2003 Barley Breeding Report

Portfolio for Progress

Inside:

Barley breeding in the big picture
Spotlight on trends and issues
Malt, feed, food and forage

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Contents

Building *a* portfolio *for* Canada's barley progress

New barley varieties developed today will anchor Canada's future success.

Skyrocketing demand for beer among China's one billion customers. An expanded domestic livestock industry reliant on feedgrains. The century's greatest disease threat in Fusarium Head Blight. A smaller crop fighting to keep up in the fast-changing, global world of agriculture and food.

These are just four of many snapshots that form the big picture of barley's future in Western Canada – one where dramatic opportunities are contrasted with unprecedented challenges. How it ultimately takes shape will have an important influence on Canadian agriculture, the livelihood of crop producers and key industries such as malting and brewing and livestock production.

Barley may be a smaller crop on the world scale, but its impact on Western Canada is large. In peak years, more than 13 million tonnes are produced across the region.

Given its broad impact, the question of barley's future in Western Canada is one that draws interest from many industry sectors. Clearly, economics, marketing and policy will all play major roles in the outcome. But when it comes to the nature of the crop itself, the success of Canadian barley rests heavily on crop development.

This task falls largely to the region's barley breeding programs. Barley breeding researchers survey the diverse landscape of demands and forecasts, along with new possibilities in the germplasm, and funnel these into breeding strategies toward specific barley varieties. Whether the ultimate goal is a superior field performer that maintains high market standards, or a groundbreaker targeting new opportunities for breakfast cereals or industrial materials, the breeding strategy represents a complex interweaving of agronomic, yield, quality, disease and pest targets.

With advances in science, the overall rate of innovation has ramped up significantly, with major progress in everything from feed barley customized to specific livestock, to malting types that reflect widening international preferences, to innovative hulless, forage and waxy types. The result is a new portfolio of barley progress – in the field and on the way – tailored for Canada's success.

But many challenges are surfacing both within and around the world of breeding. Perennial challenges include the slow uptake of new malt varieties and the failure of the market to recognize the value of superior feed varieties. Other issues – from the future of barley as a crop of choice in Western Canada, to ownership issues regarding barley germplasm, to the need for greater equity in research funding support are also becoming more prominent.

For producers, developments in barley breeding take on added resonance as a major investment. Since the 1993/94 crop year, barley growers in Manitoba and Saskatchewan have generated approximately $600,000 annually for investment in barley breeding programs through the Barley Check-off Fund administered by Western Grains Research Foundation. Since 1991, a separate provincial check off in Alberta, administered by Alberta Barley Commission has collected up to $1.2 million annually, with roughly one quarter targeted for allocation to barley breeding. These check offs are just two examples in a worldwide trend to farmer research funding.

The *Meristem Land and Science 2003 Barley Breeding Report* is a perspective on today's world of barley 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 barley breeding and the variety registration system.

Western Grains Research Foundation

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The Breeding Network

Activity and interest has risen across the board. Public programs remain dominant and farmers have risen dramatically as major funding supporters.

The Players

The three major barley breeding programs in Western Canada, along with other key players.

Agriculture and Agri-Food Canada (AAFC) Brandon Research Centre. Breeding two-row and six-row barley varieties, including hulless and specialty types, for malting, feed, forage and food. AAFC western mandate for barley varieties, including special emphasis on eastern prairie disease pressures. Supported by AAFC Cereal Research Centre, Winnipeg.

Alberta Agriculture, Food and Rural Development (AAFRD) Field Crop Development Centre, Lacombe. Breeding two-row and six-row barley varieties, including hulless and specialty types, for feed, forage, malting and food. Long-term emphasis on feed barley with nutritional quality emphasis for hog and silage production for cattle. Strong emphasis on multiple disease resistance for the western prairie. A co-operative program with Agriculture and Agri-Food Canada's Lacombe Research Centre, the Alberta Agricultural Research Institute and the Alberta Barley Commission.

University of Saskatchewan Crop Development Centre (U of S CDC). Breeding two-row and six-row barley varieties, including hulless and specialty types, for malting, feed, forage and food. Long-time leader in malting quality, including development of Harrington, and pioneering institution for hulless barley.

Agricore United. Involved in development of six-row and two-row barley varieties, including hulless and specialty types, for malting, feed, forage and food. Does not have its own breeding program, but partners with others to co-ordinate variety development for Western Canada. Key partners include Busch Agricultural Resources Inc., U of S CDC, Western Plant Breeders and W.G. Thompson and Sons.

Alberta Barley Commission (ABC). Producer organization representing barley growers in Alberta. Administers a producer check off on barley sales in the province. Funds go to various activities, including barley breeding, other barley research, policy, marketing and producer services.

Busch Agricultural Resources Inc. (BARI). The agricultural research and operations subsidiary of Anheuser-Busch Companies. BARI's research program is designed to ensure a steady supply of quality brewing ingredients. This program develops new strains of barley for general release and use by Anheuser-Busch – the world's largest brewing company. Breeding six-row and two-row barley varieties for malting and brewing purposes.

SeCan. Funding two-row hulled feed and malt barley programs at U of S CDC. Not-for-profit corporation of seed producers, processing and handling industry that distributes and markets stock seed. Research funding agreement allows SeCan first right of refusal to the marketing rights for new varieties released through the SeCan-funded program.

Western Grains Research Foundation (WGRF). Producer funded and directed organization representing 17 diverse agricultural organizations across Western Canada. Administers a producer barley check-off on CWB final payments in Saskatchewan and Manitoba. Funds go to barley breeding research.

Western Plant Breeders, Montana. Breeding six-row and two-row barley varieties, including hulless and specialty types, for feed, forage and food. Target area is northwestern United States and Western Canada. Specializes in semi-dwarf types for heavy rainfall and irrigated areas. Among the first developers of hulless waxy types.

W.G. Thompson and Sons, Ontario. Breeding two-row and six-row barley varieties for feed and malting. Heavy emphasis on feed for Eastern Canada, but has also explored potential for Western Canada. Emphasis on seed plumpness.

The Trends

In Western Canada, public research institutions remain by far the dominant breeding programs, but private companies and organizations – most notably farmer-driven ones – are making a significant mark as research funders.

Public programs carry the load

The "Big Three" remain firmly at the helm. A look at Canadian Wheat Board and other more informal variety surveys in recent years shows that the large majority of all barley varieties grown in the region were developed by three breeding institutions – AAFC Brandon, AAFRD Lacombe and the U of S CDC. These three institutions have developed nearly all two-row varieties and most six-row varieties of significant acreage. A look at barley material coming forward in the breeding pipeline suggests

these programs will likely remain as the dominant barley breeding programs in Western Canada for years to come.

Restructuring and reviews yield no major capacity change

AAFC is undergoing a realignment of its research network, which could result in changes to barley breeding programs. Though major changes are not expected, there will be a shift in focus away from individual research centres to "national research networks." This means the major AAFC barley breeding programs, which have been headquartered at the AAFC Brandon Research Centre will now be more formally tied to related barley research across the country.

The U of S CDC has also been the subject of funding reviews in recent years, but no significant changes to barley breeding programs have resulted or are anticipated. Following one recent funding review, Saskatchewan's Agricultural Development Fund (ADF), the key funding source for the U of S CDC, slightly increased its support of barley programs as part of a new five-year commitment. A regular review of other core provincial funding to the U of S is now taking place, with no major changes to barley funding expected.

Farmer check offs emerge as big funding supporters

The progress of the region's public barley breeding programs today is significantly higher than it was just 10 years ago. A major reason is a boost in support from farmers, who have risen to the forefront as major private investors in Western Canadian barley breeding.

Barley growers in Alberta have supported barley research since 1991 through a provincial check off, administered by the ABC. Producers in Saskatchewan and Manitoba have supported Prairie breeding programs through the WGRF-administered barley check off, started in the 1993/94 crop year. Farmer funding now accounts for approximately 25 percent of the operating budget of the key public programs, which by leveraging the existing public investment has considerably boosted the breeding activity in those programs.

Industry changes reduce other private funding

Industry changes have reduced other private funding support to breeding programs. The former Agricore and United Grain Growers (UGG) were each significant funding players, but cut back support substantially after the two companies merged as Agricore United in November 2001.

Formerly, UGG, in partnership with Proven Seeds, supported six-row malt barley breeding at the U of S CDC, while Agricore, in partnership with BARI supported the same type of program at AAFC Brandon. Support for the Brandon program was dropped after the merger of the two grain companies.

