time and eventually overcome individual sources of resistance. Gene stacking – using molecular markers to identify and breed multiple sources of resistance into one wheat variety – dramatically reduces the pathogen's chances of breaking down the resistance. Gene stacking requires extensive preliminary work in marker development, but is becoming more common in breeding programs.

"It's always been a challenge to stay ahead of pests as they change," says Knox. "In the past, we had no way to pinpoint the source of the resistance in a wheat line. With marker technology, we can identify multiple sources of a desirable trait and 'pyramid'

them together in one line. This produces much stronger and longer-lasting resistance."

Genetic engineering, transgenics – growing potential, cautious approach

There are major market hurdles and other obstacles to the more dramatic aspects of biotechnology in wheat, such as genetic engineering and the development of transgenic varieties, but breeders are cautiously investigating the potential.

An often-expressed frustration is the difficulty of defining terms such as genetic engineering and transgenic varieties. Typically, genetic engineering refers to the process of transferring specific genetic information from one organism to another, using modern biotechnology tools. Transgenics refer to the product.

Western Canada's first potential transgenic wheat variety, Monsanto Canada Inc.'s Roundup Ready wheat, is on the horizon and researchers are exploring other opportunities. But factors external to breeding are likely to be the deciding factor in whether and when any products from these efforts become commercially available.

Overall, the use of modern biotechnology has opened wide possibilities for wheat. In addition to boosting traditional breeding targets, there are new opportunities for using wheat as a "bio-product" for pharmaceuticals, nutriceuticals and industrial products.

CLASS-BY-CLASS UPDATES

UPDATED

Canada Western Red Spring *and new* *Canada Western* Hard White Spring

A high-stakes game of king of the castle is well underway. New white wheats and quality gains will help Canada fend off the competition.

This class remains Canada's wheat king. Canada Western Red Spring (CWRS) wheat typically makes up 60 percent of Prairie wheat acreage, and it's arguably one of the country's greatest ambassadors – customers around the globe recognize its superior milling and baking qualities, and Canada holds the title as the world's top exporter of hard spring wheat.

But a new era of competition threatens Canada's status. Major producers, such as Australia and the U.S., have raised the stakes with new high protein wheats that directly target key export markets. To counter this challenge, Canada's wheat breeders are raising the bar on their own varieties and adding an important new white-seeded hard spring wheat to the country's portfolio.

CWRS-style wheat is best known for production of high-quality pan breads. However, because of its high gluten strength, it is also used either alone or in blends for a wide range of products such as hearth breads, noodles, flatbreads and steamed breads.

The breeding challenge

Quality remains the name of the game for the CWRS class. Varieties must hold a high grade in the field and meet the requirements of high-end customers. The new effort toward hard white wheats is bringing high hopes in this area. The main advantages of this type are higher flour extract for processors and a colour preferred by key markets. The first varieties are expected to emerge within two years. They will help Canada compete with Australia, which has grown nothing but white wheats for some time. The Japanese are partial to this class for both noodles and milling.

For traditional CWRS, other key quality targets include ramping up strength to a level slightly stronger than Katepwa, and placing more emphasis on noodle colour and texture. One next step is to aim for multi-purpose varieties.

In the field, the major challenges are FHB and wheat midge, respectively the top disease and insect problems of wheat in Western

Canada. Key resistance gains for both challenges are expected to become available in new varieties over the next two years.

An emerging threat is the wheat stem sawfly – an old pest causing new problems across the Prairies. Other perennial challenges include leaf and stem diseases, particularly various strains of rust and bunt. Yield is always a top priority – breeders have made 10 to 15 percent yield gains in the last five years. Another key development is the emergence of herbicide-tolerant wheat.

List of crop developers referenced in variety descriptions.

