VOLUME 3

PULSERESEARCH

Drawing the Linkage Between Pulse Consumption and Disease Reduction

A Pulse Crop for Every Acre

The Multiple Benefits of Being Sustainable

Keeping Our Furry Friends Healthy Too

Weed Control in Pulses

Making Varieties the Best for Saskatchewan

Getting to the Root of Root Rot Problem

SASKATCHEWAN pulse Growers

IN THIS ISSUE

We explore topics from the upstream end of pre-breeding, to the downstream end of health benefits of pulse consumption. This issue also explores the greater benefits of pulse cultivation to the planet.

Cover photo by David Stobbe, courtesy of the University of Saskatchewan College of Agriculture and Bioresources.

VOLUME 3

PULSE RESEARCH

new crop options

A PULSE CROP FOR EVERY ACRE OF SASKATCHEWAN

New crop options make pulses a viable choice for growers.

While much of the pulse research focuses on managing current issues, such as diseases and developing new varieties with important traits that are suited to our growing conditions, a large part is also strategically forward-looking. A part of Saskatchewan Pulse Growers' (SPG) strategic growth strategy is to establish at least one viable pulse crop option for every acre in Saskatchewan.

> PULSES ADD TO THE SUSTAINABILITY OF CROP ROTATIONS BY BREAKING DISEASE AND WEED CYCLES IN NON-PULSE CROPS.

There are two emerging pulse crops that hold great potential for Saskatchewan — soybeans and faba beans — and in the past five years, the province has seen significant growth of these two crops. Soybean seeded area has jumped from an estimated 12,000 acres in 2010, to 250,000 acres in 2015, while faba bean seeded area jumped from 15,000 acres in 2010, to an estimated 62,000 in 2015. For 2016, soybean acreage has fallen to 235,000 acres and faba bean acreage sits at approximately 50,000 acres. Both crops have seen heavy competition from peas and lentils, as well as canola this year.

"We expect soybean acres to continue to grow as the availability of well adapted short season varieties increase and as growers become more familiar with growing the crop," says SPG's Executive Director Carl Potts.

Not only are these crops good options for growth in Saskatchewan because of the conditions here, they also offer a variety of potential benefits to growers, such as increased profits and reduced inputs. Currently, there is growing worldwide demand for pulse crops, as consumers are increasingly looking for sources of plant-based protein.

SPG's goal is to not only ensure Saskatchewan is growing enough pulse crops to meet worldwide demand, but also to give growers in the province more options to grow pulse crops. Furthermore, growing more pulse crops will have a longer-term impact on sustainability, Potts says.

"Pulses add to the sustainability of crop rotations by breaking disease and weed cycles in non-pulse crops, so adding pulse crop options for all areas of the province is an important long-term goal for sustainable cropping systems," he says. "Adding additional pulse crop options for areas already growing significant amounts of pulses can also help to reduce disease and weed pressure for existing pulse crops."

For example, faba beans and chickpeas are less susceptible to some root diseases such as Aphanomyces, which have been impacting pea and lentil production in recent years.

This research priority area will focus on nurturing these two crops so that growers have varieties well suited to their soil zones, and have all the information they need to grow them, including information about seeding rates, fertility, pest management, and harvest management.

"We also continue to support variety development that results in better yielding varieties with improved disease resistance and end-use characteristics," Potts says.

This is why SPG is currently funding a variety of research projects that ultimately aim to extend the knowledge around why and how to grow these two crops in Saskatchewan, as well as developing end-use markets for these crops.

Dr. Jeff Schoenau's research concerns nutrient uptake requirements of soybean grown under Saskatchewan conditions, and the contribution that the residue makes to the nutrition and yield of following cereal and canola crops grown in rotation (in comparison to pea and lentil).

Credit: University of Saskatchewan

CONTINUED: A PULSE CROP FOR EVERY ACRE OF SASKATCHEWAN

Agronomy

One of the best ways to increase production and adoption of a new crop in the province is to better understand its benefits and contributions, and how they compare to those of other regional crops.

One SPG-funded research project, led by Dr. Jeff Schoenau, aims to do just that by researching the nutrient uptake requirements of soybeans grown under Saskatchewan conditions, and the contribution that the residue makes to nutrition and yield of following cereal and canola crops grown in rotation (in comparison to pea and lentil).

"Soybeans appear to be a good crop option, with good yields and ability to derive nitrogen from the atmosphere, which is an important benefit of having a pulse crop in rotation," says Dr. Schoenau, a Professor and Ministry of Agriculture Strategic Research Chair in the University of Saskatchewan's Department of Soil Science.

So far his research, which began in 2014, has found that soybeans had comparable yields to peas and lentils at the four test sites across the province. The nutrient uptake was closely correlated with the yields, with soybeans having medium-to-high uptake of phosphorus, potassium, calcium, and magnesium when compared to peas and lentils. There were also higher contents of phosphorus and potassium in the grain.

"The higher amounts of phosphorus and potassium in soybean grain, which is removed during harvest, points to the need to pay more attention to the fertility of these nutrients when soybeans are grown in rotation," he says.

The research also showed that the amounts of nitrogen in the soybean plant derived from fixation of atmospheric nitrogen were lower compared to peas and lentils, but with a slightly higher proportion of nitrogen derived from the atmosphere for soybean compared to the other two pulse crops. About 60 per cent of the nitrogen in the soybean plant was determined to come from fixation, indicating that — similar to the traditional pulses — nitrogen-fixation inputs can be significant for this crop when properly inoculated and managed, Dr. Schoenau says.

"The supply of available nitrogen and phosphorus from the soil to wheat and canola grown the following year on soybean, pea, and lentil stubble was similar among the stubble types at the sites."

Once the research is complete, Dr. Schoenau hopes to confirm relative nutrient requirements of different pulse crops and their impact on yield and nutrition of crops that follow in rotation, which will help growers optimize their short- and long-term nutrient management in rotations containing pulse crops.

"It will enable growers to adjust and fine-tune their fertilizer rates according to the specific crops they are growing."

More SPG-funded research is looking at developing nitrogen and phosphorus management recommendations for soybean production in Saskatchewan. Meanwhile, soybean breeding projects at the University of Saskatchewan's Crop Development Centre (CDC) are focused on developing short season, herbicide tolerant varieties with improved yield and disease resistance.

Another way to promote new crop options is to make them agronomically appealing to growers. And for soybean growers in Saskatchewan, one of the most crucial aspects for success is weed management.

This is why SPG has invested in research led by Dr. Chris Willenborg, Assistant Professor at the University of Saskatchewan's College of Agriculture and Bioresources. Dr. Willenborg's research aims to provide soybean growers with better options for managing glyphosate-resistant canola volunteers in glyphosate-resistant soybean crops, through use of pre-emergence and in-crop herbicides, seeding dates, and seeding rates.

The research is set to wrap up in late 2016, but Dr. Willenborg has made several important discoveries so far, including that 2,4-D herbicide (which is registered for use prior to seeding soybeans in Eastern Canada) consistently damaged the crops in trials run at four locations across Manitoba and Saskatchewan.

"However, we typically waited 7–10 days after application and it may require a longer period of time between application and seeding," he says.

Furthermore, he found that pre-emergence applications of Roundup WeatherMAX® combined with FirstRate® or Authority® were just as effective at reducing volunteer canola biomass and dockage. Post-emergence treatments of Roundup WeatherMAX® plus Odyssey®, Viper®, Reflex®, or Basagran® Forte exhibited the lowest canola dockage.

What proved to be the most effective method of control however, was a combination of pre- and post-treatments, which Dr. Willenborg estimates should provide season-long control of multiple volunteer canola flushes.

The CDC is currently working on developing tools for breeding new faba bean varieties that combine good adaptation with low vicine/convicine, with the goal of growers having access to superior varieties desired by end markets and end-users.

CONTINUED: A PULSE CROP FOR EVERY ACRE OF SASKATCHEWAN

"Herbicide treatments containing either Express® SG or Heat® as the pre-emergence herbicide, plus a post-emergence herbicide application, consistently showed lower crop injury and higher soybean yield," he says. "Examples of herbicide combinations that worked well include Express® SG plus Basagran®, Heat® plus Viper®, or Express® SG plus Viper®. These combinations provided good volunteer canola control, relatively low soybean phytotoxicity, and high yield."

Research so far has also found that higher seeding rates and later seeding dates generally resulted in higher soybean biomass and yield, and lower volunteer canola biomass.

"While we are still analyzing the data, it appears that fields with a high population of volunteer canola will need to be seeded at a higher rate in order to effectively compete with volunteer canola," says Dr. Willenborg. "We found generally 60 plants per square metre (plants/m^2) tended to produce strong yield and reductions in volunteer canola biomass and dockage, but seeding rates above 40-50 plants/m^2 may not be economical when the possible herbicide options listed above are considered. However, growers must consider the potential contribution to the seedbank of any volunteer canola plants that do produce seeds."

Overall, Dr. Willenborg believes that the herbicide recommendations that will result from this research will help soybean growers better manage their crops and minimize the impact of volunteer canola on soybean crops.

"In addition, our work suggests that by combining a two pass herbicide system with a slightly elevated seeding rate, it is possible to grow soybeans in rotation with canola, even if both crops possess the glyphosate-resistant trait," he says.

However, he urges growers to always consider the long-term feasibility of a crop rotation that relies heavily on a single trait for weed control, such as glyphosate resistance. While it is possible, growers need to manage these rotations with weed resistance and long-term sustainability in mind.

"Proper herbicide rotation and mixtures are key to avoid selecting for resistant weeds in such systems."

Another SPG co-funded project, led by Dr. Kan-Fa Chang, of Alberta Agriculture and Rural Development, looked at how root rot affects faba beans and explored fungicide seed treatments for managing fusarium root rot in the tannin-free faba bean cultivar Snowbird.

The results showed that Fusarium affected the crop in terms of declining seedling emergence and seed yield, and that some seed treatment fungicides showed potential for controlling the disease. Further work is needed to support registration of these seed treatments but overall this research demonstrated potential for increasing economic returns to faba bean growers with improved fusarium root rot control, an area which SPG will continue to explore.

Other SPG-funded research related to the agronomy of these new crops aims to improve the nitrogen contribution to prairie cropping systems through faba beans, to develop a rhizobial inoculant for faba beans, and to optimize seeding rates, row spacing, inoculant options, and disease management in faba bean varieties. The effects of moisture management on soybeans and faba beans in Saskatchewan is also being looked at.

End-Use Markets

In order to promote growth of new crops in Saskatchewan, it is also critical to ensure we are growing varieties that are not only well-suited to local growing conditions, but that meet end-use market needs.

One challenge to the faba bean market is that in some regions of the world (particularly the Mediterranean and Africa), some people suffer from a disease known as favism which can be linked to serious allergies to faba beans. People who suffer from this disease, usually men, are lacking an enzyme that impacts the blood circulation in their body, causing the destruction of red blood cells.

It can be potentially life-threatening, but one Italian researcher strongly suspected that faba bean cultivars with low levels of vicine and convicine (V/C) were not dangerous for people who suffer from favism, and decided to test this. Funded by SPG, Dr. Paolo Arese, at the University of Torino Medical School's Department of Genetics, Biology and Biochemistry, conducted research on seven male volunteers who were highly susceptible to favism (previous research on less-susceptible females strongly suggested there were no threats with the research). The volunteers were given raw, dehulled faba beans in quantities that exceeded normal human consumption levels for seven days and their blood was tested after each ingestion. The short and long-term results of these blood tests showed that there was no indication of hemolysis or stress on red blood cells. This lead the team to conclude that low V/C

faba beans were safe for human consumption even in those that suffer from, or are susceptible to, favism.

These results have been adopted by faba bean breeders globally. The CDC is currently working on developing tools for breeding new varieties that combine good adaptation with low V/C, with the goal of growers having access to superior varieties desired by end markets and end-users.

Other SPG-funded research focuses more specifically on end-use characteristics of faba bean, exploring the benefits of the crop as ingredients in novel food products and their effect on glycemia, appetite, and metabolic control.

For a list of SPG-funded research focused on developing new crop options for Saskatchewan, flip to page 38.