In a notable development on the plus side, SeCan – a major variety handler and marketer – has started supporting two-row feed and malt barley breeding at the U of S CDC.

New funding for Fusarium Head Blight nursery

Fusarium Head Blight (FHB) has emerged over the past decade as the most serious disease of barley in Manitoba and eastern Saskatchewan, resulting in multimillion-dollar losses annually, and its incidence has steadily spread westward. In response, an FHB nursery in Brandon, Man., was established in 1998 as a screening facility to help plant breeders develop new barley varieties with greater resistance to Fusarium.

This nursery, along with a smaller nursery at Glenlea, Man., provides a valuable resource for breeders across the country. The Brandon nursery was established with federal funds and provincial grants from Manitoba's Agri-Food Research and Development Initiative (ARDI) and Saskatchewan's ADF. The provincial funding ends in spring 2003, but WGRF has approved new funding to help support the facility through 2006.

American programs look to Canada

More U.S breeding programs are targeting registration of their varieties in Western Canada. Breeding programs such as those at the University of Minnesota, North Dakota State University and BARI, have registered several six-row white-aleurone varieties, which have gained wide acceptance in Manitoba and eastern Saskatchewan. On the feed side, Western Plant Breeders of Montana is another notable breeder with key varieties grown in Western Canada.

Global players test the waters

Outside of the U.S., interest in Western Canada from international breeding programs and variety owners remains lukewarm at best, but there are periodic attempts to test the waters. Canterra Seeds and others have acted as domestic conduits for international varieties from Europe, Australia and other countries, but few non-North American varieties have been registered and they have yet to make a dramatic acreage mark.

The peak in international interest was 2001, when a perceived shift in philosophy in the malting and brewing industry fueled an interest in European-style barley lines. A handful of international varieties were put forward for registration, but none had a major impact and interest waned substantially in 2002.

The Growing Role *of* Farmers

Barley breeding in Western Canada is riding a new wave of progress – thanks largely to an infusion of investment by producers. The growing role of Prairie farmers reflects a major trend in crop development research around the world.

Farmer investment boosts barley breeding in Western Canada

Farmers have emerged as a major, driving force of barley breeding in Western Canada. Over the past decade, producer support has considerably boosted breeding activity and given growers significant equity in the genetics of their crop.

Barley producers in Manitoba and Saskatchewan support research through the Barley Check-off Fund, administered by the farmer funded and directed Western Grains Research Foundation (WGRF). Barley producers in Alberta support research through a provincial check off managed by the Alberta Barley Commission (ABC).

The impact of farmer funding is great because it builds on the substantial public investment already in place. Because the check offs qualify as industry funding, they are also eligible for programs such as the federal Matching Investment Initiative (MII), which can as much as double 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), the Alberta Agricultural Research Institute (AARI), Saskatchewan's Agriculture Development Fund (ADF), Manitoba's Agri-Food Research and Development Initiative (ARDI) and the Manitoba Rural Adaptation Council Inc. (MRAC).

The WGRF barley check off is set at $0.40/tonne, deducted only from Canadian Wheat Board final payments to producers in Saskatchewan and Manitoba. It generates approximately $600,000 annually, allocated exclusively to barley breeding programs. 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. (For full, updated information on Western Grains Research Foundation, the Barley Check-off Fund and farmer-funded breeding progress, visit **www.westerngrains.com**.)

The barley check off in Alberta, managed by ABC, has been set at $0.40/tonne but will be raised to $0.50/tonne beginning in August 2003. The ABC check off, which includes both feed and malt barley, generates up to $1.2 million in normal production years. It supports a range of activities, including barley breeding at AAFRD Lacombe, other barley research, policy, marketing and producer services. Roughly one quarter of the ABC check off is targeted for allocation to production research, which includes barley breeding.

Long-term investment pays dividends, builds equity

Because developing a new barley variety and bringing it to market can take from eight to 13 years, most new lines supported by farmer check offs have only begun to emerge from the breeding pipeline, and will show up in full force over the next five to 10 years.

- Higher yields – 10 to 20 percent greater than a decade ago
- Tailored feed barleys for improved feeding efficiency, animal performance
- Top quality malt barleys with dramatic leaps in field performance
- Stronger, multiple disease and pest resistance
- Specialized agronomics for a wide range of soil and climate zones
- Barley silage varieties with improved standability, yield and disease resistance
- Ongoing progress toward Fusarium Head Blight resistance
- Many other advances, which are detailed in other sections of this report

The check-off investments have also given farmers significant equity in barley genetics and a say in breeding direction. One example that confirms this equity is the plant breeding royalties that have started to stream back to WGRF, based on a percentage of royalties breeding programs receive on sales of farmer-funded varieties. WGRF has reinvested these funds into the originating breeding research programs. ABC and other supporters of the AAFRD Lacombe program have also decided to reinvest royalties in the breeding program.

Canadian farmers part of global trend

Canada's farmer-funding trend in barley breeding is a reflection of a larger movement in grains research around

the world. Canada's competitors, such as Australia, the United States and the European Union, all have extensive public cereal breeding efforts supported by farmers, and several are significantly out-funding Canada.

Australian growers drive broad effort. Approximately 50,000 Australian grain growers support research through a mandatory levy on barley, wheat, 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. Royalties from research funded by the GRDC 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.

Europeans back range of systems. Check-off style systems are becoming more common throughout the major grain-producing nations of Europe. Britain is perhaps the best example, 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.

American producers support check offs. Producers in the U.S. are using check offs to fund market development work and research they view as a critical component of staying competitive and meeting customer demands. North Dakota and Montana growers lead the charge among producers in several key grain states that support breeding and other initiatives through check offs on barley.

Spotlight *on* trends *and* issues

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

Barley's position as a competitive global crop

The most fundamental issue facing barley development today is the crop's ability to compete. In the big leagues of global crop development, barley is positioned below higher profile crops such as corn, soybeans, rice and wheat on the research priority list. Were it not for malting and brewing, the crop would likely drop far off the global radar.

But despite barley's second-tier global status, it remains an important crop for Western Canada. In a good production year, the region produces 11 to 13 million tonnes of barley, which has played an important role in fueling the domestic livestock industry, and the malting and brewing industry. It has also given farmers a valuable cropping option that grows well in the region and carries potential for premium market grades.

However, even at home, barley's status is not guaranteed. Today, producers have more options than ever, and the trend to globalization is evaporating regional niches. This environment makes it more difficult to generate interest and support for barley development research, which is critical to maintaining barley as a viable option long term.

Case in point is the domestic feed market. Over 70 percent of western Canadian barley has been traditionally used as feed. It has played a vital role as the major feed source for the region's multi-billion dollar cattle industry, and has also provided a valuable feed source for other livestock sectors. But today, subsidized U.S. corn, CPS wheat used as feed, and other crop alternatives, pose an increasing challenge. The threat of Fusarium Head Blight, which is pushing some Canadian growers away from both wheat and barley, further complicates matters.

A related concern on the research front is barley's ability to compete for research dollars with popular emerging crops such as pulses, which have strong lobbying efforts.

Research innovations that add value to barley, along with further market development efforts, will help the crop overcome these challenges, but many factors – including the ability of industry and markets to adopt and recognize the value of these innovations – will ultimately come together to decide the crop's long-term destiny.

Who will breed and who will pay?

Because barley is not as lucrative on the seed side as higher profile crops, the breeding network and how it is funded are likely to evolve relatively slowly. However, while no major shifts are expected in the foreseeable future, the rapid evolutions of science, agriculture and business leave the long-term possibilities wide open.

For now, the central question is how to maintain the productivity of the current network. Several of the region's barley breeding scientists will retire over the next decade and there's a good possibility at least a few won't be replaced. This may not necessarily reduce capacity – advances in plot mechanization and computer analysis are moving to the point where one breeder with adequate support staff can handle as much as what would have required two or even three breeders in the past. Limited public research dollars and increasing competition from other crops have thus far set the stage for long-term downsizing. However, Canada, Europe and Australia have made significant investments in barley that bode well for general stability.

In Western Canada, the major impact of producer funding is particularly key. Farmer investment in barley breeding has ensured strong breeding programs over the past decade and boosted the capacity of the core institutions. This bodes well for barley breeding in the region as long as producers maintain a strong interest. On a niche basis, there is also a more promising environment today for further increased private funding collaboration with public programs.