- Agricore United
- Agriculture and Agri-Food Canada (AAFC)
- AgriPro
- Alberta Agriculture, Food and Rural Development (AAFRD)
- Proven Seed
- University of Alberta
- University of Manitoba
- University of Saskatchewan Crop Development Centre (U of S CDC)

Note: Variety acreage figures are from the 2003-04 Canadian Wheat Board variety survey. Variety and cultivar descriptions are a rough sketch of key traits; they are not comprehensive. Years listed beside variety names indicate year of full registration, except where otherwise indicated. It typically takes two more years before seed becomes widely available to farmers.

The leading varieties

AC Barrie – 31.8 percent
Prodigy – 7.4 percent
CDC Teal – 7.3 percent
AC Intrepid – 6.6 percent
McKenzie – 6.4 percent

Key varieties in the field and on the way

AC Cadillac (1996). High yield, high protein, large kernels, very high test weight, very good bunt and loose smut resistance and improved leaf spot resistance. Not as susceptible to FHB. AAFC Swift Current.

AC Elsa (1996). Higher yield than AC Barrie with high protein and improved leaf spot resistance. AAFC Swift Current.

AC Splendor (1996). Very early maturity, very high protein and very good leaf rust resistance. AAFC Winnipeg.

McKenzie (1997). High yield, pre-harvest sprouting resistance, good leaf rust and bunt resistance. Saskatchewan Wheat Pool.

AC Intrepid (1997). High yield, early maturity, strong straw and very large kernels. AAFC Swift Current.

Prodigy (1998). High-yielding and resistant to stem rust, leaf rust and bunt. Saskatchewan Wheat Pool.

AC Abbey (1998). First semi-dwarf, solid-stemmed wheat in this class. AAFC Swift Current.

Alikat (1999). Adapted to acidic soils and agronomically similar to Neepawa. University of Alberta.

CDC Bounty (1999). High yield potential and higher protein percentage than Neepawa. U of S CDC.

5500HR (2000). High yielding, high test weight variety for non-stem rust wheat growing areas. AgriPro / Agricore United.

5600HR (2000). Strong straw, high test weight, high yielding. AgriPro / Agricore United.

Snowbird (2000). CWRS-style white wheat supported for interim registration and market evaluation. AAFC Winnipeg.

Kanata (2000). CWRS-style white wheat supported for interim registration and market evaluation. AAFC Winnipeg.

Superb (2000). High-yielding semi-dwarf. AAFC Winnipeg.

5601HR (2001). Yield and protein comparable to AC Barrie, but about two days later maturity. AgriPro / Agricore United.

Harvest (2001). Higher yielding, improved sprouting resistance, one day earlier maturity than AC Barrie, protein content similar to Neepawa. AAFC Winnipeg.

CDC Imagine (2002). Features tolerance to the Clearfield line of herbicides. U of S CDC.

Lovitt (2002). An early maturing, leaf rust resistant AC Barrie-type with pre-harvest sprouting resistance. AAFC Swift Current.

PT416 (2002). An early maturing, high-yielding wheat with excellent common bunt resistance. AAFC Winnipeg.

Journey (2002). High grain yield, protein and test weight. Good rust resistance. Saskatchewan Wheat Pool / AgriPro.

Lillian (2003). Touted as a successor to AC Abbey, as sawfly-resistant wheat of choice. Key advantage is higher grain yield and protein potential with good disease resistance. Maturity similar to checks. Taller and weaker straw than the semidwarf AC Abbey. AAFC Swift Current.

BW781 (2004). Semi-dwarf with medium maturity. Yields higher than AC Barrie, with intermediate disease resistance. Targeted at western Prairie. Short strawed with high test weight. High yield. U of S CDC.

PT555 (2004). Medium-early maturity. Standard height. Higher yielding than AC Barrie. Targeted at Parkland production zone. U of S CDC.

PT559 (2004). Standard height, intermediate maturity. Yield a bit lower than AC Barrie. Good test weight. Disease profile intermediate to checks. U of S CDC.

UPDATED

Canada Western Amber Durum

Breeders are raising the bar on quality to target premier pasta.