PROJECTS FEATURED IN THIS ARTICLE

PROJECT TITLE	INVESTIGATORS	FUNDERS	END DATE
Very Short Season Herbicide Tolerant Soybean Varieties Adapted to the Canadian Prairies	Dr. Elroy Cober, Agriculture and Agri-Food Canada	Saskatchewan Pulse Growers ($102,500), Agriculture and Agri-Food Canada	March 31, 2018
Management of Volunteer Glyphosate-Resistant Canola in Glyphosate-Resistant Soybean Crops	Dr. Chris Willenborg, University of Saskatchewan, Department of Plant Sciences	Saskatchewan Pulse Growers ($93,015), Agriculture Development Fund, Western Grains Research Foundation	March 31, 2017
Developing Nitrogen Management Recommendations for Soybean Production in Saskatchewan	Chris Holzapfel, Indian Head Agricultural Research Foundation **Co-investigator(s):** Garry Hnatowich, Irrigation Crop Diversification Corporation, Stewart Brandt, Northeast Agricultural Research Foundation, Christiane Catellier, Indian Head Agricultural Research Foundation	Saskatchewan Pulse Growers ($123,732)	March 31, 2018
Developing Phosphorus Management Recommendations for Soybean Production in Saskatchewan	Chris Holzapfel, Indian Head Agricultural Research Foundation **Co-investigator(s):** Garry Hnatowich, Irrigation Crop Diversification Corporation, Stewart Brandt, Northeast Agricultural Research Foundation, Jessica Weber/Gazali Issah, Western Applied Research Corporation, Christiane Catellier, Indian Head Agricultural Research Foundation	Saskatchewan Pulse Growers ($106,740)	March 31, 2018
Nutrient Content and Release From Soybean Residues in Comparison to Other Pulse Crops in Saskatchewan	Dr. Jeff Schoenau, University of Saskatchewan, Department of Soil Science	Saskatchewan Pulse Growers ($61,835), Western Grains Research Foundation, Agriculture Development Fund	April 15, 2017
Moisture Management Effects on Soybean and Faba Bean in Saskatchewan	Dr. Dale Tomasiewicz, Agriculture and Agri-Food Canada	Saskatchewan Pulse Growers ($79,890)	March 31, 2018
Optimum Seeding Rate, Row Spacing, and Disease Management in Faba Bean Varieties	Dr. Steven Shirtliffe, University of Saskatchewan, Department of Plant Sciences	Saskatchewan Pulse Growers ($449,591)	March 31, 2018
Nutrient Uptake and Nitrogen Fixation by Faba Bean in Saskatchewan Soils	Dr. Jeff Schoenau, University of Saskatchewan, Department of Soil Science	Saskatchewan Pulse Growers ($37,518), Agriculture Development Fund	November 1, 2018
Development of a Rhizobium Inoculant for Faba Bean	Dr. Diane Knight, University of Saskatchewan, Department of Soil Science	Saskatchewan Pulse Growers ($174,996)	June 30, 2018
Effects of Faba Bean Fractions as Ingredients in Novel Food Products on Glycemia, Appetite, and Metabolic Control	Dr. Harvey Anderson, University of Toronto, Department of Nutritional Sciences	Saskatchewan Pulse Growers ($649,999)	March 31, 2018
Risk Assessment of New Fava Bean Cultivars with Low Content of Vicine and Convicine (FEVITA beans) in Hemizygous Male Subjects with Total G6PD-Deficiency	Dr. Paolo Arese, University of Torino Medical School, Department of Genetics, Biology and Biochemistry	Saskatchewan Pulse Growers ($38,000)	Completed January 31, 2011

sustainable production

THE MULTIPLE BENEFITS OF BEING SUSTAINABLE

Pulses make environmental, economic, and long-term sense for growers.

The term sustainability is thrown around a lot these days.

But what exactly does it mean in relation to pulse crops, and why is this concept increasingly important to pulse growers in Saskatchewan and to the pulse industry in general?

Saskatchewan Pulse Growers (SPG) aims to answer some of these questions through research around pulses and sustainability, one of the major focuses of the organization's overall research program.

The idea of sustainability is multi-faceted, says SPG Director Lee Moats.

"Sustainability means a lot of things to a lot of people — there is quite a broad interpretation of the term," says Moats, who also operates a zero-till farm in the Riceton area with his wife Laurie.

"For a lot of us I think it has a lot to do with economics as much as with environment, but of course the two go hand-in-hand."

A 2012 Agriculture and Agri-Food Canada report supports this definition, relating sustainability principles for agriculture to "stewardship of land, air, and water, and other natural resources as well as quality of life and long term profitability for food producers and rural communities."

On the environmental side of sustainability is the idea that pulse crops contribute to improved soil health, overall environmental footprint, and long-term sustainability, facts which have been supported by research. Economically speaking, farming sustainably improves yields, reduces input costs, creates long-term financial stability, and there are economic gains with crops following pulses in rotation.

Sustainability is not only attractive to growers in terms of opportunities for increased yields and lower input costs, but also for end-use markets, as there is growing consumer demand for sustainably sourced food products and sustainable metrics for food production. This consumer demand is a trend which is growing consistently, Moats says.

"When I came on the SPG Board, really there was only one company talking to us about sustainability and they were more interested in oats than in pulses," he says. "But in the past five years, sustainability has become a corporate word and many of the big companies are interested in this idea — it has become commonplace."

Research backs this claim up. A 2014 Nielsen survey showed that 55 per cent of global consumers reported being inclined to pay more for products and services from companies that were committed to social and environmental sustainability. By the next year that number had jumped to 72 per cent. In the past decade, many of the world's leading companies have adopted programs and marketing campaigns to demonstrate their commitment to sustainable practices, including PepsiCo, Starbucks, Molson Coors Brewing Co., Kellogg Co., Loblaws, Canadian Tire, Rogers Communications, Telus, Air Canada, and the list goes on.

Since the areas of grower economics and consumer demand clearly hold great potential for the growth of the Saskatchewan pulse industry, SPG has made it a priority to generate viable proof of the type of information these communities are looking for, Moats says.

"If you are going to talk about sustainability, you need to have some level of confidence in what you are saying. We have many features to do with

pulse crops that have great sustainability benefits to our cropping systems but the question is, what are the real scientific proofs that relate to that?"

"That is critically important — consumers that are interested in sustainability want to know the real truth, real facts."

Understanding the Pulse Contribution to Sustainability

Putting some scientific metrics around pulses' contribution to sustainability is a fundamental component of SPG's research strategy, and the organization continues to fund research projects that aim to do just that.

One of these projects, led by Dr. Yantai Gan, a Research Scientist with Agriculture and Agri-Food Canada, has already derived several important conclusions about how various crop rotations affect soil health, environmental footprints, and long-term sustainability in Saskatchewan.

In terms of soil health, the research so far shows that agronomic practices influence the soil's biological diversity and functionality, with positive implications for plant growth.

"Pulse crops positively influence soil microbial community structure and such effects are carried over to affect the productivity of subsequent crops," Dr. Gan says. "Plant roots modify soil microbial environments, leading to the crop rotational effect. The plant genotype also influences the root fungal community structure."

Understanding the negative repercussions on sustainability is also important so that we can work towards improvements. Dr. Gan's research also showed negative repercussions for plant growth as well. For example, he found that foliar fungicides can negatively affect the composition of rhizobacterial communities. He also found that raising nitrogen levels can increase the risk of nitrous oxide emissions from cropping.

But all this information contributed to an important understanding of the mechanisms responsible for the crop rotational effect.

"This discovery provides a scientific basis that soil health can be improved by manipulating rhizospheric traits of host plants and that the crop rotational effect can be enhanced by modifying microbial communities through use of beneficial agronomic practices."

In terms of environmental footprint, the research showed that rotations including lentils, for example, have proven benefits as the higher nitrogen concentrations in lentil residues provided greater nitrogen benefits to subsequent crops.

Pulse crops contribute to sustainable crop rotations.

"It is clear that the use of grain legumes to replace the summerfallow phase of the rotation is one of the key components for obtaining a reduced or negative carbon footprint in wheat cropping," Dr. Gan says.

In order to measure sustainability, Dr. Gan and his team conducted a three-year cropping sequence study which was repeated for five cycles in Saskatchewan. They found that diversifying cropping systems with pulse crops can enhance soil water conservation, improve soil nitrogen availability, and increase system productivity.

Overall, the research contributed several takeaways to the greater discussion of pulses and sustainability, which translates to benefits for the Saskatchewan pulse industry.

"Pulses deliver several unique services to global trade and society as a whole," Dr. Gan says.

> FARMING SUSTAINABLY IMPROVES YIELDS, REDUCES INPUT COSTS, [AND] CREATES LONG-TERM FINANCIAL STABILITY.

CONTINUED: THE MULTIPLE BENEFITS OF BEING SUSTAINABLE

"With the increased global demand for plant-based protein sources and with the desire of diversifying human diets, Saskatchewan pulses are well positioned for global trade. Also, with the Canadian government's current science agenda on promoting research to combat climate change, nitrogen-fixing pulses can play an important role in reducing both on-farm direct emissions and indirect emissions associated with the inorganic nitrogen fertilizer supply chain."

In order to further these results, Dr. Gan's research over the next five years will aim to address the need to increase crop yield at the system level while minimizing negative environmental impacts of crop production.

"A systems approach allows for the integration of various improved agronomic practices in a package that growers can adopt to increase crop yield and reduce crop inputs or improve the efficiency per unit of input, while enhancing economic returns and minimizing environmental footprints."

Along similar lines to Dr. Gan's research, ongoing research by Dr. Richard Farrell and his colleagues compares nitrous oxide emissions from different pulses (including peas, lentils, chickpeas, and faba beans), oilseeds (including canola and flax), and wheat crops, alone, and in rotation. The research is also looking at the longer-term benefits of growing pulses.

"Everyone knows that when you grow pulses you do not put much fertilizer on so you get lower emissions," says Dr. Farrell, Associate Professor in the Department of Soil Science, at the University of Saskatchewan's (U of S) College of Agriculture and Bioresources. "This research is more about trying to demonstrate that pulse crops have a benefit that goes beyond just the year in which you grow them. What we are trying to show is that the pulse residues do not really contribute a lot to the next year's emissions either."

The research also aims to address the fact that the average emission factor in Canada for nitrogen added to soils is one per cent, regardless of the source of nitrogen. Research specific to the Western Canadian prairies indicates that for this region the number is closer to 0.4 to 0.6 per cent, but still does not take nitrogen source into account. When research wraps up in 2017, Dr. Farrell hopes to be able to make a strong case for lowering the emission factor for crop residues, especially for pulse crops.

"We are hoping to be able to come up with a better emission estimate," he says. "What we would like to be able to show is that the amount going into the atmosphere is actually much lower than that one percent — those inventory numbers are much too high already."

Since about 17 per cent of all agriculture-based emissions are currently attributed to the decomposition of crop residues, his hope is that this research will impact the greenhouse gas inventory for Canada, potentially decreasing the numbers associated with pulse crops.

"Everyone already suspects that but our data will prove it," he says.

More SPG-funded research on the topic of pulse sustainability is being carried out by Dr. Diane Knight, a Saskatchewan Ministry of Agriculture Strategic Research Chair with the U of S's Department of Soil Science. Along with her colleagues, Dr. Knight is looking at cropping sequence effects on nitrogen-fixation and carbon and nitrogen inputs of peas, lentils, and chickpeas.

To carry this out, the team conducted studies in both the field and in the greenhouse to measure and compare the amounts of carbon and nitrogen in above- and below-ground residues added by different pulse crops, including chickpeas, peas, and lentils in different rotation sequences with wheat, and canola or mustard.

What they have learned so far is that cropping sequence has a large effect on productivity and biological nitrogen fixation (BNF).

"Not surprisingly, each of the pulse crops performed least well when grown in a continuous rotation compared to diverse rotations," Dr. Knight says. "Growing lentils and chickpeas after canola or mustard in rotation negatively affected BNF and productivity in both pulse crops compared to when the pulses were grown immediately after wheat. Therefore at least in the Brown soil zone, it is recommended that the pulse crops not be grown immediately after a brassica crop."

In a different study conducted in the Dark Brown soil zone, the pulse crops were not negatively affected by being grown immediately after canola.

Dr. Knight has also learned that first-year crops in a three-year rotation influenced productivity and BNF.

"In the third year of a rotation sequence where chickpeas or lentils were grown alternately with wheat, the pulse crops were up to 40 per cent more productive and fixed

PROJECTS FEATURED IN THIS ARTICLE

PROJECT TITLE	INVESTIGATORS	FUNDERS	END DATE
Cropping Sequence Effects on Nitrogen Fixation and Carbon and Nitrogen Inputs of Pea, Lentil, and Chickpea	Dr. Diane Knight, University of Saskatchewan, Department of Soil Science	Saskatchewan Pulse Growers ($254,956)	Completed April 30, 2015
Direct Assessment of the Release of Fixed Nitrogen in the Rhizosphere of Pea, Lentil, Chickpea, and Faba Bean	Dr. Richard Farrell, University of Saskatchewan, Department of Soil Science **Co-investigator(s):** Dr. Diane Knight, University of Saskatchewan, Department of Soil Science, Dr. Raynald Lemke, Agriculture and Agri-Food Canada	Saskatchewan Pulse Growers ($65,785), Western Grains Research Fund, Agriculture Development Fund	September 30, 2016
Enhancing the Long-Term Sustainability of Pulse Cultivation Using System Approaches	Dr. Yantai Gan, Agriculture and Agri-Food Canada	Saskatchewan Pulse Growers ($1,004,036)	March 31, 2021
Lifecycle and Socio-Economic Analysis of Pulse Crop Production and Pulse Grain Use in Western Canada	Monique Wismer, Saskatchewan Research Council	Saskatchewan Pulse Growers ($112,395)	Completed June 30, 2011
Moving Forward to Sustainable Development of the Saskatchewan Pulse Industry	Dr. Yantai Gan, Agriculture and Agri-Food Canada	Saskatchewan Pulse Growers ($855,775), Agriculture and Agri-Food Canada	Completed March 31, 2016
Quantifying the Contribution of Pulse Crop Residues to Greenhouse Gas Emissions, Nitrogen Nutrition and the Growth of a Subsequent Wheat Crop: A Dual Isotope Labelling Approach	Dr. Richard Farrell, University of Saskatchewan, Department of Soil Science **Co-investigator(s):** Dr. Diane Knight, University of Saskatchewan, Department of Soil Science	Saskatchewan Pulse Growers ($368,845)	September 30, 2018

more nitrogen than chickpeas and lentils in rotations where peas were grown as the first crop in rotation, followed by wheat and then chickpeas or lentils," she says. "We suspect that, at least in the Brown soil zone, growing the same pulse crop repeatedly in rotation, separated by wheat, might serve to encourage microflora populations that are optimal for that crop."