Overall, a wild card in this picture may be the rising combination of intellectual property rights and biotechnology advances. Traditionally, barley breeding has not been lucrative enough to attract much private interest. But this has potential to change significantly with the new opportunities for innovation opened up by biotechnology and the greater opportunity to capture value for those innovations through intellectual property protection. Advances in molecular biology allow researchers to pinpoint, and therefore patent, desirable traits, which creates a framework for generating revenue from varieties that contain those traits.

Sharing the funding burden

A penny off the price of every bottle of beer. A nickel per head off cattle deliveries. When the volume kicks in, imagine what that funding would mean for barley research.

This may sound like a pipe dream of barley researchers, but it's the type of hypothetical example that comes up frequently around the issue of fairness and equity in research funding. As it stands, the large bulk of barley breeding is funded out of the public purse, and barley growers have chipped in a sizeable chunk through their support of research check offs. That begs the question, should others - namely the malting and brewing industry and the livestock industry - be contributing more? Both industries arguably benefit at least as substantially as growers from progress in barley development.

Most feed barley is purchased based on price alone and much of the supply is based on failed malt varieties. Increasing feed industry sophistication may improve the situation, but so far that hasn't been the case. Growers who sell feed barley in Alberta contribute to breeding research through the ABC check off, but the feed barley industry as a whole in Manitoba and Saskatchewan has not contributed to breeding research.

On the malting and brewing side, the domestic industry contributes to a variety of basic research projects – some of which indirectly support breeding programs – and participates in the testing system toward new varieties. Through BMBRI, it also co-ordinates the pilot scale Collaborative Malting Quality Tests. However, the brewing and malting industry has not been a significant direct contributor to specific breeding work.

Driving a more balanced turnover of malt varieties

The tide is finally turning – backed by advances in breeding and new interest from domestic and international maltsters and brewers, a new generation of malting barley varieties has emerged to take over the reign of Harrington, Canada's long-time malt king.

For farmers, this change is a major breath of fresh air. Harrington has brought international renown to Canadian malting barley and established an unprecedented run as a market leader. But the variety has been on its last legs in the field for much of the past decade. The new varieties have major benefits for farmers, such as improved disease resistance, yield and agronomic quality.

It's important to note that turnover in six-row malt barley – which boasts a major market share – has been relatively good. But on the two-row side, the question of how to maintain the right balance of farmer and market needs remains a pressing one for the future. The core dynamics remain the same. Growers need a regular turnover of varieties to keep up with constantly changing disease and other agronomic pressures, but by the same token don't want too many varieties to choose from. The brewing and malting industry is naturally cautious about changes that could affect malt and beer production systems or the quality of their end product.

Recognizing the value of superior feed

It's a tried and true recipe that's rapidly become outdated: the higher the bushel weight, the higher the feed value. For years, that has been the standard for judging the quality of feed barley in Western Canada, but many say that just doesn't make sense in today's industry.

Scientists now have sophisticated technology to measure feed quality. Research indicates that while bushel weight

is correlated with feed value, it does not provide the whole picture. In fact, barley of the same test weight can have a considerable variation in feed energy. And since the digestive process is different depending on the livestock, the nutritional targets must be tailored separately for hogs, dairy cattle, beef cattle and poultry.

While the research shows that quality in feed barley is not necessarily correlated to bushel weight, this is not reflected in the grain grading system. There's insufficient reward for the crop farmer who's producing the better quality versus the one who is not.

Advances in grain analysis technology are becoming more widely available in the industry. Many feel a good way to use this technology would be to evaluate barley on a matrix grading system that includes factors such as protein and energy value. The market would then dictate price, based on awareness of this information.

Growth over the past decade in domestic livestock feeding is helping fuel the drive for change. As the feeding industry increases in scale and becomes more sophisticated, there is more emphasis on using specific feed barley instead of unselected malt barley.

Research innovations continue to up the ante. Hulless barley, though struggling of late, has been the most dramatic example of feed barley innovation. New hulless varieties with low phytate content and hulled varieties with a slow rate of dry matter disappearance are on the radar. Overall, new technology for screening is leading to a range of varieties with superior feed value, tailored for specific livestock. This includes new applications for Near-Infra-Red Reflectance Spectroscopy (NIRS), which evaluates protein content and other key feed traits.

Help is also coming from collaboration in the research and development community. One example is the Crops / Livestock Interface group at the U of S CDC, which supports collaboration between both groups to keep feed barley improvements in line with industry needs. Another is AAFRD Lacombe's relationship with the University of Alberta, which is supporting the development of barley varieties tailored to the nutritional and environment needs of the livestock industry.

Kick-starting new potential in hulless

One of the most heralded achievements in barley breeding of the past decade is hulless barley. With an estimated over 500,000 acres grown in 1998 and projections at that time of 30 percent or more of barley acreage in future years, the crop was pegged as a sure-fire winner for the expanding hog industry.

But the crop has since met some major stumbling blocks. Some of the first modern hulless varieties had problems with adhering hulls. Hulless barley received good initial interest from growers, but the industry was ill-prepared to handle, process and market what was essentially a new crop. With the livestock industry still purchasing based largely on price alone, the added feed value of hulless barley was slow to get recognized, which restricted incentive throughout the supply chain. For processors, an added workload was required to cater to the new crop. Hulless also required segregated handling to keep it separate from hulled barley.

All of this is topped off by the stiff competition from U.S. corn, CPS feed wheat and other feed alternatives that are challenges for feed barley as a whole – while hulless barley compares well in feed quality, it can have a tough time competing with the high yield of other feed crops. As a result, even today's barley growers draw roughly the same price for hulless feed barley as they do for unselected malt varieties.

In the final analysis, many feel hulless barley was probably introduced before the industry was ready for it. An unfortunate outcome, considering the crop represents a major innovation. Particularly for monogastrics such as hogs, hulless barley is a superb feed, with approximately 15 percent higher digestibility than hulled barley and a much higher proportion of protein and energy.

This potential has breeders focused on a new generation of hulless barley with further improvements, backed by a stronger focus on overcoming handling, processing and marketing challenges. New advances such as low phytic acid barley promise to boost the incentive for hulless. Breeders are also exploring new opportunities such as hulless malt barley. The traditional brewing process relies on barley hulls to act as a filter, but a future trend toward new "pressure mash" filters may reduce this need.

Genetic ownership

The questions are many. 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 barley, 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 barley breeding community that this will limit access to germplasm

– the genetic raw material of breeding programs. 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.

For farmers, a major benefit is the equity stake they have gained through the direct funding of research. This position gives producers significant leverage in determining how genetic material and varieties developed by farmer-funded programs are managed.

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 that could become a competitive disadvantage.

Grappling with Fusarium

It came out of nowhere. Now it's looming large as the most damaging cereal disease in Western Canada.

For barley, the effect of Fusarium Head Blight (FHB) has been devastating. There are no effective controls and the scientific search for genetic resistance has proven bleak and tremendously challenging. In the field, FHB has been a key contributor to the significant reduction in barley acreage. Six-row barley in general has been more susceptible to FHB than two-row barley. In barley breeding programs, the resources needed to battle FHB have forced researchers to draw funding away from other important barley development goals.

While there appears to be no immediate genetic solution, breeders hope to reduce Fusarium damage by eliminating lines that appear particularly susceptible. With co-operation from the barley breeding network, disease nurseries for FHB screening were established to screen lines for reaction to the disease and the mycotoxins it produces.

FHB has yet to become a major problem in Alberta and western Saskatchewan, but programs targeted at this region aren't taking any chances. For one example, AAFRD Lacombe is placing significant resources into FHB resistance – working closely with CIMMYT in Mexico – to help ward off the threat.

Far out on the horizon is a technology that could ultimately provide the solution to Fusarium in barley: genetic engineering. In most cases, transformation technology for barley is on the backburner until there's a clear indication of market acceptance. But researchers are developing the technology in the meantime to get the option ready.

Changes to the variety registration system

The Canadian Food Inspection Agency (CFIA), which oversees variety registration, has proposed a major overhaul of the entire system, with changes expected in 2004.

The centre of debate has been a CFIA recommendation to remove agronomic performance from the prior merit assessment requirement for barley. A minimum of one year of agronomic data would still be collected, but only for the purpose of making this information available to farmers and others. After objections from the research community, producer group representatives and some seed companies, the CFIA reversed this recommendation, opting to retain agronomic merit as a requirement for barley. But changes have not been finalized and the fundamental debate surrounding registration requirements is sure to remain for some time.

There are several key arguments for removing required agronomic merit assessment – it would allow varieties to enter the marketplace more rapidly, reduce costs to the testing and registration system, and would give farmers more choice. Arguments against emphasized this could result in a large influx of inferior-yielding varieties, have a negative impact on performance testing and make it more difficult for farmers to get good agronomic information for decision-making.

