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Spotlight on AWC-funded

Research

Alberta Wheat COMMISSION

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Investing in wheat research projects that maximize crop performance and increase farmers' access to high performing varieties.

As a major funder of strategic wheat research, the Alberta Wheat Commission (AWC) makes it a priority to invest in projects that will result in better returns for farmers. Our research investments promote maximum crop performance and consistent access to new, premium varieties. We prioritize farmers' needs through improved genetics, pest management and technology advancements that support better efficiency.

AWC is proud to have built a research portfolio valued at more than $2 million annually. Our research program is highly collaborative with the intent of leveraging additional producer-focused investment through our funding partners. AWC typically invests in projects in the areas of crop establishment and growth, integrated pest management, genetics and 'omics', quality and processing, and winter wheat. Throughout this publication, you'll find AWC-funded projects that highlight several of these areas and demonstrate the valuable work happening in our research community.

More information on AWC's research program, as well as descriptions of projects we've invested in, can be found at **albertawheat.com**

Stories written by Geoff Geddes | The Word Warrior
www.thewordwarrior.ca

Our research came about because herbicide resistant weeds are a big issue in western Canada and getting worse. There are also issues in organic farming where they don't have sprays for certain weeds".

Rolling Out the "Unwelcome" Mat for Weeds

With winter turning to spring on the Prairies, growers hope to give weeds the cold shoulder, and research on *"In-Crop weed clipping for weed control"* may help them do that.

We usually target weeds at the seed leaf stage so they're dead before they produce any seeds that could compete with your crop," said Dr. Steve Shirtliffe, professor of agronomy in the Department of Plant Sciences at the University of Saskatchewan.

"Our research came about because herbicide resistant weeds are a big issue in western Canada and getting worse. There are also issues in organic farming where they don't have sprays for certain weeds."

When weeds escape herbicide control, the seeds they generate can persist for lengthy periods. A number of tools exist to combat the problem, such as the Integrated Harrington Seed Destructor (IHSD). Integrated at the rear of a combine harvester, IHSD kills weed seeds contained in harvest trash and returns inert organic matter to the field.

A GOOD KIND OF COMB OVER

For this project, researchers tested the Swedish-designed CombCut machine. According to the developers, the CombCut's static knives catch and cut broadleaf weeds and volunteers, while slender crops like wheat should slip through unharmed. In crops too thick or bushy for the machinery to comb through, it can be raised above the canopy to shear off weeds that are outpacing a given crop.

"We have been testing this machine in lentils and wheat, using mostly wild mustard and tame mustard as surrogate weeds. We're finding that in lentils it works very well because they're short, but results in wheat are more of a challenge. Producers expecting to get into that weed canopy to clip weeds should know there is a real limit to how far they can go."

While there was some reduction in weed seed with wheat, it was less than expected, and there were issues with crop damage.

"For farmers considering a machine like this for wheat, I would tell them to think twice about it; having said that, they may find a use for it in another phase of their rotation that will affect wheat. 90 per cent of people growing lentils will follow them with wheat, so this sort of technology could have value as an overall cropping tool to reduce production of herbicide resistant weeds."

As for the effectiveness with wheat weeds alone, it may be too soon to judge. The two years chosen for testing were both dry ones, so the research results might represent a worst case scenario.

"We did see some positive effects in our testing, so we will collate the data and determine the value proposition for producers to gauge if this sort of equipment is worth the investment."

LESSONS LEARNED

Oftentimes, research that doesn't fully achieve its initial objectives can still be a source of valuable knowledge, and this project is no exception. Regardless of what they find regarding weed-busting technology, scientists learned that controlling weeds in the fall has a great impact on the number of weeds emerging the following year. This holds true even in areas that are already brimming with weeds in the weed seed bank.

"That was a surprising revelation that adds to our knowledge of weed seed management. Producers often ask what difference it makes if more weeds go to seed, and we are learning that the difference is substantial. We know a few weed seeds can live for long periods, but most die young. If you prevent that seed production in an area one year, the effect is quite noticeable in the subsequent growing season."

Regardless of final outcomes, the project reinforced the ultimate goal of research in agriculture today: figure out what works, what doesn't, and what has the highest "bang to buck" ratio for producers. Keep that up, and the knowledge base for industry will continue growing like a weed.