While continuously cropping pulse crops is neither recommended nor practiced by growers, increasing diversity beyond growing a pulse crop every second year did not necessarily improve nitrogen-fixation and productivity, Dr. Knight says.

"In the Brown soil zone, growing a pulse crop alternately with wheat should maximize the benefit of the pulse crop."

Dr. Knight expects the overall outcome of her research, which is halfway complete, will provide concrete information on optimal rotation sequences in the different soils zones.

"The overall goal of this and related research is to find the best fit for the different pulse crop species in different regions of the province. Reducing nitrogen fertilizer usage is an economic and environmental goal."

Other SPG-funded research in the area of sustainability has focused on analyzing the lifecycle and socio-economic effect of pulse crop production and pulse grain use in Western Canada, and examining the soil carbon and nitrogen balance with lentil crops.

For a list of research related to sustainability, flip to page 38.

The Importance of Sustainability for Growers

Beyond the main objectives of increasing economic benefits for Saskatchewan farms and promoting marketable attributes for consumers, Moats also believes that Saskatchewan growers are interested in the idea of sustainability — and have been for longer than it has been fashionable — for reasons beyond just increasing their profits.

"On a personal level I am very interested in sustainability, not for consumer interest but in terms of intergenerational transfer," he says.

"The question will be, did our farm survive to be passed on to the next generation? And how can we continually be making improvements in this area? I think this idea is shared by growers everywhere."

pulses and animals

KEEPING OUR FURRY FRIENDS HEALTHY TOO

Research finds pulse-based foods healthy for animals.

Pet owners in North America are spending more and more on their furry friends.

According to 2014 data from market research group Packaged Facts, Canadians spend approximately $6.6 billion a year on their animals, while that number is closer to $61 billion in the United States, according to the American Pet Products Association.

Further data from Agriculture and Agri-Food Canada shows that Canadian pet owners are becoming increasingly focused on feeding their pets natural, high-quality foods made from ingredients they recognize.

What does all this have to do with pulse growers in Saskatchewan?

Pulses represent a relatively unexplored but huge opportunity for the North American pet food industry. Research is showing that pulse starch can be a healthy and cost-effective alternative ingredient to corn and rice starch in pet food, says Dr. Lisette Mascarenhas, Director of Research and Development at Saskatchewan Pulse Growers (SPG).

"We are seeing more and more research that speaks to the health benefits of pulses in pet food and animal feed," she says. "All of this is contributing to people looking to pulses as a viable source of resistant starches for pet food."

Beyond just cat and dog food, research also indicates pulses hold potential as a healthy and sustainable ingredient for aquaculture and livestock feed as well.

This is why SPG has placed some emphasis in this emerging area, Mascarenhas says. Not only does this strategy hold great potential for increasing the demand for pulses in North America, it would also help diversify markets for Canadian pulses, which is key to managing market-related risks.

Because this is a newer area of research compared to agronomy and plant breeding, SPG is careful to choose projects for funding which hold potential payoff for growers.

"We must see value or a premium in the end product for the grower," Mascarenhas says.

Another major goal of supporting this research is to fill in the knowledge gaps in terms of flavour and formulations for major pet food companies, as they consider pulses as a pet food ingredient.

"Through research we are learning how these foods should be formulated for pets so they accept foods with pulses," Mascarenhas says. "So what the research is focused on is trying to develop flavour combinations and various approaches that would impart a favourable taste for pets, so that they would eat them."

Pulses as Pet Food

Dr. Lynn Weber, a Researcher and Associate Professor in the Western College of Veterinary Medicine at the University of Saskatchewan, has been studying how and why to include pulse starches in cat and dog food for many years, with funding from SPG.

So far her research has shown that pea, lentil, and faba bean starches are a valuable alternative to the commonly-used corn starch, as they are able to lower the glycemic index and insulin levels in these animals, and have fewer adverse side effects.

In her most recent research she has also observed that the animals she studies — particularly the cats — seem to have more gut and digestion problems with the corn starch than the pulse starch-based foods.

CONTINUED: KEEPING OUR FURRY FRIENDS HEALTHY TOO

"It definitely seemed that the cats had a lot of gut problems with the corn diet," she says. "They did not like eating it at all and some refused. One of the reasons they refused to eat it was because their stomachs hurt. Those observations were qualitative but we definitely noticed they had gut problems on the corn diet, and the pulses seemed to make it better."

But just as kids do not like to eat their vegetables, cats and dogs do not like the taste of pulse-based foods as much, so the challenge at this point is making the pulse-based foods more palatable, Dr. Weber says.

For her next project she is going to try fermenting the pea starch with yeast, which is often used as a flavour enhancer in pet food.

"It has a meaty taste that cats, dogs, and even fish like," she says. "The fermented yeast may also have beneficial effects in the gut — it seems to reduce gut inflammation."

> PEAS ARE NUTRIENT DENSE, CONTAINING VERY HIGH LEVELS OF ENERGY AND PROTEIN, AND THEY ARE HIGHLY PALATABLE AND VERY DIGESTIBLE.

As an added benefit to this research, Dr. Weber hopes that some of her takeaway on palatability may also be usable in human diets.

Since she began her research in the area, Dr. Weber has seen a lot of pickup from the pet food industry.

"Anything that is grain-free these days on the market has pulses in it, and at least a quarter of the regular pet food is grain-free, while about half of the high-end food is grain-free," she says.

"The big companies are taking our information which is exactly what we wanted, and this is benefitting Saskatchewan pulse growers."

Pulses as Aquaculture Feed

Dr. Weber has also done research, supported by SPG, to translate her knowledge of pulses in cat and dog food into aquaculture feed, which she feels is the next big market to crack.

Currently, the primary ingredient in aquaculture feed is fishmeal, but this is not sustainable, Dr. Weber says.

"Not only are we facing a major ecological disaster because we are getting rid of these small-course fish that feed the larger fish, but the overfishing of the larger fish is made worse because the little ones are being overused to make fishmeal," she says.

Using pulses as an alternative to fishmeal would be beneficial for many reasons. Not only would they offer relief from the overused fishmeal ingredient, causing big cost breaks, preliminary research has also suggested that pulses have similar or better effects on the end quality of the fish as fishmeal.

"With fish you want ingredients that are cheap and help them grow fast," she says. "We found that you can actually replace up to 30 per cent of the aquaculture diet very safely with any of the pulse starches and the fish subsequently grow just as well or maybe a little bit better."

Other SPG-funded research in the area of pulses and pet food focuses on how to best process and prepare pulses for inclusion in pet food and aquaculture, as well as the use of canola, peas, and flax fractions in aquafeeds.

Pulses as Feed

Another research area of increasing interest to pulse growers is that of pulses as feed ingredients for livestock.

This idea is nothing new for Dr. Vern Anderson, Beef Research Project Leader at the Carrington Research Extension Center in North Dakota.

Dr. Anderson has 34 years of experience in beef cow-calf and feedlot research and recently led a study, funded by SPG, focused on the effects of including field peas in beef finishing diets and how this influenced beef palatability attributes.

The major conclusion of this research was that peas offer a multitude of benefits as feed.

"Peas are nutrient dense, containing very high levels of energy and protein, and they are highly palatable and very digestible," he says. "They also improve pellet quality in manufactured feeds, and depending on the scenario, they can improve animal performance or feed efficiency while increasing or assuring high values for juiciness, tenderness, and flavour in beef steaks."

PROJECTS FEATURED IN THIS ARTICLE

PROJECT TITLE	INVESTIGATORS	FUNDERS	END DATE
Omnivores Versus Carnivores: Can Higher Levels of Pulse Starch be Tolerated in a Wider Range of Species Than Corn?	Dr. Lynn Weber, University of Saskatchewan, Veterinary Biomedical Sciences	Saskatchewan Pulse Growers ($227,000), Natural Sciences and Engineering Research Council of Canada (NSERC), AGT Food and Ingredients, Horizon Pet Foods	July 31, 2016
Improving Pulse Palatability & Health Benefits to Increase Pulse Market Share of Pet Foods	Dr. Lynn Weber, University of Saskatchewan, Veterinary Biomedical Sciences	Saskatchewan Pulse Growers ($305,376), AGT Food and Ingredients, Horizon Pet Foods	March 31, 2021
Does the Inclusion of Field Pea in Beef Finishing Diets Influence Beef Palatability Attributes of Multiple Muscles in Cattle Genetically Indexing for Poor Carcass Parameters	Dr. Vern Anderson, Carrington Research Extension Centre, North Dakota State University, Department of Animal Sciences and Dr. Kasey Carlin, North Dakota State University, Department of Animal Sciences	Saskatchewan Pulse Growers ($26,300)	Completed August 31, 2011
Saponins in Peas and their Effects on Palatability in Pigs	Dr. Pascal Leterme and Dr. Denise Beaulieu, Prairie Swine Centre	Saskatchewan Pulse Growers ($137,040)	Completed September 30, 2013
Zero-Tannin Faba Beans in Nursery, Growing-Finishing Performance, Carcass, and Pork Quality Traits	Dr. Eduardo Beltranena, University of Alberta	Saskatchewan Pulse Growers ($7,500)	Completed December 31, 2007
Maximizing the Use of Field Pea in a Commercial Barn Operation	Dr. Denise Beaulieu, Prairie Swine Centre	Saskatchewan Pulse Growers ($83,950)	Completed September 30, 2013

But Dr. Anderson says his results were not a shock, as there is already lots of evidence pointing to the fact that peas are extremely beneficial to feed diets, including those of sheep, swine, horses, and even bison. Now the challenge is ensuring steady prices and supply and communicating these benefits to cattle farmers.

"There is a dramatic need to continue education regarding the use of peas as feed throughout the pulse growing regions of the world," he says. "Past research seems to fade but peas are as valuable as a feed today or in 20 years as they were 10 or 20 years ago. New growers, new livestock producers, and new feed manufacturers need continual education."

The next steps for this research will focus on using peas in beef diets for cattle known to be less than tender, and determining and understanding the biological mechanism of how peas improve tenderness and flavour. More research is also needed on the use of peas as a forage, grazed cover crop, dry hay, mixed hay or silages, as well as the effects of pea on nutrients, animal performance, and beef eating attributes, Dr. Anderson says.

But overall he believes so strongly in his research that he is part of what he describes as a cult-like following of pea-fed beef advocates.

"I am sold on pea-fed beef, and purchase beef from a known source," he says. "My wife and I enjoyed a ribeye steak last weekend from a pea-fed steer that was fantastic off the grill."

Other SPG-funded research on the topic of peas as feed has focused on using various techniques to develop superior pea varieties for feed, studying the effects of saponins in peas on palatability in pigs, and looking at nutrient parameters.

SPG has also funded research specific to lentils, exploring the economic value of cull lentils in swine diets, and faba beans, looking at the effect of zero-tannin faba beans on the growing and finishing performance of pork, as well as carcass and quality traits.

For more information on ongoing research in this area, turn to page 38.

Beagles are being fed pulse pet food as part of Dr. Lynn Weber's research.

better options for weed control

WEED CONTROL IN PULSES

New research offers better options to control weeds.

Ask most pulse growers in Saskatchewan what some of their biggest challenges are for growing pulses and it is likely you will hear the same response over and over again — weed control.

Unlike cereal and oilseed crops, pulse crops are generally not competitive with weeds and are highly susceptible to yield loss as a result of weed competition.

Furthermore, the development of herbicide resistance in weed populations is a growing concern for growers in Saskatchewan, as resistance has developed rapidly here and in other major pulse growing regions of the world.

> GLOBALLY MORE THAN 400 BIOTYPES OF RESISTANT WEEDS HAVE BEEN DISCOVERED, AND IN CANADA ALONE THERE HAVE BEEN APPROXIMATELY 100 SPECIES OF RESISTANT WEEDS CONFIRMED.

Currently there are limited options for herbicides on the market for Saskatchewan growers, and that is not likely to change anytime soon, says Allison Fletcher, Research Project Manager with Saskatchewan Pulse Growers (SPG).

"Ag chemical companies do not often register chemistries solely for pulses, because globally it is a small market, so we end up screening chemistries that have initially been tested on other crops, in the hopes of finding something that is suitable for use on pulses," she says. "There is not a lot of research done, relatively speaking, in this area by private companies, so we have to step up in that area to fill in the gaps."

As a result of the lack of control options, the impact of weeds in pulses can be devastating. Research shows that pulse crops, the most susceptible crops to weed interference, commonly suffer yield losses of 20 to 40 per cent, but that number can climb up to 80 per cent in a bad year.

For all these reasons, weed research has long been a priority for SPG not only through research projects but also through the Weed Research Program, which is specifically targeted to developing Saskatchewan-focused, integrated management techniques for weed control. Earlier this year, SPG renewed its commitment to the program with a more than $2 million investment.