Pressure on Canada's grain handling system

Innovations from barley breeding are giving farmers more options and are enabling Canada to provide one-stop shopping to its customers. While this trend is creating

new opportunities for the industry, it heightens the requirements for shepherding specific barley types through the system. The industry is addressing this with a growing emphasis on contracting and identity preserved (IP) handling. But for many niches there is still a lot of risk involved for grain handlers, which will ease only with time and familiarity.

For some farmers, one of the concerns surrounding this trend is "quality control fatigue," with everything from Hazard Analysis & Critical Control Point Programs (HACCP) to Environmental Farm Plans on the horizon.

BREEDING HIGHLIGHTS

MANY INNOVATIONS ARE EMERGING ACROSS WESTERN CANADA'S BARLEY DEVELOPMENT NETWORK. HERE ARE A FEW SPECIFIC EXAMPLES THAT ILLUSTRATE BROADER PROGRESS AT ALL THE MAJOR BARLEY DEVELOPMENT INSTITUTIONS.

AC Metcalfe
heralds breakthrough of new generation malts

Higher yielding varieties with major boosts in agronomics and disease resistance represent a giant leap forward in field performance.

It's a reversal of numbers that may signal a dramatic reversal of fortune for Prairie malt barley producers.

In 2001/2002, Harrington, the longtime king of Canadian malt barley, held strong as the Prairie malt barley acreage leader, with 37 percent of acreage, according to the CWB survey. Second place went to newcomer AC Metcalfe, with 27 percent. In 2002/2003, the numbers flip-flopped – AC Metcalfe grabbed 38 percent to Harrington's 26, knocking the old variety off the top for the first time in nearly 20 years.

AC Metcalfe and other malt varieties such as CDC Kendall and CDC Stratus have moved steadily closer in Harrington's rearview mirror over the past several years. The past year's breakthrough shows they have finally arrived, due to advances in breeding; market development efforts by domestic malting and brewing companies, CWB and grain companies; and increasing interest among both domestic and international maltsters and brewers.

For farmers, the newer varieties yield five to seven percent higher than Harrington, with higher test weights, improved kernel plumpness and vastly improved disease resistance. All feature high malting quality and AC Metcalfe in particular is gaining broad acceptance as a variety of choice by the malting and brewing industry.

"It's clear now that we're finally in a state of real change," says Dr. Bill Legge, the AAFC Brandon barley breeder who developed AC Metcalfe. "The survey numbers for AC Metcalfe versus Harrington were almost a straight reversal from the previous year, and this and the CDC varieties are enjoying some good interest both from growers and the malting and brewing industry. It's very satisfying to see."

That sentiment is echoed by Dr. Bryan Harvey, the U of S CDC malt barley breeder who developed Harrington more than 20 years ago. "We're convinced we've got a better product in the newer varieties, not only for the farmer, but for the maltster and brewer," says Harvey, who has worked with colleague Dr. Eric Lefol on the latest CDC malt varieties.

Change long overdue for growers

Harrington barley is arguably the most successful cereal variety in the history of western Canadian agriculture. For more than two decades, it has been the region's barley acreage leader and the international favourite among two-row customers.

But Harrington's popularity has become a mixed blessing for farmers. Remarkably, even today, the variety is popular around the globe. However, its performance in the field makes reaching a malting grade difficult and the variety's yield penalty has increased every year. Many two-row malt varieties with improved field performance became available during Harrington's reign, but received little attention or demand from the traditionally conservative malting and brewing industry. As a result, producers who wanted to earn a malt premium were largely stuck growing an agronomically outdated variety.

Creating better variety turnover

On a comparative basis, turnover on the six-row malt side – a major malt barley market – has been progressive.

But for two-row malt, even with the shift, the question of how to maintain the right balance of farmer and market needs remains for the future.

"I certainly hope the turnover improves, even though AC Metcalfe is my variety, and I think we've seen some good signals that's what will happen," says Legge. "A malting variety is always going to have to last a little longer than varieties in other crops, but nonetheless we don't want them hanging on for 20 years like Harrington. Producers get tired of growing material that's years out of date genetically, and in the long run it really sets malting barley back for the industry as a whole."

If the breeding pipeline is any indication, both producers and the malting and brewing industry can look forward to continued strong malt barley progress in the years ahead. Emerging two-row varieties such as CDC Copeland, AC Bountiful, Newdale, Calder and CDC Select along with six-row varieties such as Legacy, CDC Yorkton and BT954 feature further improvements in yield, kernel plumpness and malt enzyme activity. Newer malt barley breeding programs, such as one at AAFRD Lacombe, are also producing promising malt barley material that is expected to emerge over the next five years.

Tortillas
blaze new trail for barley in human food

The $4 billion U.S. tortilla market is just a start, as researchers tap barley's unique advantages for functional foods that appeal to health-conscious consumers.

The birth of the idea was simple enough. As a mother who regularly serves tortilla-based snacks, such as wraps, to her children, cereal chemist Dr. Nancy Ames of AAFC Winnipeg soon noticed the drawbacks of wheat and corn-based tortilla products – they had a short shelf life, limited nutritional value and often broke apart too easily.

Fast-forward several years and the seed of this idea has spawned lucrative opportunities for barley in the $4 billion U.S. tortilla market, blazing a new trail for the crop in the human food sector.

"I recognized the limitations of tortillas as a consumer, and then realized, as a researcher, that barley could solve those problems," says Ames.

Longer shelf life, unique health benefits

The potential for tortillas and other food opportunities was opened up years ago by barley breeders developing hulless food and specialty starch barley varieties. It is just one example of many food barley initiatives at research institutions across Western Canada. These efforts have explored everything from tortillas to breakfast cereals, to pearled barley and food additives with value-added nutritional and health components.

Further research by Ames and colleagues has also shown that barley has several advantages for tortilla-based products. In comparison to corn and wheat-based products, barley products have a stronger texture, longer shelf life and are easier to process. Perhaps most exciting, barley contains higher dietary fibre, beta-glucan – a cholesterol-lowering nutraceutical which the other products don't have – and other components reported to have desirable health benefits.

Currently, less than one percent of Canada's barley crop goes to food markets, but given these benefits, a breakthrough in the tortilla market could help drive broad food market potential, says Ames. "Barley is really the perfect functional food. I don't know why it has been in the shadows for so long."

Tortillas are the fastest growing segment of the U.S. baking industry and Ames says sales are expected to climb to $6.5 billion within two years.

Ames has collaborated with Texas A&M researchers on a number of projects to further examine barley's potential as an ingredient for traditional corn and wheat type tortillas.

Hulless barley opens door to tailored food varieties

Barley breeders such as Dr. Mario Therrien, of AAFC Brandon, Dr. Brian Rossnagel of the U of S CDC, and Dr. Jim Helm of AAFRD Lacombe have all worked on screening and developing barley cultivars with superior food quality. They've found some good variation in barley properties that bode well for developing tailored food varieties. On this breeding end, a fundamental breakthrough that has jump-started barley's potential in food has been the development of hulless barley.

"For the food industry, the hull is not only a useless item, it's a negative because it doesn't grind up well during processing," explains Rossnagel. "The processors are used to using 'naked grains,' so that's where hulless barley really opens up the food potential."

Fusarium boot camp
identifies promising low-DON lines

Better information on how lines respond to FHB and its mycotoxins will help growers choose the best varieties to lower their risk.

When it comes to topics that spark equal frustration among Prairie farmers and cereal breeders, Fusarium Head Blight (FHB) is arguably at the top of the list.

In the field, it's become the top barley disease challenge – particularly in the eastern prairie – causing losses upwards of $100 million in peak years, with no significant control options on the horizon. On the research front, the picture is just as bleak – no major new resistance sources and a complexity causing many to dub FHB the most challenging cereal disease of the past century.

Now, a new disease screening effort is bringing a much-needed ray of light. Researchers are using an FHB screening nursery, established in Brandon, Man., in 1998, as a unique Prairie "boot camp" to test thousands of barley lines under high Fusarium conditions.

Unique facility

The nursery, combined with a smaller effort at Glenlea, Man., provides a unique and valuable resource for breeders across the country, says barley breeder Dr. Bill Legge, of AAFC Brandon. It is run by specialists in pathology and breeding, along with a team of technicians, who screen thousands of lines annually for resistance to FHB and for lower deoxynivalenol (DON) content. DON is the mycotoxin produced by the FHB-causing pathogen, *Fusarium graminearum*. The results have dramatically boosted the speed and efficiency of breeders to identify barley varieties with lower susceptibility to Fusarium and select promising lines for breeding.