DR. STEVEN SHIRTLIFFE

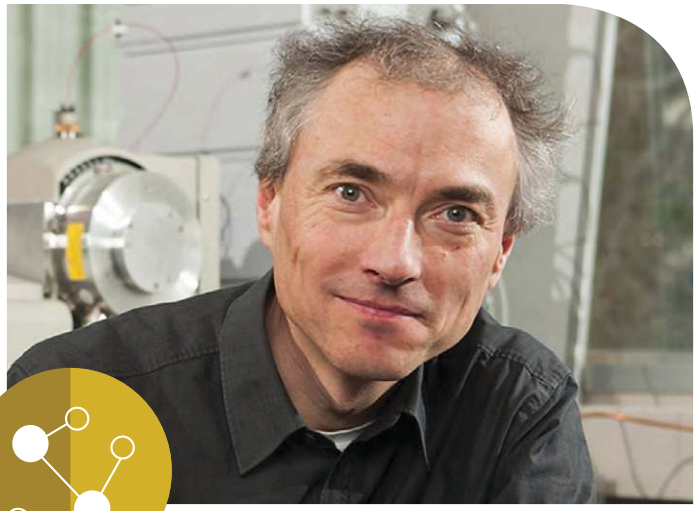
Dr. Steven Shirtliffe is a professor of agronomy in the Department of Plant Sciences at the University of Saskatchewan. He was the first person in Canada to conduct research on harvest weed management and has 20 years of experience in weed control and agronomic trials in western Canada.

Specific highlights of his work include the following: extensive experience in weed control studies in lentil and pulse crops, including mechanical and cultural weed control methods; determination of optimum seeding rates for canola, lentils and field peas; development of integrated cultural management methods for controlling wild oat in tame oat and integrated weed control in lentil.

Dr. Shirtliffe has supervised more than 15 graduate students. He is the author of over 55 peer reviewed scientific papers and book chapters as well as numerous conference proceedings and producer presentations.

Did you know?

- *Half of Canada's arable land is in Saskatchewan.*
- *The Department of Plant Sciences at the University of Saskatchewan is home to a new crop imaging centre that is the first of its kind in Canada.* ***The centre is part of the Global institute of Food Security (GIFS).***
- *A phytoPET device at the centre is helping crop breeders develop new strains of lentils, wheat and canola.*



DR. MICHAEL GÄNZLE

As the replacement of wheat with other cereals in food production became more common, Canadian producers looked for science to shed some light on why certain wheat products are better tolerated than others by those with reaction issues.

Interest in **Fermentation** Technology on the Rise

For lovers of bread and other wheat products, wheat intolerance can be, well, hard to tolerate. For most people, the issue is cut and dried: Non-celiacs can process gluten, and therefore wheat products, and celiacs can't. In the middle, though, are those who don't have celiac disease, yet have trouble digesting wheat-based foods. Fortunately, research is rising to the challenge with the project *"Fermentation technologies for improved nutritional quality and digestibility of wheat products"*.

Fermentation is a baking process where yeasted dough rises, developing volume and flavor. It occurs when yeast converts sugar present in flour into carbon dioxide and ethyl alcohol.

"Over the last few years, we've seen some non-celiacs who have an adverse reaction to wheat. Although we heard from bakers who said their bread didn't cause such a reaction, we had no indication as to why that was."

One of the challenges is that, different from celiac disease where gluten proteins are clearly identified as the culprits that triggers disease, the molecular basis for "gluten sensitivity" — which may be better termed "wheat intolerance" — remains obscure as gluten proteins are likely not the cause for the condition.

As the replacement of wheat with other cereals in food production became more common, Canadian producers looked for science to shed some light on why certain wheat products are better tolerated than others by those with reaction issues.

For the past decade, many people have studied fermentation to see how it can be used in products for celiacs that are 100 per cent gluten and rye-free, said Dr. Michael Gänzle, professor and Canada Research Chair in Food Microbiology and Probiotics in the Department of Agricultural, Food and Nutritional Science at the University of Alberta.

"There is strong evidence that fermentable monosaccharides [the most basic form of carbohydrate] and disaccharides [the sugar formed when two monosaccharides are joined] play a role in adverse reaction to wheat, but not in celiac disease. This gives us good targets to look at in the fermentation and bread production process."

Dr. Gänzle's project includes two streams of research, with the first stream relating to carbohydrate metabolism. Wheat contains 1-3 per cent fructans, which are non-digestible carbs that are rapidly fermented by microbes in the intestine. Significantly, the science is quite solid in linking fructan content in food to negative reactions to wheat in some individuals. The project also targeted specific proteins that are associated with adverse reactions.