A new era has dawned for Canada Western Amber Durum (CWAD), the number two wheat class in Western Canada. Canada is already a world leader in volume production, with durum comprising approximately 30 percent of Prairie wheat acreage, and breeders are shifting gears to take a run at top quality markets.

Durum's combination of hard kernels, strong gluten and high protein content is its key to success. The kernels mill well to produce semolina, the raw material for making good quality pasta and couscous, while strong gluten ensures good cooking characteristics and pigment gives a bright yellow colour.

The breeding challenge

Where is Canada's road to durum gold? A good starting point is Italy, the small but influential market that sets the pace for premier pasta. The desert durums from the American southwest are usually preferred by the Italians because they have significantly higher gluten content than conventional Canadian varieties. The Australians have also gained ground in this market.

In response, Canadian researchers are aiming for greater strength in new Canadian durum varieties, in part to meet the demands of premium pasta processors in Italy and other countries. As part of this effort, Canada has explored potential for a new "extra strong" durum subclass – an effort that continues to evolve. Improved gluten strength is required to firmly establish this new subclass, and greater protein is needed to compete with desert durums.

In conventional durum, where an AC Avonlea type with stronger gluten is a main target. Improved yellow colour has been a perennial target, but breeders have now reached an ideal level. On the disease front, most varieties have excellent rust and bunt resistance, and further disease improvements such as FHB and loose smut resistance are in the works.

Durum is one of the crops most susceptible to FHB, and no sources of resistance have been found in a durum genetic background. As a result, breeders are turning to ground-breaking breeding techniques to bring in resistance from spring wheat sources. Wheat midge resistance is another key priority.

The leading varieties

Kyle – 49.2 percent
AC Avonlea – 31 percent
AC Morse – 9.1 percent
AC Navigator – 4.8 percent

Key varieties in the field and on the way

AC Morse (1996). Improvements to yield, quality and gluten strength. Concerns with leaf diseases, but short stature gives it potential for eastern Prairie. AAFC Winnipeg.

AC Avonlea (1997). High yield, high protein, shorter and stronger straw than Kyle, with improved yellow colour and good cooking quality. AAFC Swift Current.

AC Navigator (1998). The first extra strong durum variety to receive full registration. Initially granted interim registration, the line received a recommendation for full registration in 2002. AAFC Swift Current.

AC Napoleon (1999). Features low cadmium accumulation. In the Black Soil Zone had a higher yield than AC Avonlea and Kyle and stronger gluten than AC Avonlea, but lower protein and test weight than AC Avonlea. AAFC Winnipeg.

DT712 (2004). Touted as a successor to AC Avonlea, with lower cadmium content, higher strength, higher yield, slightly higher test weight and similar disease profile. Adapted across the Prairies. AAFC Swift Current.

UPDATED

Canada Prairie Spring

Breeders have developed a strong collection of wheats with several end-use quality types. CPS varieties give Canada flexibility in the marketplace and help tap important niches.

They're the young guns among Canada's wheat classes, and they're starting to show some fire. Canada Prairie Spring Red (CPSR) and White (CPSW), introduced in the mid-to-late '80s, are versatile lower protein alternatives to the main bread wheat class that are helping Canada tap the growing potential in niche markets. Together, they comprise roughly eight percent of Canada's wheat acreage.

The progress in CPSR is one of the most exciting recent developments in wheat breeding – new varieties are reaching the goals of the class and are set to compete with U.S. hard red winter wheat. CPSR is best suited for French-style hearth and flat breads. CPSW is targeted for various Asian noodle markets, where its pale colour is in demand. One-third of Canada's CPS production is expected to be used for noodles. The high yield of CPS varieties has also made the class attractive as high quality feed for the expanding domestic livestock industry.

The breeding challenge

Across-the-board improvements are showing up in CPS programs across the Prairies, including 10 percent yield gains, improved noodle making quality, earlier maturity and improved pre-harvest sprouting resistance. Breeders are also updating resistance to leaf spot and are beginning to tackle other key problems, such as FHB and wheat midge.