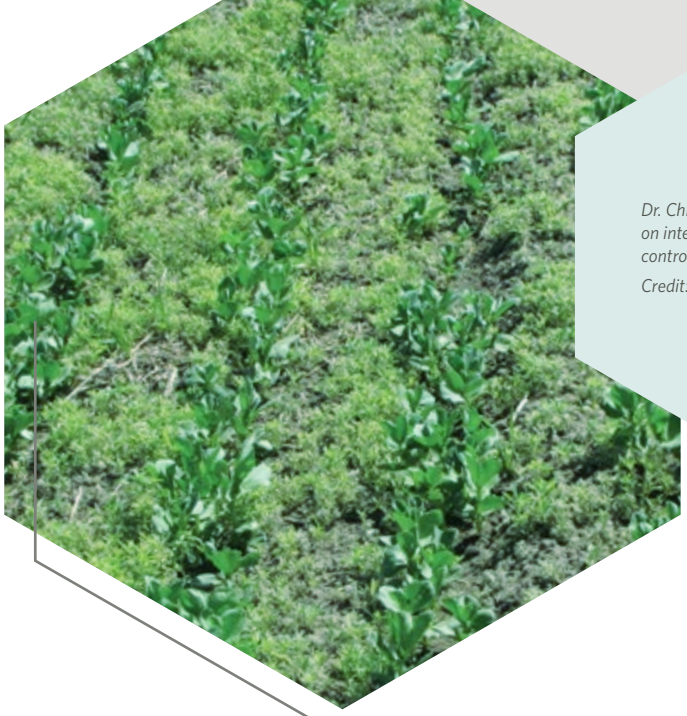
Previous investment in weed control research has already yielded some significant developments, Fletcher says. For example, in the past five years the industry has been able to collect a significant amount of data for submission to the Pest Management Regulatory Agency (PMRA) for approval of minor-use herbicides. Researchers have also developed imidazolinone (IMI) tolerant chickpea varieties, and improved the tolerance of field pea to Odyssey®. Furthermore, research has allowed for the reduction of the sulfentrazone (Authority®) re-cropping interval for canola to 12 months and for lentils to 24 months after application.

There have also been small developments in managing cleavers in high organic matter soils by herbicide layering, which refers to the act of combining pre-seed, short-term soil residual herbicides, with post-emergence, in-crop treatments.

But there is still lots of work left to do. For the next five years SPG-funded weed research will focus on diversifying growers' options for weed management and moving towards a more integrated approach.

This work will include:

1) Developing control and management guidelines for weeds that are problematic right now,
2) screening candidate herbicides for use, especially in faba beans and soybeans,
3) aiming to understand more about the ecology of the weeds in order to come up with management strategies, and
4) developing re-cropping guidelines to be used following application.



Dr. Chris Willenborg's research on intercropping as a weed control option in pulse crops.
Credit: University of Saskatchewan

Some other newer-to-Saskatchewan alternatives might also be explored, Fletcher says.

Focusing on More Integrated Methods For Weed Control

Managing weeds without herbicides is becoming an increasingly popular aspiration amongst the Western Canadian pulse industry, as levels of herbicide resistance continue to grow.

Globally more than 400 biotypes of resistant weeds have been discovered, and in Canada alone there have been approximately 100 species of resistant weeds confirmed. The majority of these cases have been discovered in the past 30 years, in which time only one new control option has become available.

Furthermore, weed resistance appears to be rapidly increasing, says Dr. Chris Willenborg, Assistant Professor at the University of Saskatchewan's College of Agriculture and Bioresources.

"We have seen a marked increase in the spread of glyphosate-resistant weeds across the globe," he says, adding that approximately three new biotypes of glyphosate-resistant weeds are discovered every year. "Based on these trends, I do not believe relying exclusively on herbicides is in our best interest over the long term."

Dr. Willenborg is currently leading research which aims to determine and develop the most effective management techniques for weeds, including integrated methods used in combination with one another.

"Using multiple tactics, also known as 'many little hammers,' creates synergies that result in better weed control than when any single weed control method is utilized alone," he says. "Combining two tactics that work similarly should yield twice the yield benefits, but when you have synergism, you may end up with two or three times greater weed control and crop yield."

The methods can include row spacing, seeding rates, and weed seed management, which refers to managing the weed seeds leftover in the fields to ultimately decrease the number of weeds during production. Currently growers do this through the use of dry-down products or machines like the Harrington Seed Destructor, but Dr. Willenborg's research looks at biocontrol options such as beneficial insects and their role in weed seed predation, to attack the problem at a different level.

"Weed seed predators destroy significant proportions of weed seeds and if we can better understand this process and how best to create environments that favour these processes, we can improve our ability to manage weed seeds and reduce the level of germinating weed seeds we encounter each spring," he says.

"And the best part is that these predators work for free, since they require the nutrients in the seeds as part of their diets."

But despite the desire to move away from chemical control options, Dr. Willenborg cautions that a completely chemical-free approach is not possible for most pulse crops. Instead his research will focus on using chemicals in a more judicious, integrated manner instead of as a single solution.

"Much of the work we are doing actually still involves herbicides because this is the major tool on which we depend for weed control, especially in pulse crops.

CONTINUED: WEED CONTROL IN PULSES

"Herbicides are often the most cost-effective and efficacious way to control weeds and thus, they are still integral to any cropping system."

For example, the idea of a two-pass herbicide system or herbicide layering is an option that shows promise, he says.

"Our previous work has shown excellent weed control if we use both a pre-emergence herbicide followed by a post-emergence herbicide. We are building on that and trying to develop this system for use in pulse crops with hard-to-control weeds like herbicide-resistant kochia and cleavers."

This technique can also help manage resistance, as applying a pre-emergence herbicide can help reduce the size of the weed population that is exposed to a post-emergence herbicide application, which reduces the selection pressure applied by the post-emergence product.

Overall Dr. Willenborg estimates his research will yield solid information about a more integrated approach to weed control that growers may start putting to use in the next 5 to 10 years. In the meantime, he recommends growers stick to good agronomy and proper timing of weed control tactics, and perhaps consider combining their current approaches to find an integrated system of their own. There are also some mechanical options for weed control currently available, such as post-emergent harrowing, weed wicking, inter-row tillage, and rotary hoes, but these are not always as cost-effective as herbicides.

Glyphosate Resistance

Glyphosate, first introduced in Canada in 1974, is the most widely used herbicide in the world and is a key herbicide for weed control in pulses in Western Canada, as well as for a number of other crops. To give an idea of the scope, glyphosate usage in Western Canada surpasses that of the next top 12 herbicides combined.

Therefore it was only a matter of time before weeds in Western Canada developed resistance to this popular herbicide. In 2011, a case of glyphosate-resistant kochia was confirmed in Alberta, and by the next year it had spread to Saskatchewan.

Once the resistant weeds start spreading, it is important to be able to monitor their distribution and abundance, as this type of information is critical in developing and adopting prevention and control measures to reduce the evolution and spread of the resistant biotype. This is why SPG invested in research led by Dr. Hugh Beckie, a weed scientist at Agriculture and Agri-Food Canada, which aimed to determine the presence of glyphosate-resistant kochia in the province.

Dr. Beckie's research surveyed crops in southern and central Saskatchewan, as well as kochia plants from a minimum of 300 populations, to determine the level of glyphosate resistance.

The takeaway from this research was that proper herbicide rotation and mixtures are key to avoid selecting for resistant weeds in such systems, Dr. Beckie says.

"This research reinforces the importance of judicious use of glyphosate in crop and non-crop situations, as well as the potential for glyphosate resistance to evolve in weeds other than kochia," he says. "Tank mixing glyphosate with another herbicide mode of action, either pre-emergence or post-emergence, is important to delay glyphosate resistance."

For the next phase of research, Dr. Beckie is currently investigating all the aspects of glyphosate resistance in kochia, from pollen and seed dispersal to best management practices. This work will include a new round of field surveys, to determine the occurrence and spread of glyphosate-resistant kochia, which will take place in Alberta in 2017, Manitoba in 2018, and Saskatchewan in 2019.

Going forward there will undoubtedly be new resistant weeds that develop in Western Canada, Dr. Beckie says, with high risk especially for wild oat, green foxtail, cleavers, and wild buckwheat.

"Glyphosate-resistant weeds are continuing to evolve rapidly in other parts of the world, so it is unrealistic to think we are immune to this phenomenon."

What we can do, however, is aim to stay on top of these new developments by better understanding the weeds as they evolve.

Understanding Weeds

Since the 1970s, weed surveys have regularly been conducted in each of the Prairie provinces in order to understand which weeds are growing where, and to document changes between surveys. This data is ultimately used by researchers, industry members, and extension groups to develop weed management recommendations for growers and to set research and education priorities.

However, the last weed survey in Saskatchewan was conducted 10 years ago, which is why

SPG invested in a new one in 2014/15, led by Julia Leeson, Weed Monitoring Biologist with Agriculture and Agri-Food Canada.

"Quantitative field surveys of weed populations are used to reveal the current size, extent, and order of importance of species," she says. "Tracking the increase or decrease in weed populations and the changes in the composition and structure of weed communities indicates the extent by which various weeds are spreading or being controlled and thus the effectiveness of weed management programs."

The results of this survey will be combined with results from a farm management questionnaire survey, which will provide detailed information on what growers are doing to produce a crop. This information can also help identify particular weed management practices that are important determinants of distinctive weed communities, Leeson says.

"Predicting shifts in weed populations and communities that might occur because of anticipated changes in agronomic practices, weed control management, and agricultural policy will allow agricultural agencies to develop weed management strategies that meet the future needs of growers."

The results of Leeson's 2014/15 survey so far show that the number one weed in lentils and peas is volunteer canola, and of the species currently in the top 20, narrow-leaved hawk's-beard, spiny annual sow-thistle, and shepherd's purse have increased in rank in both crops. Perennial sow-thistle and round-leaved mallow also increased in rank in lentils, while wild mustard and barnyard grass species increased in peas. Black medick and false cleavers also are currently ranked amongst the top 20 weeds in peas, and have increased in both crops.

"Most of the other species found in the top 20 have not changed much in rank since 2003 including green foxtail, wild oats, wild buckwheat, stinkweed, Canada thistle, kochia, and dandelion," Leeson says.

Other completed and ongoing SPG-funded research in the area of weed control includes looking at combinations of chemicals and other management techniques for better control of herbicide-resistant broadleaf weeds in pulses, developing measurement tools for Group 1 and 2 herbicide resistance in weeds, reducing weed seed production in herbicide resistant weeds, and more.

For a listing of ongoing research in this area, visit page 38.

PROJECTS FEATURED IN THIS ARTICLE

PROJECT TITLE	INVESTIGATORS	FUNDERS	END DATE
2014 Saskatchewan Weed Survey	Julia Leeson, Agriculture and Agri-Food Canada	Saskatchewan Pulse Growers ($100,000), Agriculture Development Fund, Western Grains Research Foundation	August 31, 2016
Development of Rapid Assays for Determination of Group 1 and 2 Herbicide Resistance in Weeds	Dr. Hugh Beckie, Agriculture and Agri-Food Canada	Saskatchewan Pulse Growers ($26,666), Western Grains Research Foundation, Agriculture Development Fund	September 30, 2016
Enhancing Weed Science in Pulse Crops: Towards a Robust Strategy for Long-term Weed Management	Dr. Chris Willenborg, University of Saskatchewan, Department of Plant Sciences	Saskatchewan Pulse Growers ($2,023,021)	March 31, 2021
Glyphosate-Resistant Kochia (*Kochia scoparia*) in Saskatchewan	Dr. Hugh Beckie, Agriculture and Agri-Food Canada	Saskatchewan Pulse Growers ($13,500), SaskCanola, SaskFlax	Completed August 31, 2014
Integrating Cultural, Chemical, and Mechanical Weed Management for Controlling Herbicide Resistant Broadleaf Weeds in Lentil	Dr. Steve Shirtliffe, University of Saskatchewan, Department of Plant Sciences	Saskatchewan Pulse Growers ($86,250), Agricultural Development Fund	Completed April 1, 2014
Weed Science and Herbicide Technologies for Pulse Crops	Dr. Chris Willenborg, University of Saskatchewan, Department of Plant Sciences	Saskatchewan Pulse Growers ($772,850)	Completed March 31, 2016
Reducing Weed Seed Production in Herbicide Resistant Weeds with Pre-Harvest Herbicide Application	Dr. Steve Shirtliffe, University of Saskatchewan, Department of Plant Sciences	Saskatchewan Pulse Growers ($104,650), Western Grains Research Foundation	March 31, 2018

developing adopted varieties

MAKING PULSE VARIETIES THE BEST FOR SASKATCHEWAN

What it takes to develop varieties that are well-adapted to the province.

We often hear how important breeding programs are for the success of the pulse industry in Saskatchewan, as they consistently provide growers with options for new pulse varieties with the most desirable traits for production and end-use markets.

However, we do not hear as often about pre-breeding research, which refers to all the work that is done to identify traits such as disease resistance, herbicide resistance, and nutritional quality and mobilize into a breeding program for new variety development.

Pre-breeding research is a significant area of focus for the Saskatchewan Pulse Growers' (SPG) research program, for a number of reasons.

Not only does this work allow for the introduction of new traits into cultivated, high performing varieties, it also ensures plant breeders can adopt the latest techniques for variety development which ultimately helps get new varieties into growers' hands faster.

Pre-breeding research also allows local researchers to collaborate with the global research community, in order to access new breeding technologies and tools that have been developed in other areas of the world, says Dr. Lisette Mascarenhas, Director of Research and Development at SPG.

"Pre-breeding is essentially about traits development," she says.

"If there is a wild lentil that has natural resistance to diseases, but it is a low yielding type, researchers can take that trait and move it into a locally adapted, high yielding variety. You have to adapt the variety to the local area so that it performs to its maximum potential."

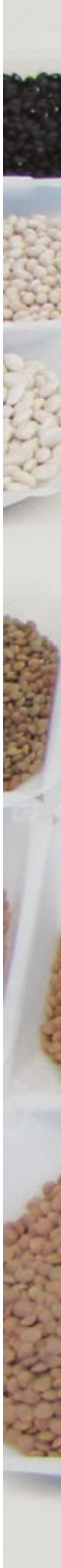
Pre-breeding research has led to the introduction of important traits in current varieties, such as herbicide resistance and improved disease resistance. Ongoing work in this area is developing potential methods for developing Aphanomyces-resistant traits for peas and lentils, which could then potentially be moved into a variety adapted to Saskatchewan growing conditions.

