



CANOLA DISCOVERY FORUM

NOVEMBER 13-14, 2019 | RBC CONVENTION CENTRE | WINNIPEG

**CDF + CLUB DAY
PROCEEDINGS**



2019 CANOLA DISCOVERY FORUM

PRE-EVENT Wednesday, November 13th

10:30 am – 12:00 pm RBC Convention Centre; Registration (Second Floor Concourse)

DAY 1 Wednesday, November 13th

12:00 – 1:00pm **Hot Buffet Lunch**

1:00 – 1:15 pm **Opening Remarks and 2019 CDF Objectives**

Curtis Rempel, CCC Vice President, Crop Production and Innovation

1:15 – 2:15 pm **Canola Council of Canada IPM Agronomy Messaging for 2019/20**

- Weed Management: *Ian Epp, CCC Agronomy Specialist*
- Insect Management: *Keith Gabert, CCC Agronomy Specialist*
- Disease Management: *Clint Jurke, CCC Agronomy Director*

2:15 – 2:45 pm **2019 Canola Industry Update**

Curtis Rempel, CCC Vice President, Crop Production and Innovation

2:45 – 3:15 pm **Networking Break and Speaker's Corner**

3:15 – 3:25 pm **Canola Agronomic Research Program & Canadian Agriculture Partnership Funded Research Updates**

Delaney Ross Burtnack, Manitoba Canola Growers Association

3:25 – 4:55 pm **IPM Research Projects Highlights**

- Patch Management for Clubroot Control
Mary Ruth McDonald, University of Guelph
- Genetic Resources for Integrated Pest Management
Dwayne Hegedus, AAFC Saskatoon
- Biotechnologies Role in Integrated Pest Management
Steven Whyard, University of Manitoba

4:55 – 5:10 pm **Research Hub**

Taryn Dickson, CCC Resource Manager

5:10 – 5:15 pm **Day 1 Closing Remarks**

5:30 – 7:00 pm **Welcome Reception (Delta Hotel by Marriott)**

DAY 2 Thursday, November 14th

7:30 – 8:15 am **Hot Buffet Breakfast and Opening Remarks**

8:15 – 8:30 am **Current IPM Strategy for Canola Production**
Warren Ward, CCC Agronomy Specialist

8:30 – 10:00 am **Transitioning into Stronger Crop Rotations**
1. *Tyler Wist, AAFC Saskatoon*
2. Biologicals: Emerging technologies for growers
John Kruse, PlantResponse Biotech
3. Crop Rotation Decisions - Dollars and Sense
Murray Hartman

10:00 – 10:30 am **Networking Break and Speaker's Corner**

10:30 – 11:30 am **Producer Panel: Measuring IPM Success**

- *Scott Keller, Alberta*
- *Troy LaForge, Saskatchewan*
- *Shane Friesen, Manitoba*
- *Dana Maxwell, Ag-Quest*
- Moderator: *Daryl Domitruk, Manitoba Pulse & Soybean Growers*

11:30 – 12:15 pm **Understanding and Interpreting Clubroot Testing**

- Clubroot Pathotypes: *Keisha Hollman, University of Alberta*
- Clubroot Soil Sampling: *Kim Kenward, 20/20 Seed Labs*

12:15 – 1:15 pm **Hot Buffet Lunch**

1:15 – 2:30 pm **Emerging Threats: Farming in a Regulatory World**

- *Alan Schlachter, Crop Life Canada*
- Canola Industry's 2019 Neonic Water Monitoring Program:
Mark Walker, Canadian Canola Growers Association

2:30 – 3:00 pm **Networking Break and Speaker's Corner**

3:00 – 4:00 pm **Market Access: Stewardship of IPM Technology**

- *Jennifer Marchand, Cargill Ltd*
- *Gord Kurbis, Canada Grains Council*

4:00 – 4:30 pm **Recap & Planning for the Future**
Curtis Rempel, CCC Vice President, Crop Production and Innovation

2019 CANOLA DISCOVERY FORUM

DAY 1 Wednesday, November 13th

CDF 2019 Opening Remarks

Curtis Rempel, CCC Vice President, Crop Production and Innovation

Welcome to 7th annual Canola Discovery Forum. We would like to acknowledge all of the events sponsors as well as our core funders.