On the fructan side, work is well underway in documenting how and why fructans are degraded during fermentation. The hope is that the answers will contribute to a clearer identification of fermentation strategies that dispel negative perceptions of wheat among some consumers.

"On the protein side, many in the research community are making significant contributions in the area of protein digestion. Our aim is to find solutions in the next few years that allow the baking industry to make wheat more easily tolerated in the bigger picture, which could reverse the decreasing use of wheat in overall production."

As part of the project, Gänzle is analyzing aspects of sourdough bread related to taste, smell and shelf life. It appears likely he will demonstrate that better tasting breads are also better tolerated, something he did not see coming.

"If you asked me 10 years ago, I would have said that sourdough bread has nothing to do with gluten intolerance."

He and his team are also intrigued by early findings on the individuality of tolerance and the capacity to determine which people do or do not tolerate certain dietary components.

"The digestion of fructose or gluten is very different for different people, so this project may contribute to an understanding of why humans vary in their digestive abilities."

If all goes as planned, research could unlock solutions that benefit consumers, bakers, growers and the industry as a whole. Now that's an outcome that's easy to swallow.

ABOUT DR. MICHAEL GÄNZLE

Dr. Gänzle is professor and Canada Research Chair in Food Microbiology and Probiotics in the Department of Agricultural, Food and Nutritional Science at the University of Alberta. Trained as a food engineer in his native Germany, he earned a PhD in food microbiology and had a particular interest in sourdough and cereal fermentation.

He came to Canada in 2005 after receiving his first academic appointment. By then he had expanded his research interests to include food safety and preservation.

Current research projects focus on the functional characterization of lactic acid bacteria, production of oligosaccharides from sucrose or lactose, and intestinal microbial ecology with a focus on the use of prebiotic carbohydrates and dietary fibre to improve host health.

Dr. Gänzle has over 230 refereed publications and over 25 extramurally funded research grants.

Did you know?

- *Although sourdough breads that are produced in different parts of the world look and taste very differently, the microorganisms that occur in sourdoughs worldwide are almost exactly the same. San Francisco Sourdough Bread is produced with the same bacteria and yeasts as Italian Panettone or Chinese steamed bread.*
- *Sourdough bacteria have not adapted to baking but are recruited from other ecosystems. Some bacteria come from flowers or insects, some from the intestine of humans or animals, and others from leaves.*
- *Sourdough bacteria not only produce acid but also compounds with sweet, savory or salty taste. Sourdough bread can be produced with less salt and sugar without losing appeal.*

DR. ANDRÉ LAROCHE

DR. DOUGLAS J. CATTANI

Worried About Stress Resistance? Help is at Hand

Even though you can't wear them like you can with blue jeans, finding genes that fit your needs when it comes to disease resistance can still be a comfort. In short, that was the goal of the research project, *"Identifying new genes in domesticated intermediate wheatgrass to improve biotic and abiotic stress resistance and grain quality for wheat"*.

"We were interested in what we might learn about resistance from wheatgrass that could be applied to other wheat lines," said Dr. Jamie Larsen, plant breeder for Agriculture and Agri-Food Canada (AAFC). "We also wanted to study resistant and susceptible wheatgrass lines to more closely examine the genetics of resistance."

After gathering numerous wheatgrass lines, researchers in Lethbridge screened the material for stripe rust susceptibility and found it mostly resistant, but with enough susceptible lines to merit further research. Meanwhile in Manitoba, the same lines were being screened for fusarium head blight (FHB) resistance.

"Similar to wheat, we found a real spectrum of resistance to FHB," said Dr. D.J. Cattani, Assistant Professor - Perennial Crop Breeding, Department of Plant Science in the Faculty of Agricultural and Food Sciences at the University of Manitoba. "On average, though, the wheatgrass showed more resistance than wheat, so that's promising."

Through recent field testing, Dr. Cattani has identified specific wheatgrass lines that appear to have greater FHB tolerance. It's now up to his colleague – Dr. André Laroche – to isolate the genes responsible for variations in resistance using a process called GBS (genotyping by sequencing).

"GBS is a way to examine genes at the DNA level so we can distinguish between different genes among lines of wheatgrass resistant to stripe rust or FHB," said Dr. Laroche, a research scientist with AAFC in Lethbridge. "Using a gene tag, we can follow the genes related to resistance through various wheat/wheatgrass crosses, see which lines contain those genes, and then just select those lines going forward."