Overall the goals of pre-breeding research are to increase yield and yield stability in pulse crops through the introduction of new and important agronomic traits. This step is crucial to the success of the breeding program, and therefore the continued competitiveness and future success of the pulse industry, Mascarenhas says.

Pre-breeding Developments

SPG has long had a collaborative partnership with the University of Saskatchewan's (U of S) Crop Development Centre (CDC), and earlier this year renewed its funding commitment to the CDC, pledging nearly $23 million over a five-year period to fund the CDC's pulse breeding program.

During the course of this long-term partnership between SPG and the CDC, several important developments have been made in pre-breeding research, including the introduction and adaptation of several new technologies that have allowed for



The Crop Development Centre at the University of Saskatchewan is one of the biggest pulse breeding programs in the world.

CONTINUED: MAKING PULSE VARIETIES THE BEST FOR SASKATCHEWAN

improvements in crop maturity, disease resistance, yield, and market quality in Saskatchewan-adapted pulse crops and market classes.

These include DNA technologies, such as genome sequencing and marker development, analytical techniques from infrared thermometers to synchrotron science, and field plot technologies such as GPS, zero-till drills, plot combines, irrigation, and disease nurseries.

These also include improved indoor plant growth systems involving greenhouses, growth chambers, rapid generation techniques, and improved data handling and management approaches such as classical crop science statistics and bioinformatics.

"All of these technologies serve as tools to enhance pulse crop breeding, essentially to facilitate genotyping (the DNA profile) and phenotyping (the visible expression of traits)," says Dr. Tom Warkentin, Plant Breeder at the CDC and a Professor at the U of S College of Agriculture and Bioresources.

"By using improved genotyping and phenotyping tools, plant breeders can make more efficient selections."

But despite the strong track record, this area of research still faces challenges, Dr. Warkentin says.

"On a global scale the pulse crops we grow in Saskatchewan are relatively small, and therefore attract much less investment than the larger crops grown worldwide such as corn, rice, soybean, and wheat."

Therefore, the major challenge will be keeping pulse crops competitive in growers' crop rotations, which will require improved disease resistance, abiotic stress tolerance (such as tolerance to heat during flowering and pod filling), and nitrogen-fixation capability.

It will also require improved nutrient density and quality for expanded uses of pulses (such as cooking time, flavour, and milling efficiency), as well as reduced concentration of anti-nutritional factors in harvested seeds.

Finally, it will require a complete evaluation of genetic resources — in both domesticated and wild relatives, Dr. Warkentin says.

Pre-breeding Research for Agronomy Improvements

Another major focus of pre-breeding research is genomics, which refers to the study of the entire set of genes that exist within a living organism. The genome provides hereditary information for all the cells that exist within the organism and are needed for its survival.

This is very important information for plant breeding, as it can be used to better design crosses and select plants at much earlier stages of the breeding program. This information also allows plant breeders to identify the key regions of the genome that affect important complex traits of the crop, which allows for the development of molecular markers to precisely track those desirable traits during the breeding process.

Overall, the study of genomics can be used to significantly accelerate the rate at which breeders are able to make genetic improvements to crops, and develop new and improved varieties for growers.

Dr. Kirstin Bett, Plant Breeder and Professor in the Department of Plant Sciences at U of S, is currently leading several research projects related to genomics in lentils.

Her research in this area builds on studies that have already developed genomic and genetic resources for improving lentil breeding. For example, previous research was able to identify important genes in wild lentil relatives for traits such as disease resistance, as well as the sequencing of the genome.

The goal of Dr. Bett's research is to integrate genomic technologies into the lentil breeding program in order to develop new varieties that can overcome production constraints that currently affect Saskatchewan growers, such as new diseases, changes in weather patterns, pests, and weeds.

"Ultimately, having a complete lentil genome will enhance the research community's understanding and use of key agronomic traits in lentil breeding," Dr. Bett says. "Integration of such knowledge with key performance and end-use consumer traits will augment current lentil breeding practices and facilitate efficient cultivar development at the CDC."

These technologies can also be used to develop traits to meet specific market demand. For example, some

BY USING IMPROVED GENOTYPING AND PHENOTYPING TOOLS, PLANT BREEDERS CAN MAKE MORE EFFICIENT SELECTIONS.

of Dr. Bett's research focuses on helping to understand what makes lentil varieties more attractive to end-use markets through their visual characteristics.

Dr. Bett is also currently working on research that aims to understand flowering time in lentils by confirming which genes control days to flower and maturity, and developing markers related to key flowering time genes. The aim is that these genes can then be deployed into the CDC's lentil breeding program.

The overall goal of pre-breeding research is to provide researchers with the tools they need to help build a sustainable, long-term future for the Saskatchewan pulse industry.

And that means supporting the development of new varieties to keep us competitive, Mascarenhas says.

"New variety development is very important — if we did not have varieties that respond to market needs, we would be unable to remain competitive globally."

"Right now we are the world's largest exporters of pulses, so this area is exceptionally important."

For a list of ongoing SPG-funded research in this area, flip to page 38.

PROJECTS FEATURED IN THIS ARTICLE

PROJECT TITLE	INVESTIGATORS	FUNDERS	END DATE
Application of Genomics to Innovation in the Lentil Economy (AGILE)	Dr. Kirstin Bett, University of Saskatchewan, Department of Plant Sciences **Co-Investigator:** Dr. Doug Cook, University of California Davis	Saskatchewan Pulse Growers ($1,517,688 CAD + $534,876 USD), Genome Canada, Western Grains Research Foundation	September 30, 2019
Control of Flowering Time in Cultivated Lentil	Dr. Kirstin Bett, University of Saskatchewan, Department of Plant Sciences	Saskatchewan Pulse Growers ($100,000)	March 31, 2017
Lentil Genome Sequencing (LenGen): Establishing a Comprehensive Platform for Molecular Breeding	Dr. Kirstin Bett, University of Saskatchewan, Department of Plant Sciences **Co-Investigator:** Dr. Doug Cook, University of California Davis	Saskatchewan Pulse Growers ($897,001)	July 31, 2016
Sequencing the Pea Genome: Creating a Solid Foundation for Long-Term Pea Genetic Improvement	Dr. Tom Warkentin, University of Saskatchewan, Crop Development Centre	Saskatchewan Pulse Growers ($1,446,773)	July 31, 2016

GETTING TO THE ROOT OF ROOT ROT PROBLEM IN SASKATCHEWAN

Research dollars uncovering new ways to deal with root rots.

In November 2015, Saskatchewan Pulse Growers (SPG) held a meeting to determine how to focus agronomic research priorities going forward.

The number one concern that came forward from growers and agronomists at the meeting was Aphanomyces and/or root rot complex diseases.

This was not a surprise, says SPG's Agronomy and Seed Program Manager Sherrilyn Phelps.

"In 2015 we really did not have too many root rot issues, but there were a lot of people still dealing with it from 2014, so it is still forefront in their minds," she says. "They have seen the devastation that can result under the right conditions."

Although other countries, such as France and the United Kingdom, have been dealing with Aphanomyces for decades, it is a relatively new problem to the Canadian prairies, resulting from unusual weather conditions, Phelps says.

"We have just had the perfect storm for this disease to develop in our area," she says. "In the past five to six years we had consistent wet conditions across the province, so when peas were seeded in 2010 and then again in 2014, the organism was able to survive and multiply in the first pea year, and in the second pea crop it was just devastating."

Since Aphanomyces is relatively new to the Canadian Prairies, there are few effective management techniques to control the disease, even though there are seed treatments available for control of other root rot pathogens such as Fusarium, Rhizoctonia, and Pythium. Some crop protection companies have said they are working on seed treatments for Aphanomyces but there has not been a silver bullet yet.

Currently growers are advised to monitor their crops and if root rot is suspected, to send root or soil samples to a diagnostic lab for testing. If Aphanomyces is detected and the field shows uniform root rot symptoms, growers are advised to wait at least six years before planting peas or lentils, as the disease remains in the soil for a long time.

Therefore, Aphanomyces root rot continues to pose a huge risk to lentil and pea production in terms of acres and yield potential in the future, especially if environmental conditions continue to be on the wetter side during spring and early summer, Phelps says.

This is why SPG's research investments around the disease are currently focused on three main components, which aim to diversify the management options for this devastating disease:
1) Developing resistant varieties,
2) mastering early detection techniques, and
3) determining agronomic best practices to manage the disease.

It is Complicated

Adding to the existing challenge of managing Aphanomyces is its relation to root rot, which is complicated, says Dale Risula, Provincial Specialist of Special Crops with the Saskatchewan Ministry of Agriculture.

"Root rots are not just caused by one organism and that is why they are so hard to control," he says.

Symptoms of Aphanomyces root rot developing in the field after a rainfall in 2015.

CONTINUED: GETTING TO THE ROOT OF ROOT ROT PROBLEM IN SASKATCHEWAN

"Often there is more than one pathogen involved and that is why it is often referred to as a root rot complex."

Furthermore, with root rots, pathogens can infect the plants at any time during the lifecycle, he says. "The pathogen invades the roots, often near the seed, and infection spreads throughout the underground portion of the plant. Above-ground symptoms take time to appear and by the time you see the above-ground symptoms it is often too late."

> THE PATHOGEN INVADES THE ROOTS, OFTEN NEAR THE SEED, AND INFECTION SPREADS THROUGHOUT THE UNDERGROUND PORTION OF THE PLANT. ABOVE-GROUND SYMPTOMS TAKE TIME TO APPEAR.

Early infections are the most devastating in terms of yield loss, as the infection starts at the seedling stage before any yield is set. Infections can also occur later in the season and may not show up in yield loss or symptoms above ground.

"However, the stem is weakened and will lodge prior to harvest making harvesting difficult," Risula says. "These are the fields that go flat to the ground."

It is interesting to note this disease only affects peas and lentils. Chickpeas, soybeans, and faba beans all have good partial resistance and with dry beans, it depends on the variety.

Developing Resistant Varieties

Dr. Sabine Banniza, a Plant Pathologist at the Crop Development Centre and a Professor of Plant Sciences at the University of Saskatchewan, has been working on developing Aphanomyces-resistant varieties of peas and lentils.

More specifically, Banniza is the lead on two major Aphanomyces-related projects, both funded by SPG and both aiming to speed up resistant variety development through rapid generation technology (RGT), which accelerates seed germination, reducing the time to flowering and eliminating the seed maturation and desiccation period. For lentils, RGT has proven very effective, resulting in the production of five generations of Saskatchewan varieties per year.

Banniza's first project aims to identify both the strain of the pathogen of Aphanomyces in Saskatchewan as well as germplasm with high resistance and then integrate this resistance with RGT technology.

To carry this out, Banniza and her team began collecting soil samples from pea and lentil fields in Saskatchewan last year and have been isolating strains of the pathogen that will be characterized to determine what pathotypes they are. Preliminary screening with a Saskatchewan strain of Aphanomyces has already drawn a few conclusions, including that wild pea does not appear to have resistance, and that all cultivated lentil samples were susceptible.

The team is also currently working to develop a system that will intensify screening in order to identify additional sources of resistance that can then be integrated into RGT protocols.

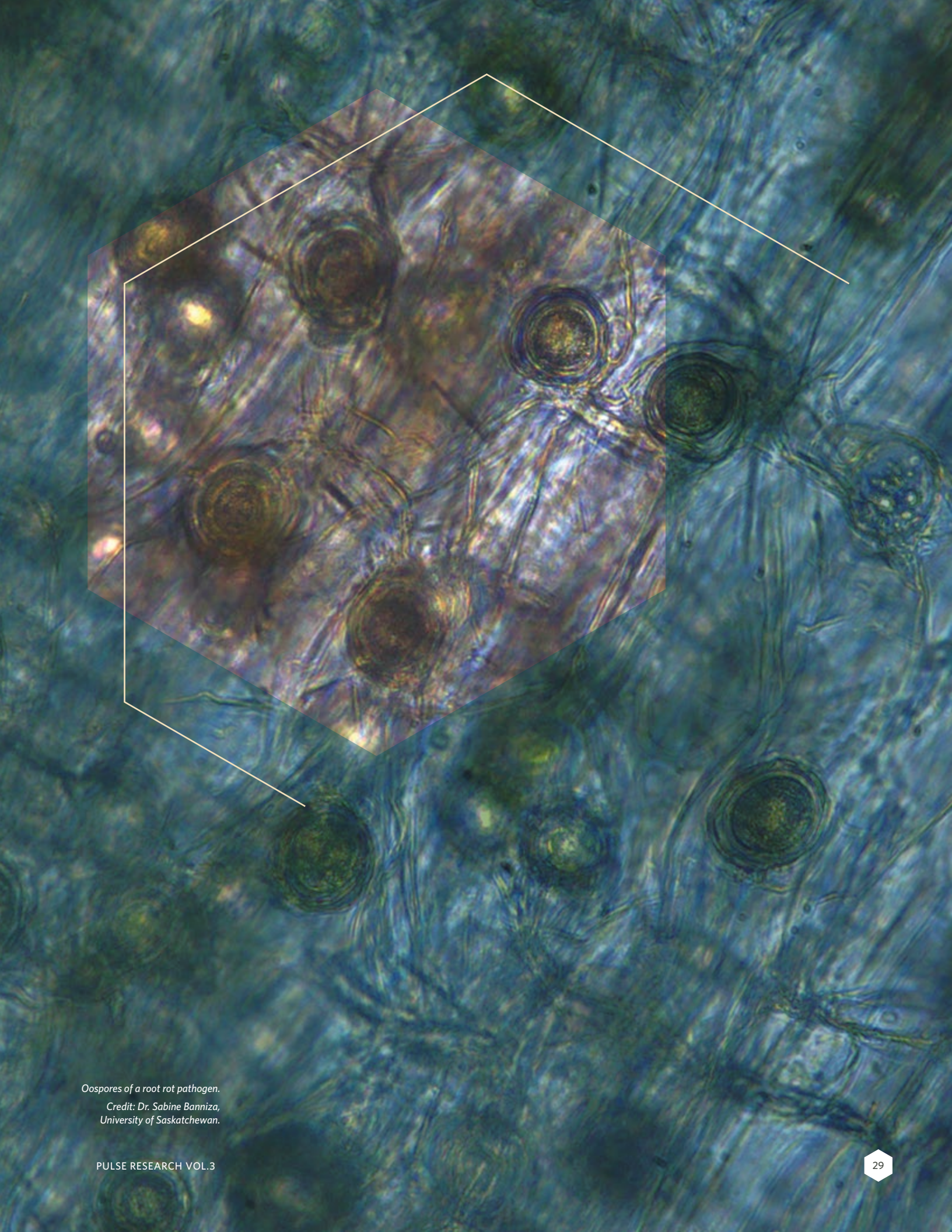
As partially resistant germplasm has already been developed in France and the United States, Banniza's research will also be able to borrow from some of this research to help guide the screening and selection process for peas for Saskatchewan.