An ongoing goal is to continue building market acceptance for the CPS class. Many countries already produce lower quality wheat and markets such as China prefer stronger varieties for blending with those lower quality types. The CPSR class has shifted to stronger gluten to meet this demand. Marketers are also advising breeders to keep a lid on protein, which is already at the highest desirable level for the class, and to push for more strength in CPSW.

The leading varieties

CPSR

AC Crystal – 64.2 percent

AC Foremost – 15.2 percent

AC Taber – 13.4 percent

CPSW

AC Vista – 54.1 percent

Genesis – 23.9 percent

AC Karma – 17.9 percent

Key varieties in the field and on the way

AC Crystal (1996). A CPSR variety with much stronger gluten combined with good performance characteristics. AAFC Swift Current.

AC Vista (1996). First in the CPSW class with sprouting resistance comparable to red varieties. AAFC Swift Current.

AC 2000 (2000). CPSW with improved milling properties and gluten strength compared to AC Karma and AC Vista. Supported for interim registration. AAFC Swift Current.

HY961 (2000). CPSR with yield about three percent above AC Crystal and one day earlier maturity. AgriPro / Agricore United.

HY962 (2000). CPSR with yield about seven percent higher than AC Crystal and two days earlier maturity. AgriPro / Agricore United.

HY639 (2000). CPSR with increased protein content. Adapted to the eastern Prairies. AAFC Winnipeg.

UPDATED

Canada Western Red Winter

Research has led to a dramatic turnaround in the performance of winter wheat varieties. The results are higher yields, tremendous soil conservation benefits and another tool for breaking crop disease and pest cycles.

The stage is set for winter wheat. Research has dramatically improved the crop, its environmental advantages have never been more important, and its agronomic benefits are winning over more farmers.

The crop is fall seeded directly into the stubble of the previous crop, a practice that helps protect precious topsoil from wind and water erosion. It emerges early in the spring, taking advantage of early moisture to spur growth and it provides temporary habitat for upland nesting waterfowl. Winter wheat also helps disrupt annual pest and disease cycles and it allows farmers to spread out their fall and spring workloads.

The breeding challenge

Further progress in disease and pest resistance remains a high priority for breeders. A major concern is Fusarium Head Blight. Winter wheat in Western Canada has largely managed to escape major FHB damage, but this is due more to good luck than to any advantage in resistance. Under the right environmental conditions, winter wheat is highly susceptible to severe epidemics - a fact that has breeding programs hard at work to provide a measure of defence. Meanwhile, breeders have started the long-term process of developing FHB-resistant varieties.

Another important research thrust is quality diversification. One example is a new effort toward white-seeded winter wheat, which will provide new markets and opportunities to farmers.

The leading varieties

CDC Falcon – 32.9 percent
CDC Clair – 26.6 percent
CDC Osprey – 10.2 percent
CDC Harrier – 7.6 percent

Key varieties in the field and on the way

AC Tempest (1997). CWRW replacement for the southern Alberta variety AC Readymade, which corrects the low flour yield problem of that variety. Has stronger straw, high protein and moderate bunt resistance. AAFC Lethbridge.

AC Bellatrix (1998). First winter wheat for Western Canada with common bunt resistance. AAFC Lethbridge.

CDC Falcon (1998). First winter wheat for Western Canada with superior leaf and stem rust resistance. U of S CDC.

CDC Raptor (1999). High-yielding, winter hardy, strong straw, short stature semi-dwarf with superior stem and leaf rust resistance. U of S CDC.

UM5089 (2001). Yields similar to CDC Kestrel, with shorter straw and improved lodging resistance. University of Manitoba.

W337 (2001). Higher yield than CDC Osprey and resistance to wheat curl mite. AAFC Lethbridge.

CDC Buteo (2002). Yield similar to CDC Osprey, with shorter straw and similar lodging resistance compared to CDC Kestrel. U of S CDC.