Employing the tag is much faster than testing plants when it comes to verifying the resistance level of new wheat lines.

"The tag helps ensure we have the right set of plants in new crosses as we advance the line every generation," said Laroche.

Harnessing the resistance in wheatgrass to make wheat more tolerant, and preserving that resistance for the long run, could have great significance for producers.

"There are two interesting avenues of impact from this research," said Larsen. "Stripe rust is a major concern in Alberta and FHB is a threat across the country. While we have sources of resistance in wheat, the sources present in wheatgrass could be superior."

Because wheatgrass is a perennial, it is challenged by disease every year. Over millions of years, natural selection has built resistant genes that may be more robust than what currently exist in wheat.

Then there is the matter of diversity and its critical role in successful wheat breeding.

"We are always concerned in breeding that the germplasm base has become too narrow," said Larsen. "If a serious disease threat emerges in that situation, crops may be challenged in finding resistance to it. Through our work on this project, we may find new sources of resistance that work really well in those cases."

For wheat producers in western Canada battling FHB, those new sources could reduce their risk.

"There's a reason that AAFC has made disease resistance such a focus over the years," said Cattani. "What we're doing is a similar process; it's all about having more options for resistance and tolerance in the toolkit to introduce in the lines we develop."

If the impact of finding novel resistance tools isn't enough incentive for science and industry, how about the impact of NOT finding them?

"When we look at the prospects a decade from now, we could be closer to a reality where we simply can't grow wheat crops because we can't fight the pathogens," said Laroche. "That's why it's important to do the work now. People might say wheatgrass is a marginal crop that they don't really grow, but there's a lot more to it. Wheatgrass is an outstanding reservoir of different disease resistance, and tapping into that will help shape the future of wheat farming in this country."

ABOUT DR. ANDRÉ LAROCHE

Dr. André Laroche is a research scientist with AAFC. He has more than 35 years of research experience in the areas of plant molecular biology and molecular phytopathology. His research interests range widely from cereal functional genomics of biotic (snow mould resistance, smut and bunt, stripe and leaf rust) and abiotic stress tolerance (winter hardiness, drought), to biorefinery, methodology development, DNA marker-assisted selection, lipid metabolism and gene modification.

His current scientific interests involve the characterization of the stripe rust pathogen isolates and their interactions with wheat, and identification of novel rust resistance genes. He also edits genes to improve their response against pathogens and to variable climatic conditions. As well, he is affiliated as Adjunct Professor with the Department of Biological Sciences, University of Lethbridge.

ABOUT DR. DOUGLAS J. CATTANI

Dr. Cattani received his BSA and MSc. from the University of Manitoba (Plant Breeding), and his PhD from Wageningen University, The Netherlands in Plant Production Ecology. He has worked with herbaceous perennials for over three decades with emphasis on breeding, perennial grass plant development and seed production.

His current position is as Perennial Crop Breeder in the Department of Plant Science at the University of Manitoba. His major interests include the breeding of intermediate wheatgrass for grain production and perennial sunflower domestication.

He has 19 refereed journal and conference publications since his return to the University of Manitoba in the fall of 2010. Current research projects and interests include the use of intermediate wheatgrass as a dual-use crop (grain and forage in the same year), breeding of intermediate wheatgrass for grain production and the investigation of other perennials (including grasses, forbs and legumes) as human food sources, concentrating on perennials indigenous to western Canada.

Did you know?

- *DNA is DNA: DNA is the genetic material of most living organisms including viruses, bacteria, fungi plants and mammals. In all these organisms, the chemical composition of the DNA is the same. Consequently, the same tools to decipher DNA can be used. The challenge is that with plants it is often more difficult to isolate intact DNA due to the presence of the cell wall around each cell.*
- *The number of genes in wheat (≈100,000) is greater than in humans (≈20,000).*
- *Western Canada accounted for more than 99% of all of the forage and turfgrass seed production in Canada between 2005 and 2016, averaging over 155,000 acres per year.*

DR. ROBERT J. GRAF

Canada Western Red Winter wheat [CWRW] is regarded as a medium protein variety, so it serves a lot of the same markets as the Canada Prairie Spring Red [CPSR] and Canada Northern Hard Red [CNHR] wheat classes," said Dr. Robert Graf, a research scientist with Agriculture and Agri-Food Canada (AAFC) in Lethbridge. "One question often raised by producers is what we can do with winter wheat to garner a higher price in the marketplace."