The Canola Council's strategy to meet the global demand includes delivering 52 bu/ac by 2025. By that time there will be a demand for oil of 26 million metric tonnes. Currently we are at 41 bu/ac and among our several strategic tools to increase yield is to gain 2 bu/ac from Integrated Pest Management (IPM), the theme of this year's forum. But it's more than just increasing yield, it's protecting the yield that you have, including oil, protein and seed yield.

To reach the 52 bu/ac goal we must also look at sustainability goals. The public feels that yield intensification will destroy soil, air and water and that to lower CO₂, we have to lower yields. Agrologists and others in our industry know that this is not the case and if we can hit 52 bu/ac, we can still take care of the environment.

The Canola Discovery Forum (CDF) is there to bring forth dialogue, debate and discussion between our industry's various stakeholders. Through this process, we can examine research gaps and move forward. The CDF also provides a platform for innovation – to discuss and prioritize. To be effective in industry, you need to do research that is of value and then translate that into knowledge that can be applied with agronomists, growers and others.

The Canadian Agricultural Partnership (CAP) is funded by core funders and provincial grower groups. Currently there are 19 projects related to IPM, with a value of \$13.7 million. We also have the Canola Agronomy Research Program (CARP) which is 100% grower funded. Between 2014 – 2019, there were 28 IPM projects funded, worth \$9 million.

This year our IPM Agenda highlights includes research project & funding updates, impact of rotations, biologicals, grower perspectives, wetland monitoring regarding neonicotinoids, and regulatory perspectives of trade.

Canola Council of Canada IPM Agronomy Messaging for 2019/2020

Weed Management

Ian Epp, CCC Agronomy Specialist

Weed control in canola can be taken for granted, but to achieve 52 bu/ac, IPM needs to be taken seriously. Weed control is an important factor in IPM and based on this past fall, we can expect increased weed populations in 2020. It is important to engage growers on IPM practices since past experiences tell us that herbicide resistance only increases over time. Resistance robs producers of yield and creates herbicide management problems in addition to canola-specific problems in the field. The main weed control methods are to scout (often done too late), spray early (maximize yield protection), control volunteers (prioritize volunteer canola, tank mix in canola, strategic disturbance, limit combine losses), good agronomy=good weed control (tank mixing and plant stands), and to try something new (stacked traits, TruFlex, Pod Shatter, InVigor Rate). There's an opportunity to catch problems early when they are still minor, yet these weed

control methods could still be better implemented by producers. Helping growers understand the benefit/implications of these tools and how to deploy them to maximize weed control is key.

Insect Management

Keith Gabert, CCC Agronomy Specialist

IPM is good agronomy, and what isn't measured, can't be managed. If crops are monitored, you will begin to see the environment that lives in your crops. Scouting in fields can tell many facts about crop health, such as flea beetle incidence. Flea beetles are not easy to predict, but good stand establishment and good agronomy are good for both flea beetles and weed control. Getting the right seed in the ground at the right depth is a challenge for growers. Flea beetles are influenced by stand establishment, air temperature, weather, and growth stage of the crops. Visiting and scouting fields is the only way to determine problems in the field, but other considerations include action and economic thresholds, scouting/monitoring/assessing risk in fields, preventing and avoiding issues where possible, and controlling pests where necessary.