Limiting DON levels is a crucial part of the effort, says Legge. "Progress in this area would allow producers to regain access to malting barley markets, and to grow feed barley with low DON levels for the expanding hog industry."

Resistance sources have been available, most notably in Chinese germplasm, but the sources are difficult to use, says Legge. Generally, they are poor agronomically, susceptible to other diseases and have poor quality. Researchers continue to pursue the challenge of incorporating these resistance sources into adapted material, and are making incremental progress.

Targeting the top prospects

While the acronym DON stands for the mycotoxin deoxynivalenol, for eastern prairie barley growers it has spelled restricted markets and major economic losses. The most common mycotoxin produced by Fusarium, it causes gushing in beer and can threaten the health of livestock and people.

While years of painstaking work lie ahead before resistant varieties become available to farmers, Legge reports that significant progress in variety evaluation and disease testing will help growers reduce their risk by taking advantage of the variable disease reactions in existing barley material.

"We are making progress and all barley breeding programs have some moderately resistant material to work with, but unless there is an unforeseen breakthrough, resistance to pathogen infection will likely be a long-term project," he says.

In general, the researchers have found that two-row barley varieties tend to have a lower mycotoxin content than six-row varieties, says Legge. Among the two-row malting varieties, the best performers have a moderate level of resistance; they include AC Bountiful, AC Metcalfe, CDC Stratus and CDC Kendall. Most six-row varieties are susceptible, but one bright spot is CDC Sisler. Performance varies in hulless varieties, with CDC Freedom delivering the most promising results.

Winning
the disease battle

The top programs have individual sources of resistance to nearly all of the major traditional barley diseases and are combining them in new varieties for superior, long-lasting protection.

Fusarium Head Blight (FHB) may be the disease that dominates the coffee shop talk, but behind the scenes, breeders have made major progress against a range of top barley diseases that perennially show up in the field.

"It's important to remember there's still a large area of the Prairies that has largely escaped FHB damage," says Dr. Brian Rossnagel of the U of S CDC. "And overall, there are several diseases that are high priorities for growers. FHB will continue to be a major challenge, but in the meantime the Prairie breeding programs have made some pretty significant improvements in resistance to other diseases that will have a more immediate impact."

In fact, new varieties from the Prairie programs feature new sources of resistance to nearly all of the major barley diseases, says Rossnagel. The target now is to combine several of these resistance sources in the same varieties.

"Every year, the lines we see moving through the co-op testing system are showing a stronger overall disease package," he says. "For example, we've identified several new sources of resistance to scald, which is very important in Alberta and northwestern Saskatchewan, and we've seen some strong progress in net blotch, another high-priority disease."

This progress is allowing researchers to shift more attention to other rising disease concerns, says Rossnagel. "There are other emerging disease issues besides Fusarium. Diseases such as spot blotch and septoria aren't necessarily new, but they've become much more important in recent years – a lot of this probably has to do with the same environmental and climatic conditions that have favoured the build up of Fusarium. Now that we're getting some of the more traditional disease concerns in better shape, there's more room to concentrate on these ones."

Collaborations at home and abroad fuel breeding

A key for Prairie breeding programs is sharing and testing material across the region, say Dr. Jim Helm and Dr. Joseph Nyachiro of AAFRD Lacombe. Disease pressures, even more so than other agronomic concerns, vary widely depending on the soil zone and microclimate.

When it comes to finding brand new sources of resistance, international collaborations are another valuable resource, they say. For example, the major Prairie breeding programs are benefiting from partnerships with the CIMMYT research program in Mexico, which had been run by the recently retired Dr. Hugo Vivar. The CIMMYT program, a world leader in resistance to cereal diseases, has combined many sources of resistance into the same genetic backgrounds.

"CIMMYT has the perfect environment to screen large numbers of populations to a lot of diseases," explains Helm, who has made major advances in scald resistance in part through his program's relationship with CIMMYT. Multi-gene scald resistance has helped Seebe, an AAFRD Lacombe variety, become the variety of choice for silage use in high scald areas of Alberta. "Scald is the number one disease that takes yield in Alberta, so advances in resistance have been a pretty big deal to producers."

AAFRD Lacombe's latest six-row, semi-dwarf, feed variety, Vivar, was named after the CIMMYT breeder for its solid, across-the-board disease resistance for the western prairies.

Cutting pollution
from hog manure

New "low-phytate" hulless barley lines promise to benefit both barley growers and livestock producers.

New hulless barley lines under development can reduce the potential of pollution from hog manure and boost barley's feed value.

The new barley will benefit both the environment and the agriculture industry in Western Canada, which has seen a dramatic expansion in hog production over the past five

years, says barley breeder Dr. Brian Rossnagel at the U of S CDC. Rossnagel hopes to have Breeder seed of the most promising line available as soon as 2005, and Certified seed available to farmers a few years later.

"We see significant advantages for both barley growers and hog producers," says Rossnagel. "Growers will have a higher valued product to sell, and hog producers can reduce the impact their operations might have on the environment."

Breaking digestion barriers

Rossnagel is developing the barley lines in collaboration with Dr. Victor Raboy of the USDA in Aberdeen, Idaho. What makes the lines unique is that they are low in phytic acid – a form of phosphorus that is almost indigestible by monogastric livestock and typically ends up in manure, says Rossnagel. Approximately 70 percent of the phosphorus in conventional barley is in the form of phytic acid.

The new low phytate (LP) barleys contain the same amount of phosphorus, but in a form that is more available for pigs and poultry, he says. The line most likely to result in the first commercial variety has 50 percent less phytic acid than conventional barley.

"There's still some phytic acid in our barley lines so we haven't eliminated phosphorus in the manure, but it's a definite improvement," he says. Several studies in the U.S. show that feeding LP corn and barley significantly reduces the amount of phosphorus in manure, reducing the potential for pollution.

Environmental benefits

Environmental benefits are what will ultimately drive LP barley, says Dr. Jim Helm of AAFRD Lacombe, another institution at the forefront of LP barley development. He points to new U.S. legislation that has shifted manure spreading guidelines from a nitrogen base to a phosphorus base. Canada may move in the same direction.

"A phosphorus base may require four to five times as much land to spread the same manure on as the nitrogen base – this becomes a very big environmental cost," says Helm. "If you look at the Alberta example, with its huge livestock industry, over 50 percent of the land in central Alberta would be needed to spread animal manure. That's potentially a real big problem that could limit livestock industry growth. Improvements in LP barley will help the crop compete with other options such as low phytate corn."

Reducing costs, pound for pound

LP barley also has good potential to reduce livestock production costs, says Rossnagel. Phosphorus is an essential nutrient for both plants and animals and Canadian regulations require retail feed manufacturers to add dicalcium phosphate to every ration to meet minimum levels of available phosphorus.

"On a pound-for-pound basis, dicalcium phosphate is one of the most expensive ration ingredients," he says. "If we can reduce the amount required, there should be an economic benefit for producers."

LP barley at the U of S CDC is based on germplasm first developed by Raboy's team in Idaho, says Rossnagel, who is sharing resources with his U.S. colleague.

New generation forage barley takes off

The top varieties provide cattle producers with multi-purpose feed options for silage, greenfeed, grazing and grain.

When it comes to silage barley, the numbers tell the story, says Dr. Jim Helm of AAFRD Lacombe.

The long-time barley breeder remembers the early days of his breeding program, when in 1977 a review was conducted of silage production in Alberta. The tally came to around 200,000 acres. Today, following years of massive cattle industry expansion, that figure is up to 1.2 to 1.5 million, and the industry has spread from its Alberta base to pockets across the Prairie.

"The importance of silage barley is often overlooked, but it's hard to deny," says Helm, developer of top silage varieties for beef cattle, such as Seebe, and for the dairy industry, such as Falcon. "To carry our livestock herds under normal years, we need well over one million acres or more of silage in this province alone, and barley is the number one silage crop."

Standability top priority for high production areas

As an Alberta-based program, AAFRD Lacombe has long placed a heavy priority on developing barley characteristics for silage, as well as for other feed options such as grazing, greenfeed and grain. For producers, the top priorities are yield, lodging and disease resistance, he

says, each of which vary in importance depending on location and production levels. This is what breeders are concentrating on in the new generation of forage varieties.

"For example, under the high production and irrigation areas where there's lots of manure spreading, standability is the number one concern – that's where the semi dwarfs have a unique advantage," says Helm. "When you get into some of the lower-yielding areas, the emphasis really becomes total biomass."