Science Supports the Quest for Quality

As a marketing slogan, "quality is overrated" never caught on, and for good reason. Attracting world class prices for your product requires world class quality, something Canadian wheat farmers have down to a science. With any commodity, however, some products command a greater return than others. That's true of the wheat industry as well, but as the project *"Development of premium quality western Canadian winter wheat"* demonstrates, research is set on raising the bar for some lower priced wheat classes.

In addressing the issue about what we can do to increase winter wheat prices, Dr. Graf proceeded from the premise that if protein concentration could be increased and some of the other perceived deficiencies addressed, an increase in value would follow.

"With this type of research, one of the main hurdles has been the difficulty in bringing the protein concentration of red winter wheat up to red spring levels. Yet, when I had the chance to compare the protein concentration in AC Tempest — a red winter variety — to CWRS, the difference was negligible. That told me that given the right germplasm, a protein boost was possible."

Apart from the protein aspect, winter wheat has had slightly lower gluten strength and less flour water absorption. Of the two, increasing absorption was the more pressing problem, as less water absorbed means less dough and fewer loaves of bread or whatever is being processed.

"We started watching for parents that had small increases in water absorption and crossed with them, always selecting for those rare segregants that had higher absorption and other key quality characteristics. We also did some 'spring x winter' wheat crosses to improve absorption that way. Over time, we were able to develop parents that had big improvements in all the quality components needed."

Through this approach, Dr. Graf began generating a parental germplasm base that he could use to start combining higher protein concentration, better gluten strength and greater water absorption into winter wheat varieties that a farmer would want to grow. As anyone in the industry knows, the timeframe for breeding new lines is measured in decades rather than years, but since their first crosses in 2000, the team has seen real progress.

Yield, lodging resistance, winter survival, test weight and disease resistance must all be built in for a line to gain acceptance, so researchers are simultaneously incorporating these traits.

"Our CWRW wheat varieties in western Canada have always had exceptional milling properties and produce a higher percentage of flour from a given amount of grain than any other class we have. They also exhibit lower ash content and brighter flour color. In recent years, our new varieties have corrected the gluten strength issue and we've gradually been increasing protein content. If we could ultimately build CWRS quality into our red winters and maintain that CWRW milling quality, we would have a product that is preferred by many parts of the industry, and that should enhance the price."

In the fall of 2017, Dr. Graf and his colleagues entered their first line in the registration trials and were encouraged by the results. Though it's not yet CWRS quality, it boasts a huge increase in water absorption and also shows continued progress in protein concentration and gluten strength.

"This line will give us some idea of how much farther we have to go, but it looks promising so far."

As integral as quality may be to new and improved red winter lines, success for a cultivar means excelling in a number of areas demanded by growers. Yield, lodging resistance, winter survival, test weight and disease resistance must all be built in for a line to gain acceptance, so researchers are simultaneously incorporating these traits.

If it sounds like a complex task, it is, but if they're successful, industry will reap the rewards.

"It's my hope that if farmers receive a better price for their hard red winter wheat, it will help to increase acres. Winter wheat has higher yields than spring wheat, so greater yields plus stronger prices should lead to more profits and make the whole system more sustainable."

Like quality, the importance of higher profits can never be overstated.

ABOUT DR. ROBERT J. GRAF

Dr. Graf is a wheat breeder and senior research scientist at AAFC Lethbridge Research and Development Centre. A graduate of the University of Saskatchewan, he started his career as a private industry spring wheat breeder with the Saskatchewan Wheat Pool.

In 1999, Dr. Graf took responsibility for AAFC's western Canadian winter wheat breeding program in Lethbridge. The program focuses on developing high yielding, agronomically superior hard red winter wheat varieties with enhanced disease resistance and quality for the various agri-climatic zones of western Canada.

During his career, Rob has developed or co-developed numerous successful spring and winter wheat varieties with improved yield, agronomics, disease resistance and end-use quality. Dr. Graf is involved with various industry and scientific committees, and particularly enjoys interacting with producers.

Did you know?

- *In 2011, the winter wheat variety Emerson, developed by Dr. Graf and his team, was the first wheat of any type in Canada rated "resistant" to Fusarium head blight. It is now the most popular winter wheat variety in western Canada.*
- *In 1997, Dr. Graf's first registered spring wheat variety, McKenzie, in addition to having break-through yields, was the first wheat variety in North America developed using doubled haploidy (A doubled haploid (DH) is a genotype formed when haploid cells undergo chromosome doubling).*

Izabela Ciechanowska is the 2018 recipient of the Alberta Wheat Commission Graduate Research Scholarship in Crop Science. This $10,000 award is available annually to graduate students at the University of Alberta in the Crop Science program.