Disease Management

Clint Jurke, CCC Agronomy Director

Blackleg, clubroot, sclerotinia stem rot and aster yellows are all complicated issues. Blackleg wasn't a large issue in the early 2000's but it began to increase and triggered discussions around trade. Controlling blackleg can be done through scouting, longer crop rotations, long variety rotation with difference resistance groups/resistance packages, and early application of fungicides in high blackleg risk situations. A race test exists to determine which genes are in the field, but there are still concerns around when plants should be sampled, what recommendations to make, what variety is the best racial match, and how to match products without labels to the races in the field. Clubroot control can exist through scouting, reducing *P. brassicae* spore production and movement, employing patch management, and deploying second generation resistance in fields with high spore loads. As an industry, these steps haven't been implemented well. It's difficult for growers to implement an IPM approach when *P. brassicae* doesn't fit a normal fitness selection model, and new pathotypes emerge every year. Clubroot is a "balancing selection" model, the pathogen genetic polymorphism is maintained. Once infected, plants are susceptible to all pathotypes. Sclerotinia is still the biggest yield robbing disease, and even though tools exist such as stem rot checklists, DNA petal tests, weather stations for monitoring outbreaks, fungicides for high risk, and resistant or tolerant varieties, we are not great at predicting when an outbreak will occur. There is a lot of potential in the industry for prediction of sclerotinia outbreaks. Aster yellows haven't been a major problem since 2012, though diverse symptomology has been observed recently. It may be more of an issue than what we thought it was in the past, and more needs to be learned about this pathogen.

Questions and Answers

Q: In terms of blackleg resistance, what's the outlook in terms of having sources of resistance, whether major or minor gene resistance in terms of efficacy, and what's the timeline for that? And looking at fungicide application as a tool, should we be using fungicides in the form of foliar

or seed treatments fungicides *now*, or should we hold it in reserve in the event that our resources and resistances aren't effective? If we use it now, we're selecting for members of the blackleg population that have less sensitivity or full resistance to the fungicide actives, and when we actually need them, they're no longer effective?

A. There are two different types of resistance – major gene resistance (which works on a gene-gene basis with pathogen), and quantitative or background resistance (slows the pathogen's development). The industry has done a good job with the new labelling system but there's difficulty with labelling quantitative resistance. The modelling for this disease indicates the best package to manage blackleg is to stack major resistance genes on a good quantitative background. But being able to identify those components, then communicate it to growers, is something they don't have a good handle on. We are looking for improvement, so this is why we reach out to the audience to engage the conversation and develop something effective to producers and industry people. If we're using fungicides then maybe we should be saving it for those high-risk situations only, but he would like to see data on if there actually is a selection risk or not and how much pressure it puts on the pathogen to change.

Q. We talked about stacked traits and True Flex. How do we control volunteers from offshoots?

A. With True Flex the volunteer management is similar – we have different modes of action to be used when needed. But we lost a mode of action on stack-trait canola. Stack-trait canola has to be employed in the right situation. Not something we use in short rotations because of the volunteers etc. It would be better to target areas with specific weed issues and keep good records on past canola varieties and tank mixes used. If we're using both effective modes of action there are benefits, as long as there's also proper management, mode of action deployment, and record keeping as well.

Q. In terms of getting a good stand established, what are your thoughts on intercropping a forage (tillage radish or clover) inter-row to establish stand and fight against weeds?

A. The more plants we grow, the more plant competition. The more competitive the crop the better, the less we rely on herbicide, the more weed control. In an intercropping situation like this, a lot of factors (weeds, disease, harvest) need to be factored in, but any opportunity to reduce selection pressure on herbicide the more we extend the use of herbicides. These are all additive things, not single fixes, to make crop more competitive.

Q. Could you elaborate on deploying more/new resistance for clubroot? Are you thinking rotations, or managing pathotypes, when to deploy resistance?

A. Will be discussed at CLUB day. The pathogen tends to increase all pathotypes in the soil. So, if pathogen is present in soil, which resistance should we use, the 1st generation/Mendel resistance, which is resistant against pathogen H? Or deploy a second-generation resistance that may be a whole different type of resistance without Mendel, or a stack with Mendel and something else. We don't really know. If the 1st generation resistance is failing, we shouldn't continue to use this resistance. If you continue to use it, you build up the pathotypes resistance. The major goal is to keep spores as low as possible. Growing a susceptible variety in a tight rotation is a bad idea, you'll build up all the pathotypes in the soil and knock out the resistance genes if the pathogen is in the field.

Q. They've been dealing with a new spore. From an agronomy perspective, noticed it was where water moves through fields. Is anyone actually looking into research with improving soil infiltration rates? Many problems we continue to talk about are on water. Digging down 2-3 inches is based on plate-y structure 99% of the time that doesn't allow water to move downward, just lateral. Is there research moving forward on this regarding limiting spore movement laterally, and moving them vertically instead? Can we wash the spores downwards?