Among highlights in recent years, the Lacombe program has released Tyto, a new generation hulless variety designed as a higher yielding, stronger strawed, disease resistant replacement to Falcon for dairy silage. It has also released Trochu and Vivar – two feed varieties that provide superior feed characteristics. These add to other top notch feed varieties from western Canadian programs, such as CDC Dolly, CDC McGwire and the newer CDC Helgason and AC Ranger, that are collectively raising the bar on feed barley performance.

New class designation to support forage barley

Further into the future, a new Forage Barley Co-operative Trial initiated in 2002, will help pave the way for registration of improved forage barley varieties, says Dr. Mario Therrien of AAFC Brandon. This more formal recognition of forage barley as a class unto itself will allow breeders to concentrate more narrowly on specific forage quality characteristics.

"The industry is recognizing that forage barley is a class by itself," says Therrien. "Tonnage is always the big concern for producers, but the quality of that tonnage is also important."

Biotech
boosts barley breeding

New tools and techniques add speed and precision, resulting in a jump in research progress and a shorter time for those improvements to make it to the field.

What will the world of barley breeding look like in the year 2020? Judging by the dramatic aspects of biotechnology that make headlines, the question might conjure images of day-glo barley kernels with everything from fish genes to pharmaceuticals.

But this is far from reality, says Dr. Mark Jordan, head of cereal molecular genetics at AAFC Winnipeg. For barley researchers across Western Canada, biotechnology simply means practical tools and techniques that help produce better varieties, faster. The evolution of this technology has been slow in barley and will likely continue to progress in small, natural steps.

"The molecular approaches used in barley breeding today have been focused on backing up the breeding programs with molecular markers for important traits the breeders were looking for," says Jordan. "For example, in the case of a disease trait, instead of having to go and screen thousands of lines outside, by inoculating fungus, breeders can quickly screen for a DNA tag in the laboratory.

"More recently, things have moved along into some new areas that are further removed from the day-to-day operation of the breeding program, ones that we think could be integral to a breeding program of, say, 2020," he continues. "One natural step forward is pinpointing, at a molecular level, the actual genes for a lot of these traits."

Breeding and genetic technology is likely to continue moving gradually in the molecular direction, he says. But while progress has been calculated and conservative, biotechnology is already making a significant impact to improve the conventional breeding process.

Molecular markers – fingerprinting genetic traits

One major innovation is the emergence of molecular marker technology, he says. Markers act like "DNA fingerprints" that make it easier for breeders to identify valuable genetic traits. Rather than having to identify the desired gene itself, breeders can rely on markers that are closely linked to areas of the chromosome that control specific traits, such as disease resistance or malting quality. Markers allow breeders to identify traits in the lab rather than in the field or from micro-malting, which can save time and money, and they help produce more reliable and consistent results.

"Eventually, with these approaches, we could find the actual genes for a lot of these traits," says Jordan. "Molecular markers are essentially a DNA tag that is somewhere near the gene. By using these as a starting point it is now possible to move along the chromosome from the marker to the actual gene involved."

Doubled haploid technology – a short cut to pure lines

Another rising technique is doubled haploid breeding, which involves producing plants from two identical sets of chromosomes.

Doubled haploid regeneration allows breeders to develop pure breeding lines in just one generation rather than the roughly eight needed with traditional breeding methods, explains Jordan. A major advantage of this technique is that it allows a much faster response to disease epidemics and other challenges.

Gene pyramiding – strengthening and adding mileage to key traits

A more recent approach related to marker development is gene pyramiding. Many common barley pathogens mutate over time and eventually overcome individual sources of resistance. Gene pyramiding – using molecular markers to identify and breed multiple sources of resistance into one barley variety – dramatically reduces the pathogen's chances of breaking down the resistance, says Jordan. This technique requires extensive preliminary work in marker development, but is becoming more common in breeding programs, resulting in much stronger and longer-lasting traits.

CLASS-BY-CLASS UPDATES

Malting & brewing

A new generation of varieties lead Canada's charge for barley's most lucrative market.

Malting and brewing remains the most profitable barley market. Despite low production years such as 2002, approximately 2.3 million tonnes of western Canadian barley are typically accepted for malting each year. Canada's malting industry remains the top customer, purchasing over one million tonnes annually. However, it's international brewers who ultimately use 80 percent of malt derived from western Canadian barley.

Traditional two-row malting barley remains the favourite of the domestic malting and brewing industry, and of a large chunk of the export market. The variety front has seen a major changing of the guard, as Harrington, after two decades as Canada's number one malt barley, finally gives way to a new generation of malt varieties. The new acreage leader, AC Metcalfe, along with other newcomers such as CDC Kendall and CDC Stratus, represent major improvements in yield, disease resistance and overall agronomics.

Globalization and change of ownership has affected the outlook of the malting and brewing industry over the past 10 years. The market is diverse, and culture and taste determine what constitutes a good beer in different areas of the world. The industry continues to experiment with blends of different varieties to tailor malt and beer for specific markets.

The major push into developing resistance to Fusarium Head Blight (FHB) disease is proving an immense challenge, but is beginning to show some progress in identifying lines that have lower levels of the DON mycotoxin. Elsewhere on the disease front, breeders have made substantial progress in all major diseases, and are turning their attention to emerging concerns such as spot blotch. Yield and other key agronomic traits have also increased substantially across the board.

For the future, breeders are exploring the potential of hulless malt varieties. The traditional brewing process relies on barley hulls to act as a filter, but new "pressure mash" filters may eliminate this need. Pressure mash filters are not yet used in North America, but they are being considered for new and upgraded facilities. Hulless varieties have the benefit of providing more extract than hulled barley, but they are prone to embryo damage from handling and germination can be affected. With more breeding work, scientists hope to solve these problems.

One of the most prominent shifts in Prairie barley acreage in the early part of the past decade has been to American-style, white-aleurone six-row malt varieties, but this has dropped off in recent years, due in part to the FHB threat, the advent of new two-row varieties for the eastern prairie and a range of commercial dynamics.

New in the field and on the way

Note: Variety descriptions are a rough sketch of key traits; they are not comprehensive. Years listed beside variety names indicate first year of registration. It typically takes two or more years before seed becomes widely available to farmers.

CDC Stratus (1994). Two-row malting barley with early maturity, plumpness and lodging resistance. U of S CDC.

CDC Kendall (1995). Two-row malting barley with early maturity and potential for high-yield. U of S CDC.

CDC Sisler (1996). Six-row malting barley that is widely adapted and has good yield. One of the best six-row varieties for FHB resistance. U of S CDC.

AC Metcalfe (1997). Two-row malting barley that is higher yielding than Harrington and has earlier maturity than Manley, moderate resistance to covered smuts, net blotch and FHB. AAFC Brandon.

Merit (1998). Two-row malting barley with good yield and moderate resistance to net blotch and FHB. High plump-to-extract ratio. Busch Agricultural Resources Inc.

AC Bountiful (1999). Two-row malting barley with high yield, good resistance to the smuts, moderate resistance to net blotch and FHB, and malting quality similar to Harrington. AAFC Brandon.

CDC Copeland (1999). Two-row malting barley featuring high yield, good plumpness, test weight and maturity. A unique malting quality profile. Moderate net blotch and stem rust resistance. U of S CDC.

CDC Yorkton (1999). Six-row malting barley with good plumpness and moderate resistance to net blotch. U of S CDC.

CDC Battleford (2000). Six-row malting barley with improved yield, plumpness, kernel weight and net blotch resistance. Shorter straw than B1602 or Tankard. Very good overall quality with low beta-glucan. U of S CDC.

Newdale (2001). Two-row malting barley featuring 24 percent higher yield potential than Harrington. Shorter and stronger straw than Harrington. Moderate resistance to spot blotch. Malting quality near Harrington, with greater hull adherence and friability. AAFC Brandon.

Legacy (2001). Six-row malting barley with higher yields than B1602 and CDC Sisler, and resistance to old stem rust races and surface-borne smuts. Busch Agricultural Resources Inc.

Calder (2002). Two-row malting barley adapted to Manitoba and Saskatchewan, with 12 percent higher yield potential than Harrington. Resistance to loose smut, moderate resistance to the surface-born smuts and FHB, quality intermediate between Harrington and AC Metcalfe, with high extract and better hull adherence. AAFC Brandon.

CDC Springside (2002). Six-row malting barley with higher yields than CDC Sisler and better test weight than check varieties. U of S CDC.