IZABELA CIECHANOWSKA

Thanks to Wheat Research, **Resistance is Never Futile**

What do chocolates and wheat disease have in common? Hopefully not much, but they can both be hard to resist when you let your guard down. That's why disease resistance in wheat is a major focus of research these days, and why a grad student with a Bachelor's in Genetics was enlisted to join the fight.

"An opportunity came up with the department of agriculture to work in wheat breeding, and they wanted someone with a genetics background," said Izabela Ciechanowska, currently pursuing her Master's in Plant Sciences at the University of Alberta, under the supervision of wheat breeder, Dr. Dean Spaner. "The job focused on bread wheat, and it was an eye-opener for me as I saw bread in the store without realizing how much research went into it."

Working with Canadian Prairie Spring wheat, Ciechanowska and her colleagues crossed two varieties grown in their greenhouse. They were excited to discover that the seeds from that cross showed good resistance to stripe rust and stem rust, diseases that are all too familiar to wheat growers.

"The whole point of wheat breeding today is to breed in genetic resistance, as it offers the best protection to most diseases. In our case, we want something that grows well on the Prairies and resists everything that comes at it. The resistance to leaf rust and stem rust specifically was encouraging, as they have both been of great concern to industry since the early 1900s."

As part of her project, Ciechanowska examined all seeds derived from the cross and assessed them in the field for how they performed and their level of resistance. In her words, the resistance level ranged from "very resistant to moderate to susceptible to dead".

Based on her field observations, she then took the seeds and performed DNA extraction, looking for the aspect of DNA that produces varying response to disease. As suggested by the name — quantitative trait loci (QTL) analysis — not all disease response can be explained by one area on the DNA. Resistance can be a complex trait that is not explainable by a single gene; yet when you consider the potential payoff, it is well worth the effort.

Resistance can be a complex trait that is not explainable by a single gene; yet when you consider the potential payoff, it is well worth the effort.

"What the seeds are carrying can be useful to breed into other plants to help with resistance to these diseases. Some of the QTLs we look for are very beneficial and resistant, while others are somewhat helpful. Once we identify all the key locations in the DNA that link to resistance, we can stack them on top of each other, breed them together and try to get them all into one plant."

The project itself won't create a new wheat variety, but by marshalling various parts or markers of DNA to work together in battling disease, they can lay the foundation for more resistant varieties in the years to come.

"When we find the markers, we will put them in a paper and others can take that information and say 'we don't have that resistance in our plants right now, so we'll take it and use it for breeding'."

Eventually, these new varieties with enhanced resistance will mean producers won't be spraying as much, and won't be losing sleep over fears that their crop may be decimated by disease.

Now that she has completed her field work, Ciechanowska is busy with the genetic analysis and hopes to have results by early next year. Resisting chocolate may still be futile, but with progress on the genetic front, fending off wheat disease is well within reach.

> *"Once you get diseases like stem rust and leaf rust in your crop, they significantly reduce grain yield by up to 30 per cent. Also, disease resistance means better quality and grade for your wheat. Quality is quite important in grain as plants that are low in protein or all shriveled from disease could be relegated to feed. At the end of the day, everything is related to the health of the plant."*

ABOUT IZABELA CIECHANOWSKA

Izabela Ciechanowska was born in Poland, and her family immigrated to Canada in 1991. Her childhood fostered interests in nature and art, leading to a degree in genetics and a diploma in design and illustration.

Her career began in various plant genetics research labs, which have helped her gain an array of laboratory skills. In her current role with the department of Agriculture, Food and Nutritional Science at the University of Alberta, Ciechanowska is applying her genetics background to wheat research, production and quality assessment. Her areas of research are disease resistance in wheat and evaluating grain for protein content and potential pre-harvest sprouting.

Did you know?

- *Cereal rusts are fungi which penetrate plant cells and absorb the plant's nutrients, weakening the plant and leaving it more vulnerable to other diseases while causing poor seed development.*
- *Disease resistant wheat varieties offer an inexpensive and environmentally conscious approach to keeping crops healthy.*
- *Ancient Romans also contended with rust in their fields. They held an annual festival called Robigalia to appease Robigus, the god of rust, in hopes of keeping their crops healthy.*

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