A. We know that majority of pathogen in soil is where the bulk of the biomass of the root is located. Spores can be found deeper in the soil profile, but because there is less root mass, there are less spores. When clubroot is found in a new area, the movement is mainly based on introduction from field to field. Once it's established, it does appear more in wet areas and it becomes easier to find larger quantities of those resting spores. But the machinery component is the most important to prevent disease movement.

2019 Canola Industry Update

Curtis Rempel, CCC Vice President, Crop Production and Innovation

The Canola Council has 3 basic functions. The first is market access and competitiveness. Even though we have lots of production in the country, we export over 90% of our canola crop. We look to resolve barriers and improve access through trade agreements.

The second is building brand health and development by promoting the attributes of canola oil and meal. Canola oil is good for cardiovascular health, weight control and brain health. Canola also has a unique fatty acid profile which provides it with a pivotal role to play in the area of public health. With a high demand for high quality protein for humans and livestock, CCC supports endeavours to position canola as a source for protein and oil in the global marketplace.

The third function is to focus on sustainable supply - to increase yields to meet global demands. CCC is an evidence-based organization and its management and technology practices are all anchored in science. Through leadership and coordination of the latest research, valuable knowledge of commercial agronomy can be translated, to be used in farming and production practices. CCC also looks to prepare for emerging threats such as changing climate on the Prairies and the profiling of different pests that may come our way, as well as supporting market access and regulatory issues.

Over the last numbers of years, yields have been languishing at a plateau, having pushed from 30 to 41 bu/ac. We are currently at 18.5 MMT with a target of 26 MMT for 2025. Trying to break yield barriers will involve climate proofing canola. Canola represents ¼ of total cash receipts for all Canadian crops. Currently we are 31% of the global rapeseed supply. In Canada, we are worth \$26 billion, from seed to processing. Half of our seed is crushed to oil and meal for export (9.3 MMT), while half is exported to be crushed in other countries (9.1 MMT). Our exported seed is worth \$11 billion, with China now becoming our largest customer, surpassing Japan. In terms of oil exports, the USA is our largest and closest market (52%), with China (at 36%) continuing to be a buyer of oil and meal over the last few months. Sixty-nine percent of

meal exports go to the USA, our major meal buyer, where it is primarily used to feed ruminants/dairy cattle. As the dairy industry grows in China, they are becoming an increasingly bigger buyer of meal.

Cows are able to make good use of turning canola protein into milk. The ruminant gut microbiome is what increases milk production efficiency, and canola fibre and protein are effective at feeding the rumen. This results in both increased savings to livestock feed and increased dairy yields. California and Wisconsin are the big buyers in the US, with large based dairy farms.

Given trade issues involving changing demographics and profiles as a healthy cooking oil and vegetable-based protein, there is a large focus moving forward on Wave 2 Markets, made up of those countries outside of our major buyers (USA, China, Japan and Mexico). IPM is a pillar of that focus looking towards 2025. In terms of trade issues, weed seeds are becoming a 'trade irritant' around the world, and although they are readily managed in canola production systems, they will start to become front and centre in our SPS thinking and will be more important as the years move on.

We need to understand blackleg as a phytosanitary problem. In 2009-2011 we had a full stop of canola shipments to China based on models of blackleg and dockage brought forth in various published papers (Bruce Fitt et al.). Federal governments were able to move forward but around it we had a memorandum to understand the risk of dockage and weed seeds transported from Canada. CCC then started down a risk mitigation pathway. The dockage issue was investigated with samples tested from both unloaded spill piles and blown spills, even modelling the drop that occurs at transfer ports to see if wind dispersed dockage could act as a source of inoculum. The conclusion was there would have to be ~75% disease infected in the dockage to have a concern - as a result, there is no risk of transmission of blackleg from dockage. In fact, China doesn't have a record of the presence of *L. maculans*, only *L. biglabosa*, and if dockage was a concern, they would have had it by now. At the same time data from CCC was published, showing a rise in blackleg incidence. China questioned why Canada could not rotate resistance groups as is done in Australia, but the disease situation is very different in Canada. We can point to our management practices and show China that we have all the practices in place. Progress has been made and we now have resistance gene labelling.