BT954 (2002). Six-row malting barley that outyields CDC Sisler and has very high enzyme levels suitable for American-style light beer. Agricore United.

Lacey (2002). Six-row malting barley that matures earlier, and is shorter than CDC Sisler. University of Minnesota.

CDC Tisdale (2002). Six-row malting barley that outyields B1602 and CDC Sisler, with moderate resistance to net blotch. U of S CDC.

CDC Select (2002). Two-row malting barley with 11 percent higher yield potential than Harrington across the Prairies, and with quality tailored to North American brewers. Good kernel weight, better plumpness than Harrington and Manley. Good resistance to lodging, net blotch and stem rust. Maturity between Manley and Harrington. U of S CDC.

The leading varieties seeded in 2002

(Source: 2002-03 Canadian Wheat Board variety survey.)

Two-row malting acreage		Six-row malting acreage	
*AC Metcalfe	37.8 percent	*Robust	38.9 percent
*Harrington	25.9 percent	*Excel	29.1 percent
*CDC Kendall	11.3 percent	*B1602	11.6 percent
*CDC Stratus	8.8 percent	Stander	7.3 percent
*Stein	6.2 percent	*CDC Sisler	4.5 percent
*Merit	5.4 percent		

* Selected for the Recommended Malting Barley Varieties List for 2003-04, released by the Canadian Malting Barley Technical Centre (CMBTC).

Livestock feed *and* forage

A move to tailored varieties for specific livestock is diversifying and adding value to Canada's top volume market for barley.

The one-size-fits-all approach was fine for the early days of feed barley. Scale, sophistication and competition were all lower and had less impact, and the livestock sector provided a handy secondary market for unselected malt varieties.

Fast-forward to the mid-'90s and beyond and the picture is dramatically different. Margins are tight, competition is high, and the realities of scale mean significant dividends are possible from even incremental improvements in feed value.

The age of feedgrains tailor-made for livestock feeding has arrived, and it's one western Canada's barley breeders have long prepared for. The popularity of specific feed and forage varieties is rising as demands become more specialized. Today, specific feed and forage varieties make up approximately 25 to 40 percent of barley acreage and an even greater percentage of the breeding effort.

Indications are that as much as 80 percent of all barley grown in Western Canada is used as livestock feed. The recent low barley production years aside, about five million tonnes of feed barley per year go into Canadian beef, 1.5 million tonnes into hogs, one million tonnes to dairy cows and 500,000 tonnes to poultry. Feed barley is, however, facing strong competition from imported corn, CPS feed wheat and other options.

Among hulled varieties, cultivars such as CDC Dolly and Vivar have raised the bar on yield, uniformity test weight and disease resistance. Hulless barley, geared primarily to the hog industry, has struggled in recent years, due largely to a variety of handling, processing and economic factors. A new research effort is directed at lowering the phytate content of hulless barley, which could re-kindle incentive for the crop.

Down the line, new breeding efforts toward barley with a slow rate of dry matter disappearance are expected to pay off for cattle producers. With the use of molecular techniques, scientists also hope to develop barley that has lower, but tailored protein. This way, more starch and/or fat can be incorporated to suit other purposes. Additionally, as the use of antibiotics is cut back in the livestock industry, preventative animal health is becoming increasingly important. This poses a further incentive to breeders for improving the inherent health benefits of grain.

Further forage barley developments are meeting demand for producers seeking multi-purpose varieties that are suitable for silage, grazing, greenfeed or grain.

New in the field and on the way

CDC Fleet (1996). Two-row feed barley with early maturity, good grain quality and strong straw. U of S CDC.

AC Rosser (1996). Six-row feed barley with good yield and disease resistance. AAFC Brandon.

AC Harper (1996). Six-row feed barley with good lodging resistance, good plumpness, and good disease resistance for the western prairies. AAFC Lethbridge.

AC Hawkeye (1996). Six-row hulless feed barley with good plumpness, threshability and yield. AAFC Brandon.

CDC Thompson (1996). Two-row semi-dwarf feed barley features strong straw strength, good quality and disease resistance. U of S CDC.

CDC Gainer (1997). Two-row hulless feed barley with low beta-glucan and good straw strength. U of S CDC.

Tercel (1997). Two-row hulless feed barley features good yield, intermediate height and shattering resistance. AAFRD Lacombe.

CDC Freedom (1998). Two-row hulless feed barley with improved threshability, straw strength and net blotch and FHB resistance. U of S CDC.

AC Bacon (1998). Six-row hulless feed barley with high yield potential and good disease resistance package. AAFC Brandon.

Jaeger (1998). Six-row hulless feed barley features short stature, good yield and straw strength, and neckbreak resistance. AAFRD Lacombe

Mahigan (1998). Six-row semi-dwarf feed barley with disease resistance and early maturity. AAFRD Lacombe

Condor (1998). Two-row hulless with high feed efficiency and protein balance. Yields 15 percent over Scout, is one to two days earlier and heavier than Scout, and has good root rot resistance. AAFRD Lacombe.

Xena (1999). Two-row feed barley with lodging resistance, high yield potential and good plumpness. Particularly suited to brown soil zone. Western Plant Breeders.

CDC McGwire (1999). Two-row hulless feed barley features combination of good yield, threshability and disease resistance for Western Canada. U of S CDC.

CDC Speedy (1999). Two-row hulless feed barley features very early maturity for delayed seeding situations. U of S CDC.

CDC Bold (1999). Two-row semi-dwarf feed barley with improved quality, straw strength and scald resistance. U of S CDC.

Niska (1999). Six-row hulled semi-dwarf feed barley with good straw strength, plumpness and lodging resistance. AAFRD Lacombe.

Peregrine (1999). Six-row hulless semi-dwarf feed barley with good straw strength, lodging resistance, and disease resistance for the western prairies. AAFRD Lacombe.

Vivar (2000). Six-row semi-dwarf feed barley. Higher yielding than all check varieties (AC Lacombe, Tukwa, CDC Earl) with high test weight, percent plump and kernel weight. Excellent disease resistance for the western prairies. Maturity equal to AC Lacombe (medium). AAFRD Lacombe.

Trochu (2000). Six-row feed barley with high percent plumpness, test weight and kernel weight. Higher yielding than AC Lacombe with smooth awns. The high percent plump kernels facilitate even processing for cattle feed resulting in increased feed efficiency. AAFRD Lacombe.

CDC Helgason (2000). Two-row feed barley that is high-yielding, heavy and plump, with disease resistance for the eastern prairies. U of S CDC.

AC Ranger (2000). Six-row forage barley variety with high grain yield potential, good disease resistance for the eastern Prairies and straw strength. AAFC Brandon.

CDC Trey (2002). Two-row feed barley targets the eastern prairie, with very strong straw strength, early maturity and higher test weight than CDC Dolly. U of S CDC.

Niobe (2002). Two-row feed barley with earliness and good lodging resistance. Higher yields than check varieties especially under high yielding conditions. AAFRD Lacombe.

Tyto (2002). Six-row feed barley that has higher grain, seed and silage yield than Falcon, as well as strong straw. AAFRD Lacombe.

Rivers (2002). Two-row feed barley with high yields, early maturity, excellent disease resistance package for eastern prairies. AAFC Brandon.

Food *and* industrial

Tortillas and breakfast cereals are just a start. Barley's unique nutritional qualities and properties are opening the door to a wide range of human food and industrial uses.

Free-radical scavengers, waxy mutations, beta-glucan boosters – while these may sound like characters out of the latest sci-fi thriller or video game, for barley breeders they are the building blocks behind a new push to specialty food and industrial markets for barley.

Barley has unique physical properties and nutritional components that have potential uses in a broad range of sectors. This is what breeders are tapping with creative breeding to generate new options for growers and the industry. Progress in hulless barley is a major factor in opening the door to these opportunities – this type of "naked" barley has greater value for human consumption because key vitamins and minerals are not lost in pearling.

One of the fastest developing niches is the specialty starch market. The first varieties developed for this niche are "waxy" types, which are high in the amylopectin component. Amylopectin is used in products such as cream fill for pastries; as a stabilizing starch, it prevents the cream from running.

For future varieties, researchers are exploring other potential barley products such as breakfast cereal, noodles, pearled barley for a Japan-targeted "minute-rice" type product, beta-glucan enhanced food additives and blending flour. That effort concentrates on tailoring the functional properties of barley, and taking advantage of the natural nutritional components of barley starch. One such component – beta-glucan – is an important source of soluble dietary fibre that is reported to reduce cholesterol. Other nutritional components breeders aim to boost in barley include everything from Vitamin E to "free radical scavengers" – antioxidants important in the prevention and treatment of diseases.