UPDATED

Canada Western Extra Strong

This unique class has featured strong benefits for blending. But with changing technology in frozen dough and rising competition from the U.S., this class may be de-emphasized in the years ahead.

Canada Western Extra Strong (CWES) is a unique class that features strong gluten and good dough mixing characteristics. It is used in blends to produce pan breads, hearth breads, buns, and whole wheat or specialty breads, and to increase the shelf life of frozen dough.

But the class faces major challenges and may be de-emphasized in future years. Breeding advances are helping improve the class, but that may not be enough to overcome technology changes in frozen dough and tough competition from U.S. hard red winter wheats.

The breeding challenge

The pioneering variety of this class is Glenlea, originally a Canada Western Utility variety that began as a specialty wheat in the 1970s. The focus of breeding efforts has been on developing updated versions of Glenlea.

Breeders have succeeded with slightly higher yield and significant protein gains, along with earlier maturity, improved test weight and superior disease resistance.

The leading varieties

Bluesky – 36.9 percent
Glenlea – 28.9 percent
Laser – 21.3 percent
Wildcat – 8.8 percent

Key varieties in the field and on the way

AC Corrine (1998). Superior sprouting resistance. AAFC Winnipeg.

Laser (1998). Higher yielding and better quality than Wildcat. University of Alberta.

Amazon (1998). Updated version of Glenlea with tan spot resistance. University of Manitoba.

AC Glenavon (1999). Featuring several improvements, including slightly higher yield, earlier maturity and improved test weight compared to Glenlea. AAFC Winnipeg.

CDC Rama (2002). Yield and maturity similar to Glenlea, but much higher protein content and improved disease resistance. U of S CDC.

ES41 (2004). Softer wheat than Glenlea, with three to seven percent higher yield and a range of similar characteristics. Softer kernel is easier to grind. U of S CDC.

ES54 (2004). Maturity two days earlier than Glenlea, with similar yield, much higher protein, shorter and stronger straw. Best leaf rust resistance in the CWES testing system. AAFC Winnipeg.

UPDATED

Canada Western Soft White Spring

New higher yielding varieties will give producers more options and help Canada offer a full range of products to its customers.

One-stop shopping – it's a powerful draw when buyers from around the world look to Canada for wheat. Canada Western Soft White Spring (CWSWS) is a small acreage crop, but it fills a niche and helps the country offer a diverse wheat portfolio.

Soft white wheat is used in pastry products, cakes, cookies, noodles, flatbreads, pizza dough and breakfast cereals. The crop is grown almost exclusively under irrigation in southern Alberta. Acreage has fluctuated with prices, but in peak years has reached around 450,000 acres.

Low protein flour from this high-yielding wheat provides the flaky texture vital to the pastry industry.

The breeding challenge

The breeding effort has evolved into two streams, one that centres on traditional markets and the other on export markets. The latest traditional CWSWS varieties feature a significant yield jump, along with stronger adult-plant resistance to the new race of stripe rust. The export stream concentrates more heavily on yield than on protein, since this market is largely price driven. Perennial disease targets include improved resistance to powdery mildew and blackpoint, as well as resistance to stem rust, leaf rust, loose smut and bunt.

Along with yield improvements, the key targets for researchers are reduced kernel blackpoint and leaf diseases common under irrigation. Breeders are also making gains in lodging and shattering resistance.

The leading varieties

AC Andrew – 41.4 percent
AC Reed – 37.9 percent
AC Nanda – 10.9 percent

Key varieties in the field and on the way

AC Nanda (1997). Good yield, improved end-use quality and resistance to blackpoint, stripe rust, bunt and powdery mildew. AAFC Lethbridge.

AC Andrew (2000). A high-yielding variety geared toward price-driven export markets. Three-year interim registration. AAFC Lethbridge.

AC Meena (2000). Improved end-use quality for premium quality markets and outyields AC Reed. AAFC Lethbridge.