"We have the advantage of other scientists having done the groundwork," Banniza says.

The second project Banniza is leading focuses on developing RGT for wild lentil crosses, as there is indication that they may have partial resistance to the pathogen. Although the technology has been successfully developed and is being used for cultivated lentil varieties, it had never been tested on wild lentil and crosses involving wild species.

"Wild seeds naturally have slow and uneven germination due to differences in dormancy rates enabling these species to survive in the wild," Banniza says. "Having compounds that would inhibit one of the plant hormones involved in seed dormancy could overcome dormancy issues and greatly improve and speed up RGT in wild, as well as cultivated lentils."

Through this research the team was able to determine changes that could be made to the environmental growing conditions of the plants rather than hormonal manipulations, which resulted



Oospores of a root rot pathogen.

Credit: Dr. Sabine Banniza, University of Saskatchewan.

CONTINUED: GETTING TO THE ROOT OF ROOT ROT PROBLEM IN SASKATCHEWAN

in seeds germinating much faster. This development translated into a substantially accelerated timeline for moving wild lentils through a single lifecycle from planted seed to harvested seed.

"For growers this means that new varieties will be available one year faster than using conventional methods," Banniza says.

And although we are at least 5–6 years out from having pea varieties with built-in resistance to Aphanomyces (and longer for lentils), these research findings are the small, but necessary steps that take us closer to the ultimate goal.

Early Detection

In areas of the world most affected by Aphanomyces root rot, soil indexing tests are a recommended practice to help avoid the disease. For example, in France, a quantitative DNA test was recently developed that helps predict root rot risk. These types of tests allow growers to assess the risk in their fields and then use this information to limit the short- and long-term impact of this disease.

To develop such a test for Saskatchewan, local growing conditions and production practices would have to be incorporated, says Syama Chatterton, a Research Scientist at Agriculture and Agri-Food Canada's Lethbridge Research and Development Centre.

"We first need to determine how oospore inoculum levels relate to disease severity levels in the different soil types common in Saskatchewan," she says.

In order to help fill in these gaps, Chatterton is leading research, funded by SPG, which aims to develop an infection model for soil zones which would outline how the disease evolves in different soil zones, how the different species and pathogens interact, and how seed treatments affect the disease.

Chatterton began by conducting a mass survey of root rot in field peas in 2013 and 2014, examining the severity and variation of the disease and its pathogens across Brown, Dark Brown, and Black soil zones in Saskatchewan. Those samples are now being used in trials that compare the response of root rot to inoculum.

So far the trials have yielded a few preliminary results. For example, it appears that Dark Brown soils are the most conducive to disease development and the presence of other soilborne pathogens has a synergistic effect on disease development by Aphanomyces.

Chatterton's research also saw her team surveying Saskatchewan fields in 2015. This phase of the research was able to give an idea of the occurrence of the disease and its relation to root rot and pathogens. Of the pea fields surveyed in Saskatchewan in 2015, 50 per cent of them tested positive for the presence of Aphanomyces and from those positive fields, on average 58 per cent of root samples tested positive for the disease.

> AVOID PLANTING PEAS AND LENTILS ON FIELDS THAT HAVE BEEN IDENTIFIED AS POSITIVE FOR APHANOMYCES AND ALWAYS ENSURE THE HEALTH AND VIGOUR OF SEEDLINGS.

"We also found that Fusarium was present in every field surveyed, and *Fusarium avenaceum* and *Fusarium solani* were the most common," Chatterton says. "These fusarium species are not as virulent or aggressive at causing root rot as *Aphanomyces euteiches*, but our observations suggest that the presence of both Aphanomyces and *Fusarium avenaceum* or *Fusarium solani* results in the most damage to roots."

Another round of trials will happen next year to ensure results are consistent within soil types and not due to field location, but Chatterton already feels the study has made progress towards larger goals.

"Results from the first year of this project suggest that quantification of *Aphanomyces euteiches* inoculum levels in field soil samples can be used to predict risk levels of Aphanomyces root rot, and represent the first step in achieving the goal of developing a quantitative DNA test to predict root rot risk," she says.

Agronomic Best Practices

Although SPG-funded research aims to develop tools that will be used in agronomic best practices, it is still too early for any conclusions that will aid

growers in coming years, and it will likely be years before any resistant lentil varieties are developed.

For now, SPG research will prioritize studying agronomic practices such as the effect of seed treatment, tillage, foliar applications, and the effect of herbicides on pre-emergence.

"We are looking to see if we can improve tolerance and reduce stresses so that the plant is healthier and better able to fight off disease," Phelps says.

Another area that is currently being studied is the effect of the disease on growing other pulses such as chickpeas, soybeans, and faba beans in rotations.

"You may be limited to growing peas and lentils once in six to eight years, but does that mean you cannot grow chickpeas, soybeans, or faba beans? We are evaluating these questions now," Phelps says.

For now the advice to growers is the same — avoid planting peas and lentils on fields that have been identified as positive for Aphanomyces, and always ensure the health and vigour of seedlings, Phelps says.

"Good seed, seed treatments where necessary, seeding into nice warm soil, making sure nutrient levels are appropriate, and minimizing other stresses that might make plants more susceptible to root rots — these are all recommended practices," Phelps says.

For a list of ongoing SPG-funded research in this area, flip to page 38.

Control pea plants grown in Aphanomyces-infested soil in the greenhouse.

PROJECTS FEATURED IN THIS ARTICLE

PROJECT TITLE	INVESTIGATORS	FUNDERS	END DATE
Integration of Aphanomyces Resistance Screening Into Rapid Generation Technology of Lentil and Pea	Dr. Sabine Banniza, University of Saskatchewan, Crop Development Centre **Co-Investigator(s):** Dr. Tom Warkentin, University of Saskatchewan, Crop Development Centre, Dr. Bert Vandenberg, University of Saskatchewan, Crop Development Centre	Saskatchewan Pulse Growers ($483,506)	April 30, 2018
Developing Rapid Generation Technology Involving Wild Lentil Crosses in Order to Produce Aphanomyces-Resistant Lentil Varieties – Proof of Concept	Dr. Sabine Banniza, University of Saskatchewan, Crop Development Centre **Co-Investigator(s):** Dr. Monika Lulsdorf, University of Saskatchewan, Crop Development Centre, Dr. Bert Vandenberg, University of Saskatchewan, Crop Development Centre	Saskatchewan Pulse Growers ($259,289)	April 30, 2017
Infectivity Model for *Aphanomyces euteiches* in Saskatchewan Soils	Dr. Syama Chatterton, Agriculture and Agri-Food Canada, Lethbridge	Saskatchewan Pulse Growers ($290,000)	March 31, 2018

DRAWING THE LINKAGE BETWEEN PULSE CONSUMPTION AND DISEASE REDUCTION

Pulses have many health benefits worth paying attention to.

Michelle Shepherd is a big fan of pulses.

A Registered Dietitian and the owner of a healthcare practice based in British Columbia, Shepherd has long been recommending pulses to her clients, many of whom suffer from chronic diseases including digestive disorders, diabetes, heart health, cancer, and polycystic ovarian syndrome.

> THE HIGH FIBRE CONTENT HELPS FEED OUR HEALTHY GUT BACTERIA AND BALANCE BLOOD SUGARS FOR GOOD HEALTH. PULSES ARE ALSO A GREAT SOURCE OF PROTEIN.

"I absolutely recommend my clients build a variety of pulses into their diet, as there are so many benefits," she says. "The high fibre content helps feed our healthy gut bacteria and balance blood sugars for good health. Pulses are also a great source of protein, which aids in managing appetite and cravings. Research on pulses shows that adding them to our diet is associated with healthier weights."

Shepherd also says she has seen a pickup in consumer interest in pulses in recent years.

"We are definitely seeing pulses come back in to the realm of the everyday diet as they become trendier and consumers are more health focused, and there is a greater interest in sustainable food," she says. "Here on the West Coast we are also seeing them on restaurant menus which helps give clients fresh ideas and raises their profile."

Shepherd has long been studying the health benefits of pulses through nutrition research papers and educational conferences, but Saskatchewan Pulse Growers (SPG) wants to ensure that the message is getting out to the healthcare community — and consumers in general — more broadly.

SPG also wants to ensure that there are more and more professionals such as Shepherd working to spread the pulse story.

This is why one of the major focuses of the organization's research program is to understand the impact of pulse consumption on metabolic diseases, says Director of Research and Development, Dr. Lisette Mascarenhas.

"We know that pulses are high in protein, fibre, and micronutrients, and research shows us that

There is current evidence that supports pulses lowering the risk of cardiovascular disease, reducing blood sugar levels, and helping people control their body weight and body fat.

CONTINUED: DRAWING THE LINKAGE BETWEEN PULSE CONSUMPTION AND DISEASE REDUCTION

a link exists between pulse consumption and satiety, low glycemic index, lower cholesterol, better gut health, and heart health," she says.

"A concrete body of evidence continues to build through clinical trials where we can demonstrate why and how pulses work. We are keen to educate consumers in North America about the benefits of pulses and why they should consume pulses."

But how is this being done?

SPG's development strategy includes several components, such as ensuring that scientific evidence is in place to support the messaging that people should eat more pulses, and engaging health professionals such as Shepherd, who are one of the key influencers on people's diets.

"We want dietitians and physicians who consult patients on metabolic disorders to evaluate the inclusion of pulses in their patients' everyday diet, similar to exercise now," Mascarenhas says. "We are well on our way to building the evidence they need to get buy-in."

SPG's strategy also involves investing in research into how commercial food manufacturers could include pulses as ingredients in their food products.

Investing in Health Claims

Dr. Peter Jones has been a Professor at the University of Manitoba and the Director of the Richardson Centre for Functional Foods and Nutraceuticals, based in Manitoba, for more than a decade.

He is very familiar with the health benefits of pulses and the research around pulses and health benefits.

"The current evidence available to us supports a therapeutic relationship between pulse consumption and risk management for a number of diseases and physiological disorders," he says, referring to research that has demonstrated the multitude of health benefits that come from consuming a pulse diet.

These benefits include a lowered risk of cardiovascular disease, reduced blood sugar levels, reduced blood pressure, and better control over body weight and body fat. Research has also shown that pulse consumption can improve other biomarkers such as hemoglobin A1C which is linked to diabetes. Recent research has also shown that pulses improve satiety and fullness.

Dr. Jones agrees with SPG that the next crucial step in developing new markets for pulses based on their health attributes is to communicate these research results to consumers, particularly in Canada and the United States, where regular pulse consumption is low. One way to transmit this information could be through health claims provided on food product labels.

"Existing and ongoing research is really addressing important research gaps, to strengthen the evidence that leads to health claims on pulses and pulse products," he says.

Pulses as Ingredients

One of these research gaps, which Dr. Jones is currently addressing through SPG-funded research, is considering how different preparations of pulses (including dehulled, split, ground, flaked, fractionated, and puréed) can be included in foods to improve their health and marketing attributes.

For example, research has found that adding 25 per cent lentil flakes to oatmeal can improve the final food product's fibre and protein content, while also reducing its environmental impact and carbon footprint — all attributes that today's consumers are interested in.

"We have all these great products to pick from and we have got all sorts of different formulations and fractions of those pulse products," Dr. Jones says. "And then we have a whole myriad of different foods into which we can park those products. We can then test the health benefits of those and try to come up with candidates that really seem to do the job better than other candidates."

The ultimate goal of this research is to extend the current knowledge base around pulses and pulse ingredients, in order to optimize the dose and combination of ingredients to allow for more commercial pulse products on the market.

More SPG-funded research from the University of Toronto aims to prove that pulse flours or pulse components could be used to produce bread that had low glycemic indices and still tasted good.

Led by Dr. David Jenkins, a Professor in the Department of Nutritional Sciences at the University

Dr. Peter Jones, Richardson Centre for Functional Foods and Nutraceuticals

Research indicates that consuming pulse-based foods can lower blood pressure.