Currently, less than five percent of Canada's barley crop is aimed at food markets, but this has potential to grow exponentially. Further industrial uses that require stable starches offer other promising opportunities.

New in the field and on the way

CDC Candle (1994). Waxy, basic agronomics. U of S CDC.

Merlin (1995). Waxy, semi-dwarf, lodging resistance, good plumpness. Western Plant Breeders.

HB 803 (1995). Two-row waxy hulless barley. Tall semi-dwarf with excellent lodging resistance, high test weight and plumpness, resistant to scald and loose smut, moderate resistance to surface smuts. Western Plant Breeders.

CDC Alamo (1999). Two-row waxy hulless barley, with pure amylopectin starch. U of S CDC.

BACKGROUND ON THE BREEDING SYSTEM

How Western Canada develops barley varieties

A short course on today's barley breeding and registration process.

Breeding and registration are the nuts and bolts of the barley 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 barley 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 barley variety still typically takes about eight to 13 years, so setting targets requires a long-term view. Along with barley quality standards set by the federal Canadian Grain Commission, the following are the general targets that most breeders pursue:

Quality. For feed, improve energy, uniformity, plumpness, digestibility and nutrition. For malt, improve extract and other malting quality characteristics. For food, develop and improve processing and cooking traits. For forage, decrease spoilage and improve cattle intake.

Yield. Increase yield over the accepted standard. In malt, yield gains are balanced with quality maintenance. However, yield receives more emphasis in feed.

Disease. Improve resistance to traditional diseases and respond to new disease pressures. Main priorities: scald in Alberta, net blotch in central and eastern prairies, Fusarium Head Blight and spot blotch in southeastern Saskatchewan and southern Manitoba.

Agronomy. Develop varieties for diverse production conditions. Key traits include: straw strength, maturity, height, stress tolerance and yield stability.

Setting breeding priorities

For most breeding institutions, barley breeding 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.

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

Market feedback. Predicting markets is difficult, so breeders hedge their bets by getting feedback from the major marketers, industry and end-use customers. Over the past decade, two of the most prominent market trends have been an expanding domestic livestock industry and diversifying domestic and international malt barley markets.

Farmer demand. Market demand for 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. Development of barley is also driven in part by farmer demand.

Innovation opportunities in germplasm. The most risky, but often most rewarding priority to pursue is innovation. Market and production needs drive innovation, but often

it's a matter of breeders seeing an opportunity and going for it. A good example is specialty starch barleys, which have opened new doors for food and industrial uses. Germplasm is the term for the genetic raw material breeders have to work with. The ability of researchers to understand and identify opportunities in germplasm is a major source of innovation.

Interest groups. Breeding is only one link in the barley development chain that includes a range of groups, such as producers, grain handlers, processors related industry, marketers, regulators and customers. Since breeding success depends on the strength of the overall chain, breeders rely heavily on feedback from these groups to set priorities. In Western Canada, key organizations include:

- **Alberta Barley Commission** – Producer organization representing barley growers in Alberta. Administers a producer check off on all barley sales in the province. Funds go to various barley research initiatives that include breeding, policy, marketing and producer services.
- **Barley Development Council** – Organization representing a wide range of groups with an interest in barley development, including Prairie researchers, industry and producers. Establishes research priorities, promotes collaboration and serves as a forum for issue discussion.
- **Brewing and Malting Barley Research Institute (BMBRI)** – Industry organization representing nine major malting and brewing companies. On their behalf, supports the development and evaluation of new malting barley varieties that will meet their needs. Trials are carried out at members' facilities, with results being contributed to the public variety registration system. Also supports basic research through annual research grants. Communicates industry needs to barley breeders and researchers, and information on malting barley quality factors to producers.
- **Canadian Grain Commission (CGC)** – Federal agency responsible for overseeing barley quality assurance in Canada. Operates the Grain Research Laboratory (GRL), which performs fundamental and applied barley quality research. The GRL plays a leading role in co-ordinating and evaluating the malting quality of two- and six-rowed barley entries in the western Canadian cooperative tests. Through the PRRCG, it participates in deciding which lines will advance to the collaborative pilot scale malting trials. The GRL is also working with plant breeders to develop barley varieties for malting and food uses.
- **Canadian Wheat Board (CWB)** – Responsible for marketing all malting barley and food barley produced in Western Canada. Also responsible for marketing all feed barley produced in the region for export. Undertakes comprehensive market development of new malting varieties domestically and internationally. Provides feedback from customers and information on market strategy.
- **Canadian Malting Barley Technical Centre (CMBTC)** – Set-up to provide applied research, education and technical support for Canadian malting barley marketers, processors and their domestic and international customers. Additional goal to support development, commercialization and marketing of new Canadian malting barley varieties. Initial capital and start-up investment for CMBTC was provided by the CWB. CMBTC currently includes 11 members in the areas of grain regulatory and marketing services, barley breeding, seed marketing, and commercial malting and grain handling.
- **Western Grains Research Foundation (WGRF)** – Producer organization representing 17 diverse agricultural organizations in Western Canada. Administers a producer barley check-off on CWB final payments in Saskatchewan and Manitoba. Funds go to barley breeding research. They are allocated based on long-term funding agreements, which also outline specific breeding targets. WGRF's regular review process includes input from a Barley Check-off Advisory Committee, comprised of farmers, barley breeders, marketing and quality specialists.
- **Various feed interest groups.** The animal nutrition research community – primarily based at the University of Alberta, University of Saskatchewan, University of Manitoba and Agriculture and Agri-Food Canada – works to help guide feed barley improvements. Various feed industry groups have also contributed ideas and support into barley research – this has traditionally been a small effort but has more promising future potential.

The breeding process

Once priorities are established, the breeding process begins by gathering genetic material from around the world. Researchers often test thousands of barley lines to find those with genetic traits useful to the breeding program. Then they 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 barley 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.

In the final years of breeding, breeders exchange material across the prairies to test performance in a range of

climates and environments. The lines that perform well then enter formal registration testing.

Registration testing

The final stage of barley variety development is registration testing, known as "co-op trials" because several breeding centres exchange material for two years of testing across the prairies.

There are four separate co-op tests: two-row, six-row, hulless and forage. Each includes agronomic, disease and quality evaluations. Malting barley lines must go through an additional two years of Collaborative Malting Quality Tests, conducted at the pilot-scale level by the industry (co-ordinated by the BMBRI in Winnipeg.) All lines must show equal-to-or-better-than performance over standard or "check" varieties to gain registration support, but breeders typically strive to release only varieties with distinct advantages over the check.

The barley lines that survive this rigorous testing process can be proposed by the plant breeder for support for registration, at the Prairie Registration Recommending Committee for Grain (PRRCG) meetings held every February. The Barley and Oat Subcommittee, which includes nearly all major Prairie barley development researchers, and end-user and producer representatives, critically examines the performance data from co-op tests and collaborative trials and decides which to recommend for registration.

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

Commercializing the variety

Malt varieties typically face a tougher time than feed varieties on the road to commercialization. By the time a feed variety is registered, its benefits are usually established well enough to proceed with seed multiplication and marketing. But malt varieties must also demonstrate commercial acceptability to the end-user, namely the maltster and brewer. Among other requirements, this involves additional time for plant-scale testing, which is considered essential for a new malting barley variety to have any chance of commercial acceptance.

Seed marketing is the next step. Some private breeding institutions choose to market varieties themselves, while others license the marketing rights to other companies. For public breeding institutions, some have licensing agreements with industry partners; others seek those agreements through the commercialization processes, variously referred to as tendering, open bid or request-for-proposals processes.

Tendering involves reviewing the proposals from seed companies that want to license and market the variety. Public institutions select the best bid, based on a range of factors including the ability to make seed quickly available to the intended farmer market. Royalty revenues and licensing fees that help recover breeding costs are other important considerations. In some cases, the interests of funding partners who have contributed to the development of a variety also come into play. Farmer representatives are included in the tendering process in the case of farmer-funded varieties.

The open bid process is similar to tendering, with the exceptions that the breeding institution has the option to not accept bids and it may negotiate openly with one or several seed companies.

Seed multiplication

Once a commercialization strategy is established, seed companies arrange seed multiplication for the variety and market it to farmers. The Canadian Seed Growers Association oversees this two-to-four year process, which includes several phases: Breeders Seed, Select, Foundation, Registered and finally, Certified seed, which becomes commercially available to farmers.

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