SWS-285 (2002). Higher yielding than AC Phil and AC Reed. Targeted toward domestic and quality-orientated export markets. AAFC Lethbridge.

UPDATED

How Western Canada develops wheat varieties

A short course on today's wheat breeding and registration process: breeding targets, priorities, process, registration testing and tendering.

Breeding and registration are the nuts and bolts of the wheat development system. Both are constantly changing in response to new technology and industry trends, but the fundamentals remain the same. Understanding the process, from a breeder's strategy to a new variety in the field, is essential to understanding the broader issues around the system. Here's a recap.

The general breeding targets

The challenge for the plant breeder doesn't change much: develop wheat varieties that will meet customer demands and perform well for farmers.

Meeting that challenge continues to be complicated. Even with advances in technology, developing a new wheat variety still typically takes about 10 years, so setting targets requires a long-term view. Along with wheat class quality standards set by the federal Canadian Grain Commission, the following are the general targets that most breeders pursue:

- **Quality:** Increase marketability, improve protein content and processing traits.
- **Yield:** 10 to 15 percent higher than current varieties.
- **Disease:** Improve resistance to traditional diseases and respond to new disease pressures.
- **Adaptation:** Develop varieties for diverse production conditions and for special needs (e.g. sawfly resistance).
- **Profitability:** Increase grade protection and water-use efficiency, reduce harvesting and residue management costs.

Setting breeding priorities

For most breeding institutions, wheat development priorities are driven by a decision-making process that includes the general public, farmers, industry, scientists, marketers and customers at the end of the value chain. The research colleagues of breeders, in pathology, agronomy, quality and other disciplines, also play an integral role.

Resources and funding obviously influence priorities, but several other key factors also come into play.

Market feedback. This comes mainly through the Canadian Grain Commission and the Canadian Wheat Board, the agencies that are responsible for grain marketing and maintaining Canada's reputation as a high quality supplier to the world. CWB has a market development division that test markets new quality types with customers. For example, a new strong-gluten durum was tested with export customers to determine its suitability for new processing demands.

Farmer demand. Market quality means nothing if farmers have trouble growing the crop. That's why breeding for changing agronomic and disease pressures, along with increased yield, are always top priorities. Many breeding centres, along with provincial extension services, conduct disease and other surveys to keep tabs on production challenges. Class development is also driven in part by farmer demand. The CPS class was developed in part to give farmers an alternative type with higher yield potential. And demand is growing for winter wheat adapted to particular areas because of the crop's agronomic advantages.

Research competition. Canada's main competitors include the United States and Australia. A key factor in setting breeding priorities is developing varieties that will compete with those countries; if breeders in a competing country are moving in a new direction, Canada must counter with its own effort. A good example is the recent shift by Canadian breeders into white-seeded bread wheat. Australia has always produced white-seeded wheat but a recent, major shift by U.S. breeding programs into that area signaled to Canada that prospects were rising for this wheat type.

Industry changes. The wheat industry is constantly evolving and the wheat development effort must keep up. For example, researchers are changing some breeding emphasis to adjust to new economic and transportation realities. With poor wheat prices, yield becomes more important. And with higher transport cost for export, feed wheat for the domestic livestock market has become more popular. Combined, these trends have resulted in renewed interest and greater emphasis on high-yielding feed wheat.

Societal issues. Another consideration is societal issues, mostly related to producing wheat in an environmentally sustainable manner. For example, winter types with characteristics that fit well in low-tillage systems are receiving greater emphasis. And genetic resistance

to diseases and insects is seen as an important alternative to chemical control. Newer issues include the need to develop varieties that fit with systems for reducing greenhouse gases and are sensitive to the debate over consumer acceptance of genetically modified crops.

Funding partners. An increasing influence on research emphasis in wheat breeding is outside funding. Though most public programs only accept outside funding that supports their research mandate, that funding removes some control of the purse strings by altering the balance of resources going to specific areas. In wheat, the largest public funding partners are producers who support breeding through the Wheat Check-off Fund administered by Western Grains Research Foundation; the targets for how that funding is to be used are negotiated by producers with advice from researchers and marketers.