CONTINUED: DRAWING THE LINKAGE BETWEEN PULSE CONSUMPTION AND DISEASE REDUCTION

of Toronto and the Canada Research Chair in Nutrition and Metabolism, and Dr. Cyril Kendall, a Research Associate in the Department of Nutritional Sciences at the University of Toronto, the research ultimately aims to position pulse breads as an alternative to wheat bread, offering advantages in cardiovascular disease and diabetes prevention and treatment.

This research has made significant progress in developing formulations and balancing ingredients that meet the health objectives set out without compromising taste.

Pulses for Disease Treatment and Prevention

Another valuable area of pulse research involves exploring the link between pulses and disease treatment and/or prevention, and to-date, plenty of SPG-funded research has proven positive links between the two.

For example, research from the University of Toronto has proven that pulses are a great food choice for anyone who suffers from diabetes or is at risk of developing it. According to the Canadian Diabetes Association, an estimated 5.7 million Canadians suffer from diabetes as of 2015, and that number is expected to increase by 44 per cent in the next decade.

This study, also led by Dr. Jenkins and Dr. Kendall, compared the effects of eating pulses daily, versus whole wheat products, on people with Type 2 diabetes over a three-month period. The results showed that the daily intake of pulses improved blood glucose control, reduced the total cholesterol and triglyceride levels, and reduced blood pressure and heart rate.

The researchers agree that these findings are significant.

"When we started glycemic index testing, pulses stood out as by far the most consistently low glycemic index food," says Dr. Kendall. "We also found they lowered low-density lipoprotein-cholesterol and most recently we have seen a blood pressure lowering effect with pulses, even in people well treated with blood pressure medications."

"Pulses, therefore, hit all the chronic disease related targets. Combine that with their excellent protein, fibre, and mineral content, all in a food that is also good for the environment in that its root bacteria fix their own nitrogen, and there can surely be no other food better suited to the 21st century and beyond."

Dr. Jenkins and Dr. Kendall's research team has since gone on to share these results at dozens of food, nutrition, and scientific conferences across North America, and in articles published in renowned scientific journals. They have also used these results to leverage funding for more related research.

Dr. Jenkins, who is also famous in the science and nutrition communities for having developed the glycemic index in 1981, has also included pulses on his top 10 list of healthy foods, based on his research findings.

More SPG-funded research from the St. Boniface Hospital Research Centre in Winnipeg also examined the link between pulse consumption and lowered diabetes risk, by examining the role that lentil consumption played in improving glucose tolerance and decreasing cardiovascular disease risk in overweight individuals with high blood cholesterol.

The results of this research showed that the lentil diet was associated with better overall control of blood glucose levels, which could delay the progression to pre-diabetes (or metabolic syndrome) and Type 2 diabetes in at-risk individuals. Further research is being done to refine these results.

Other research from Dr. Jones' lab is exploring the energy release action related to pulses, and its ensuing benefits.

"You see what happens to kids at Halloween when they eat very fast absorbed carbs," Dr. Jones says. "Pulses slow down that rate of release of blood glucose."

The research will examine the effect of eating food products containing pulses before a workout, in relation to aerobic endurance, insulin, blood glucose, appetite, and food intake post-workout. The hypothesis is that consuming pulse-based foods will have a positive effect in all these areas.

And although it is too early to have any results from the project, Dr. Jones believes the research will yield more important information about how pulses and pulse fractions can slow down the rate of release of

blood sugar and control insulin, particularly in people who might have a pre-disposition to Type 2 diabetes.

Overall the goal of all this research is to encourage more consumers to eat more pulses. This will create a new, high-value area of demand for Saskatchewan grown pulses. Currently Pulse Canada estimates that only 13 per cent of Canadians consume pulses on any given day and SPG hopes to see that number increase, Mascarenhas says.

"We want to educate every single consumer in North America about the benefits of pulses and why they should consume pulses."

For a list of ongoing SPG-funded research, turn to page 38.

Recipe ideas for including pulses in meals are available at lentils.ca and pulses.org

PROJECTS FEATURED IN THIS ARTICLE

PROJECT TITLE	INVESTIGATORS	FUNDERS	END DATE
Effect of Pulses on Glycemic Control and Cardiovascular Risk Factors in Type 2 Diabetes: A Dose Response Study	Dr. David Jenkins, University of Toronto **Co-Investigator(s):** Dr. Cyril Kendall, University of Toronto, Ahmed El-Sohemy, University of Toronto, Richard P. Bazinet, University of Toronto	Saskatchewan Pulse Growers ($300,357)	Completed November 30, 2012
Effect of Pulses on Glycemic Control and Cardiovascular Disease Risk Factors in Type 2 Diabetes: A Low Glycemic Index Study – Additional Analysis	Dr. David Jenkins, University of Toronto **Co-Investigator(s):** Dr. Cyril Kendall, University of Toronto, Dr. John Sievenpiper, University of Toronto	Saskatchewan Pulse Growers ($197,618)	Completed March 31, 2016
Evidence to Substantiate Function Health Claims for Pulse Flours and Fractions in Food Matrices	Dr. Peter Jones, Richardson Centre for Functional Foods and Nutraceuticals, University of Manitoba	Saskatchewan Pulse Growers ($427,127), Alberta Pulse Growers	June 30, 2017
Low Glycemic Index Breads from Beans	Dr. David Jenkins, University of Toronto **Co-Investigator(s):**Dr. Cyril Kendall, University of Toronto, Chris Ireland, University of Toronto, Nishta Saxena, University of Toronto	Saskatchewan Pulse Growers ($248,400)	Completed March 30, 2011

SPG RESEARCH INVESTMENT

AGRONOMY RESEARCH

PROJECT TITLE	INSTITUTION	RESEARCHER(S)	SPG FUNDING
Developing nitrogen management recommendations for soybean production in Saskatchewan	Indian Head Agricultural Research Foundation	Chris Holzapfel	$123,732
Developing phosphorus management recommendations for soybean production in Saskatchewan	Indian Head Agricultural Research Foundation	Chris Holzapfel	$106,740
Effects of vertical tillage on soil structure and crop yields in southern Saskatchewan	University of Saskatchewan – Dept. of Soil Science	Dr. Bing Si	$49,766
Development of a highly reliable biofertilizer for pulse-based rotations	Agriculture and Agri-Food Canada	Dr. Chantal Hamel	$167,604
Applying ecology for simple, nutrient use pulse-based cropping systems	Agriculture and Agri-Food Canada	Dr. Chantal Hamel	$39,799
Knowledge transfer and translation	Agriculture and Agri-Food Canada	Dr. Andrew Hammermeister	$12,000
Management of volunteer glyphosate-resistant canola in glyphosate-resistant soybean crops	University of Saskatchewan – Dept. of Plant Sciences	Dr. Christian Willenborg	$93,015
Moisture management effects on soybean and faba bean in Saskatchewan	Agriculture and Agri-Food Canada	Dr. Dale Tomasiewicz	$79,890
Has transition to no-tillage resulted in more free-living soil nitrogen-fixation?	University of Saskatchewan – Dept. of Soil Science	Dr. Diane Knight	$114,885
Development of a *Rhizobium* inoculant for faba bean	University of Saskatchewan – Dept. of Soil Science	Dr. Diane Knight	$174,996
Impact of chickpea/flax intercropping on nitrogen fixation in chickpea and nitrogen transfer to flax	University of Saskatchewan – Dept. of Soil Science	Dr. Fran Walley	$56,100
Evaluation of beneficial rhizosphere and endorhizosphere microorganisms as bioinoculants for the control of soil borne root pathogens	University of Saskatchewan – Dept. of Soil Science	Dr. Fran Walley	$150,000
Development of rapid assays for determination of Group 1 and 2 herbicide resistance in weeds	Agriculture and Agri-Food Canada	Dr. Hugh Beckie	$26,666
Evaluating Rhizobia strains for nitrogen fixation in faba bean	University of Saskatchewan – Dept. of Soil Science	Dr. Diane Knight	$88,906
Responding to climate fluctuations: Development of a *Rhizobium* collection	University of Saskatchewan – Dept. of Soil Science	Dr. Diane Knight	$84,881
Fertilization of lentils with zinc on Saskatchewan soils to increase yield, grain zinc content, and marketability	University of Saskatchewan – Dept. of Soil Science	Dr. Jeff Schoenau	$81,524
Transformations and fate of seed-placed sulfur fertilizers in Saskatchewan soils	University of Saskatchewan – Dept. of Soil Science	Dr. Jeff Schoenau	$40,738
Nutrient content and release from soybean residues in comparison to other pulse crops in Saskatchewan	University of Saskatchewan – Dept. of Soil Science	Dr. Jeff Schoenau	$61,835
Effects of early harvest on hard-seededness in dry bean	University of Saskatchewan – Dept. of Plant Sciences	Dr. Kirstin Bett	$115,311
Evaluation of cytokinin producing *Methylobacterium* as an inoculant for seedling performance, yield improvement, and drought and salt stress tolerance in pea	Trent University	Dr. Neil Emery	$190,000
Coordinated surveillance, forecasting, and risk warning systems for field crop insect pests of the Prairie ecosystem	Agriculture and Agri-Food Canada	Dr. Owen Olfert	$100,000
Direct assessment of the release of fixed nitrogen in the rhizosphere of pea, lentil, chickpea, and faba bean	University of Saskatchewan – Dept. of Soil Science	Dr. Richard Farrell	$65,786
Quantifying the contribution of pulse crop residues to greenhouse gas emissions, nitrogen nutrition and the growth of a subsequent wheat crop: A dual isotope labeling approach	University of Saskatchewan – Dept. of Soil Science	Dr. Richard Farrell	$368,845
Pea yield formation in warming temperatures – phenological mechanism	University of Saskatchewan – Dept. of Plant Sciences	Dr. Rosalind Bueckert	$92,000
Using synchrotron methods to detect heat resistant pea – pollen and leaf wax structure	University of Saskatchewan – Dept. of Plant Sciences	Dr. Rosalind Bueckert	$143,175
Yield loss study of Stemphylium Blight on lentil	University of Saskatchewan – CDC	Dr. Sabine Banniza	$105,387

PROJECT TITLE	INSTITUTION	RESEARCHER(S)	SPG FUNDING
Secondary effects of strobilurin fungicides on pulse crops in Saskatchewan	University of Saskatchewan – CDC	Dr. Sabine Banniza	$168,758
Integrating weed control for organic pea and lentil production	University of Saskatchewan – Dept. of Plant Sciences	Dr. Steven Shirtliffe	$104,341
Reducing weed seed production in herbicide resistant weeds with pre-harvest herbicide application	University of Saskatchewan – Dept. of Plant Sciences	Dr. Steven Shirtliffe	$104,650
Optimum seeding rate, row spacing, and disease management in faba bean varieties	University of Saskatchewan – Dept. of Plant Sciences	Dr. Steven Shirtliffe	$449,591
Infectivity model for *Aphanomyces euteiches* in Saskatchewan soils	Agriculture and Agri-Food Canada	Dr. Syama Chatterton	$290,000
Moving forward to sustainable development of the Saskatchewan pulse industry	Agriculture and Agri-Food Canada	Dr. Yantai Gan	$503,522
Evaluating inoculant options for faba beans	Irrigation Crop Diversification Corporation	Garry Hnatowich	$305,780
2014 Saskatchewan weed survey	Agriculture and Agri-Food Canada	Julia Leeson	$100,000
Improved iron chelates for treatment of iron chlorosis in Saskatchewan pulse and fruit crops	University of Saskatchewan – Dept. of Chemistry	Matthew Paige	$15,333
Diversifying cropping options for the brown soils through intercropping	Agriculture and Agri-Food Canada	Dr. Myriam R. Fernandez	$68,678
Evaluation of contrasting forage pea cultivars in mixtures with cereals for greenfeed production in Saskatchewan	University of Saskatchewan – Dept. of Plant Sciences	Dr. Bill Biligetu	$84,079
Nutrient uptake and nitrogen-fixation by faba bean in Saskatchewan	University of Saskatchewan – Dept. of Soil Science	Dr. Jeff Schoenau	$37,519
Crop response to foliar applied phosphorus fertilizers	University of Saskatchewan – Dept. of Soil Science	Dr. Jeff Schoenau	$20,010
Enhanced Saskatchewan soil data for sustainable land management	University of Saskatchewan – Dept. of Soil Science	Dr. Angela Bedard-Haughn	$57,768
Crop water footprints and virtual water flows: A comprehensive evaluation of crop water use in Saskatchewan	University of Saskatchewan – Dept. of Soil Science	Dr. Bing Si	$115,000
Enhancing weed science in pulse crops: Towards a robust strategy for long-term weed management	University of Saskatchewan – Dept. of Plant Sciences	Dr. Christian Willenborg	$2,023,021
Enhancing the long-term sustainability of pulse cultivation using system approaches	Agriculture and Agri-Food Canada	Dr. Yantai Gan	$1,004,036*
Intercropping chickpea with flax	Agriculture and Agri-Food Canada	William May	$23,460
Moving forward to sustainable development of the Saskatchewan pulse industry	Agriculture and Agri-Food Canada	Dr. Yantai Gan	$352,000
Adaptation and establishment of soybean (Glycine max) under no-till in south Saskatchewan	Indian Head Agricultural Research Foundation Wheatland Conservation Area	Dr. Chris Holzapfel, Dr. Brian Nybo	$67,625
Effect of seeding rate and seed size on lentil diseases, weeds, yields and profitability	University of Saskatchewan	Dr. Steven Shirtliffe	$65,580
Managing herbicide resistant weeds in pulses with alternative modes of action	Agriculture and Agri-Food Canada	Dr. Hugh Beckie	$12,000
Frequency and sequence of annual pulses in cropping systems. Phase II	Agriculture and Agri-Food Canada	Dr. Yantai Gan	$125,099

TOTAL AGRONOMY SPG FUNDING **$8,841,431**

**Projects have been approved and the contract is under development.*
Projects listed reflect those active during the September 1, 2015 to August 31, 2016 fiscal year.
Funding amounts in these tables represent Saskatchewan Pulse Growers' multi-year commitment to each project.