The breeding process

Once priorities are established, the breeding process begins by gathering genetic material from around the world. Researchers often test thousands of wheat lines to find those that have the genetic traits that will be useful to the breeding program. They then develop a strategy for incorporating those traits into a new variety.

In its simplest form, breeding involves making a cross between two parent plants. The offspring are evaluated for the desired traits and the process is repeated for about 10 generations until undesirable material is weeded out and the good genetics are "fixed" in a wheat line. Researchers can speed up the process by using winter nurseries to grow additional generations in the off-season or by using new biotechnology techniques, which can take years off the breeding process.

Registration testing

The final stage of wheat variety development is registration testing, known as the "co-op trials" because several breeding centres exchange material for testing across the Prairies. Co-op tests involve three years of field evaluation at numerous locations, extensive disease resistance screening and quality testing at the Canada Grain Commission's Grain Research Laboratory in Winnipeg.

The wheat lines that survive this rigorous testing process can be proposed by the plant breeder for registration at the Prairie Registration Recommending Committee for Grain (PRRCG) meetings held every February. The Subcommittee for Wheat, Rye and Triticale, which includes nearly all Prairie wheat development researchers, critically examines the performance data on lines submitted to the co-op trials and decides which to recommend for registration. Lines are evaluated in three categories: agronomic performance, end use suitability and response to diseases.

Lines that receive a recommendation are submitted for formal approval to Canadian Food Inspection Agency's (CFIA) Variety Registration Office. For public institutions, requests for marketing license proposals are then sent out to seed companies across Western Canada as the first step in the tendering process.

Tendering the variety

At the tendering phase, registered varieties move toward commercialization. Companies compete with one another to bid on the top wheat prospects – a process that largely determines who will have access to new varieties and how long it will take to get seed into farmers' hands. Producer interests are a high priority with public research institutions, but royalty revenues and licensing fees are also key considerations. In some cases, the interests of funding partners who have contributed to the development of a variety also come into play.

Typically, to ensure fairness and objectivity in the process, tenders are chosen by a committee of research managers, people involved with commercialization, and a few selected industry representatives. A representative of Western Grains Research Foundation speaks for the interests of producers who support wheat breeding through a check-off, which the Foundation administers.

Licensing is then negotiated with the selected seed company, which normally multiplies the seed and markets the variety to farmers. Seed multiplication is usually carried out after registration and takes two or three years before there is enough seed to hit the market.

Wheat stakeholders could see operational changes to the registration approval system over the next several years. At the 2004 PRRCG meeting, PRRCG members voted to dissolve the committee, effective April 1, 2005, and shift full powers to its four crop-specific subcommittees – including the Wheat, Rye and Triticale Subcommittee – allowing them to become independent recommending committees.

The resolution, which still requires approval by the Variety Registration Office of the CFIA, is largely the result of a desire for greater control among the subcommittees to handle appeal processes and other governance issues, and to deal directly with the Variety Registration Office on crop-specific issues.

This thinking has emerged in part due to a request by CFIA that the PRRCG re-examine its role as part of the CFIA's broad review of the variety registration system. The CFIA is almost finished its large-scale review of Canada's variety registration system, and is preparing to move forward as early as late 2004 with a proposal for significant restructuring, though major changes for western wheat are not expected.

Further information on the future of barley variety registration is available at **www.meristem.com,** in the *Meristem Land and Science 2004 PRRCG Report.*

Technical Review Assistance

This *Wheat Breeding Report* was originally produced in 2003, with technical review assistance from wheat development experts listed below. Variety lists and other key information was updated for 2004, with technical review assistance from appropriate sources.

Dr. Ron DePauw, Wheat Breeder, AAFC Semiarid Prarie Agricultural Research Centre, Swift Current
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