SPG RESEARCH INVESTMENT

GENETIC IMPROVEMENT RESEARCH

PROJECT TITLE	INSTITUTION	RESEARCHER(S)	SPG FUNDING
A reverse introgression and genomics strategy to develop and characterize chickpea germplasm for yield and climate-resilience traits	University of Saskatchewan – CDC	Dr. Bunyamin Tar'an	$197,184
Understanding genome architecture and genome dynamics of elite Canadian chickpea varieties for facilitating molecular breeding	University of Saskatchewan – CDC	Dr. Bunyamin Tar'an	$299,705
Toward next generation chickpea breeding: Resequencing diverse chickpea accessions	University of Saskatchewan – CDC	Dr. Bunyamin Tar'an	$590,488
Application of abscisic acid (ABA) analogs for improving pulse crop agronomy and physiology	University of Saskatchewan – CDC	Dr. Bunyamin Tar'an	$275,000
Virus Induced Gene Silencing (VIGS) to test gene function in pulse crops	University of Saskatchewan – Dept. of Biology	Dr. Christopher Todd	$99,015
Cell and tissue culture science and application	University of Saskatchewan – CDC	Dr. Kofi Agblor	$424,731
Soyagen: Improving yield and disease resistance in short-season soybean	Université Laval	Dr. Francois Belzile	$115,000
Integrating genetic and genomic resources for lentil improvement	University of Saskatchewan – Dept. of Plant Sciences	Dr. Kirstin Bett	$341,100
Deployment of tepary bean genetics to improve stress tolerance in common bean	University of Saskatchewan – Dept. of Plant Sciences	Dr. Kirstin Bett	$148,067
Lentil genome sequencing (LenGen): Establishing a comprehensive platform for molecular breeding	University of Saskatchewan – Dept. of Plant Sciences University of California Davis	Dr. Kirstin Bett Dr. Doug Cook	$897,001 CAD $571,226 USD
Application of genomics to innovation in the lentil economy (AGILE)	University of Saskatchewan – Dept. of Plant Sciences University of California Davis	Dr. Kirstin Bett Dr. Doug Cook	$1,517,688 CAD $534,876 USD
Towards generating multiple-fungal disease resistance in lentil	University of Saskatchewan – CDC	Dr. Sabine Banniza	$297,820
Integration of Aphanomyces resistance screening into rapid generation technology of lentil and pea	University of Saskatchewan – CDC	Dr. Sabine Banniza	$483,506
Developing rapid generation technology involving wild lentil crosses in order to produce Aphanomyces-resistant lentil varieties	University of Saskatchewan – CDC	Dr. Sabine Banniza	$259,289
Development of improved markers for Mycosphaerella Blight resistance in pea	University of Saskatchewan – CDC	Dr. Tom Warkentin	$185,150
Sequencing the pea genome: Creating a solid foundation for long-term pea genetic improvement	University of Saskatchewan – CDC	Dr. Tom Warkentin	$1,446,773
Weed science and herbicide technologies for pulse crops	University of Saskatchewan – Dept. of Plant Sciences	Dr. Christian Willenborg	$772,850
Pulse Crop Advancement Agreement	University of Saskatchewan – CDC		$22,617,300
Saskatchewan pulse crop regional variety trials	University of Saskatchewan – CDC	Dr. Tom Warkentin	$1,300,000
Very short season herbicide tolerant soybean development	Agriculture and Agri-Food Canada	Dr. Elroy Cober	$102,500
Control of flowering time in cultivated lentil	University of Saskatchewan – Dept. of Plant Sciences	Dr. Kirstin Bett	$100,000
Marker-assisted introgression of useful new diversity into the pea genome for rapid cultivar improvement	University of Saskatchewan – CDC	Dr. Tom Warkentin	$175,880
Pulse crop regional trials in Saskatchewan	University of Saskatchewan – CDC	Dr. Tom Warkentin	$1,871,494

PROJECT TITLE	INSTITUTION	RESEARCHER(S)	SPG FUNDING
Soybean variety evaluation trial	Manitoba Pulse and Soybean Growers		$38,333
Marker-assisted selection for Aphanomyces resistance in pea for rapid development of adapted pea varieties with improved Aphanomyces resistance	University of Saskatchewan – CDC	Dr. Sabine Banniza	$308,360
Pea Genetic Improvement Program (PGIP)	Limagrain-Advanta Crop Development Centre Agriculture and Agri-Food Canada DL Seeds Institute of Field and Vegetable Crops		$3,257,720
Dry bean improvement for sustainable production in Canada: Development of dry bean germplasm and varieties adapted to South-Western Ontario	University of Guelph	Dr. Peter Pauls	$125,000
Develop and assess molecular diagnostic procedures for the rapid, specific and sensitive detection of root rot pathogens in symptomatic field pea roots	Agriculture and Agri-Food Canada University of Alberta	Dr. Bruce Gossen Dr. Syama Chatterton Dr. Stephen Strelkov	$109,970

TOTAL GENETIC IMPROVEMENT SPG FUNDING **$39,694,739**

**Projects have been approved and the contract is under development.*
Projects listed reflect those active during the September 1, 2015 to August 31, 2016 fiscal year.
Funding amounts in these tables represent Saskatchewan Pulse Growers' multi-year commitment to each project.
USD funding commitments were calculated at 1.3 exchange rate for the purpose of conveying the total funding for the research area.

SPG RESEARCH INVESTMENT

END USE PROCESSING AND UTILIZATION RESEARCH

PROJECT TITLE	INSTITUTION	RESEARCHER(S)	SPG FUNDING
Characterization of quality, bioactive, and anti-nutritional compounds of pulses prepared with various cooking conditions and grown in different environments in Saskatchewan	Agriculture and Agri-Food Canada	Dr. Elsayed Abdelaal	$195,081
Development of innovative high value pulse-based food products with enhanced functional and nutraceutical properties for potential utilization	Tamil Nadu Agricultural University	Dr. Hemalatha Ganapathyswamy	$199,790
Quantification and bioassay development for toxicity testing of faba bean varieties	University of Calgary	Dr. Judit Smits	$234,600
Value-added applications of pulse proteins for human foods	University of Alberta	Dr. Lingyun Chen	$149,500
Characterization, modification, and commercialization of lentil bran as a food ingredient	Alliance Grain Traders	Dr. Mehmet Tulbek	$100,000
Effect of genetics and the environment on the quality and utilization of faba bean flour and protein concentrates	University of Saskatchewan – Dept. of Food and Bioproduct Sciences	Dr. Michael Nickerson	$33,605
Modification of pea starch for increased utilization in the food industry	Manitoba Food Development Centre	Dr. Paulyn Appah	$84,820
Development of high value-added pellet products based on combination of pea/lentil screenings, lignosulfonate and calcium chemical compounds (additive) as well as canola meal to maximize extra benefit for pulse producers and processing industry	University of Saskatchewan – Dept. of Animal and Poultry Science	Dr. Peiqiang Yu	$68,195
Enhancing quality and value of meat ingredients for further processing	University of Saskatchewan – Dept. of Food and Bioproduct Sciences	Dr. Phyllis Shand	$75,128
Characterization of phytochemicals and dietary fibres in pulse processing by-products for value-added functional food products	Agriculture and Agri-Food Canada	Dr. Rong Cao	$218,500
Processing platform for food functionality of faba bean	Saskatchewan Food Industry Development Centre Inc.	Dr. Shannon Hood-Niefer	$399,930
Incorporation of Canadian pulse-based ingredients into rice noodle targeting the Chinese market	Agriculture and Agri-Food Canada	Dr. Steve Cui	$98,670
The utilization of pulses in the manufacture of crumb used as a binder in a model meat system	Alberta Agriculture and Rural Development	Michelle Sigvaldson	$155,000
Omnivores versus Carnivores: Can higher levels of pulse starch be tolerated in a wider range of species than corn?	University of Saskatchewan – Veterinary Biomedical Sciences	Dr. Lynn Weber	$227,000
Improving pulse palatability & health benefits to increase pulse market share of pet foods	University of Saskatchewan – Veterinary Biomedical Sciences	Dr. Lynn Weber	$305,377
Modification of a commercial lentil, pea, and faba bean protein isolate production process for improved flavour profiles	University of Saskatchewan – Dept. of Food and Bioproduct Sciences	Dr. Michael Nickerson	$115,000*
Entrapment of heart healthy oils using lentil protein isolates by spray drying	University of Saskatchewan – Dept. of Food and Bioproduct Sciences	Dr. Michael Nickerson	$59,225*
Salvage values of damaged faba forage and faba bean in ruminant livestock systems: • Effect of frost/frozen damage • Feed values of normal faba forage and faba bean for both beef and dairy cattle • Effect of varieties, effect of processing method, and/or effect of tannin level	University of Saskatchewan – Dept. of Animal and Poultry Science	Dr. Peiqiang Yu	$245,691
Growing the market for pulse flours: Creating innovative bakery products and a pulse database for the food industry	Canadian International Grains Institute (CIGI) University of Saskatchewan University of Manitoba	Elaine Sopiwnyk Dr. Michael Nickerson Dr. M. Aliani	$1,842,824*
Characterization of protein composition and quality from different pea cultivars	University of Saskatchewan - Dept. of Food and Bioproduct Sciences	Dr. Michael Nickerson	$87,500
Characterization of structure, physicochemical and physiological properties of starch from Canadian grown pulse crops to develop novel functional food ingredients and functional foods for human health benefits	Agriculture and Agri-Food Canada McMaster University Memorial University	Dr. Qiang Liu Dr. Michael Thompson Dr. Ratnajothi Hoover	$238,878
A quantitative assessment of the anti-nutritional properties of Canadian pulses	University of Saskatchewan University of Manitoba Agriculture and Agri-Food Canada	Dr. Michael Nickerson Dr. Susan Arntfield Dr. Janitha Wanasundara	$33,408

PROJECT TITLE	INSTITUTION	RESEARCHER(S)	SPG FUNDING
Utilization of yellow pea, lentil and faba bean fibre and starch for meat product applications	University of Saskatchewan Agriculture and Agri-Food Canada	Dr. Phyllis Shand Dr. Janitha Wanasundara	$13,726
Thermal pretreatment of pulses for innovative ingredients and consumer-ready meat products ii: Going global	University of Saskatchewan Agriculture and Agri-Food Canada	Dr. Phyllis Shand Dr. Janitha Wanasundara	$53,343

TOTAL END USE PROCESSING AND UTILIZATION RESEARCH $5,234,790

**Projects have been approved and the contract is under development.*
Projects listed reflect those active during the September 1, 2015 to August 31, 2016 fiscal year.
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HEALTH AND NUTRITION RESEARCH

PROJECT TITLE	INSTITUTION	RESEARCHER(S)	SPG FUNDING
Starting young: Incorporating local pulses in the menus of Saskatchewan childcare centres	University of Saskatchewan – College of Pharmacy and Nutrition	Dr. Carol Henry	$99,935
Effects of faba bean fractions as ingredients in novel food products on glycemia, appetite and metabolic control	University of Toronto	Dr. Harvey Anderson	$650,000
Evidence to substantiate function health claims for pulse flours and fractions in food matrices	Richardson Centre for Functional Foods and Nutraceuticals	Dr. Peter Jones	$427,147
Health and performance benefits of a pulse-based diet for soccer players during regular season play	University of Saskatchewan – College of Kinesiology	Dr. Philip Chilibeck	$30,608
Efficacy of pea hull fibre supplementation on gastrointestinal transit time-induced proteolytic fermentation and enhancement of wellness in older adults, individuals with lifestyle-related chronic disease, and overweight children	University of Florida	Dr. Wendy Dahl	$212,715
Effect of pulses on glycemic control and cardiovascular disease risk factors in Type 2 Diabetes: A low glycemic index study – Additional analysis	University of Toronto	Dr. David Jenkins	$197,618
Mitigating arsenic related health problems in Bangladeshi populations by introducing high-selenium lentils into the everyday diet	University of Calgary	Dr. Judit Smits	$283,170
Acute human feeding trials to define the minimum effective dose for reduction of post prandial blood glucose by two common market varieties of Canadian lentil	Agriculture and Agri-Food Canada	Dr. Dan Ramdath	$157,550*
Determining the link between pulse foods, gut health, and chronic disease	Agriculture and Agri-Food Canada University of Guelph	Dr. Krista Power Dr. Emma Allen-Vercoe Dr. Lindsay Robinson	$329,563
Effect of a pulse-based diet on the health of women with polycystic ovarian syndrome: Phase II investigation	University of Saskatchewan	Dr. Gordon Zello	$231,251
Blood glucose attenuation and satiety levels in humans following consumption of whole lentil and yellow pea and their food products; effect of processing and starch fractions	Agriculture and Agri-Food Canada University of Guelph	Dr. Dan Ramdath Dr. Alison Duncan	$281,747
The effect of variety and processing on the protein quality of Canadian pulses	University of Manitoba	Dr. James House	$181,703

TOTAL HEALTH AND NUTRITION RESEARCH $3,103,052

**Projects have been approved and the contract is under development.*
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SASKATCHEWAN pulse Growers

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