In the area of risk mitigation, CCC is working on protecting key tools of IPM. Seed treatments for flea beetle control can be justified as one part of the IPM approach. Research is ongoing but working with flea beetles is a very difficult model. PMRA looked at samples of flowing water, well water, and irrigated water – which all showed extremely low levels of detection of neonicotinoids. The monitoring of standing water on the wetlands is not covered by any one jurisdiction, so CCC is taking on the responsibility to work with groups like Ducks Unlimited and unlike the PMRA's 'single snapshot', CCC's model would use a 14-21 day approach for monitoring. Even when we have high levels of precipitation after seeding and product moves into wetlands, we still do not have detection of neonics. Breeding birds are a good bioindicator for potential effects on aquatic invertebrates and they should be our proxy. Since neonicotinoid

seed treatments were introduced and neonics have been monitored, waterfowl numbers have actually increased and wetlands are in great shape.

Canola Agronomic Research Program and Canadian Agriculture Partnership Funded Research Updates

Delaney Ross Burtnack, MB Canola Growers

The Canola Agronomic Research Program was started in 1985 is funded by the 3 major canola grower groups. With Alberta Canola, SaskCanola and Manitoba Canola working together, CARP is able to fund multiple research projects and award \$1-2 million in agronomic research for various programs that run over 2-3 years. Some examples of this research are:

- Stewardship of blackleg gene resistance - Dr. Dilantha Fernando, University of Manitoba
 - Feasibility of harvest weed seed management - Dr. Steve Shirtliffe, University of Saskatchewan
 - Monitoring flea beetle abundance and species distribution - Julie Soroka, Ag Canada, Saskatoon
 - Re-evaluation of economic thresholds for lygus and cabbage seedpod weevil – Hector Carcamo, Ag Canada, Lethbridge
 - How to properly manage canola in storage – Joy Agnew, PAMI, Humboldt
 - The best way to get nitrogen to our canola crops – Mario Tenuta, University of Manitoba
- Other ongoing CARP projects include: Determining the role of natural enemies, alternative control methods for sclerotinia, canola threshing losses, and assessing the use of planters optimizing canola establishment. The next call for Letters of Intent for full proposals to continue CARP's support for excellent research will be roughly June 2020.

The Canola AgriScience Cluster was awarded funding by the Canadian Agricultural Partnership (CAP). This cluster is a partnership between AAFC and the canola industry, including CCC and the 3 major provincial grower groups. It is a 5-year program funding 23 projects with more than \$20 M from private and public contributions as well as \$12 M funded by AAFC.

There are 5 themes awarded through the cluster:

1. Differentiated quality and enhanced environmental food processing (oil seed extraction techniques)
2. Differentiated quality and sustainability livestock production using canola meal
3. Increased production - yield and quality optimization for sustainable supply
4. Sustainability and climate change – improving nutrient & water use efficiencies
5. Sustainability and climate change – IPM

(The next series of CDF speakers have all been funded by the Cluster 'theme 5'.)

Information and results can be found in a variety of sources including the CCC website, the Canola Science Digest, online newsletter Canola Watch, face to face events like CanolaPalooza, as well as CCC agronomy specialists.

Thank you to all those who have made these funding programs a success.

IPM Research Projects Highlights

Patch Management for Clubroot Control

Mary Ruth McDonald, University of Guelph

Clubroot (CR) is caused by *Plasmodiophora brassicae* and is unique as it survives off of a living organism to reproduce. CR can lead up to 100% yield loss. The resting spores can be very persistent, living for many years in the soil. It multiplies in the root of the plants, to be released with the ability to multiply again.

Why has research taken place in Ontario when canola is grown mainly in Western Canada and CR is found in Alberta? Clubroot has been found in vegetable crops for centuries and has existed naturally in the East. As a non-regulated pest in Ontario, research there has allowed for trials at different locations with different weather patterns.

The research objectives of the Canadian Canola Clubroot Cluster Pillar 3 have been progressing well but we must work to keep the numbers low (resting spores/gram of soil). Symptoms will be seen as spore numbers increase. In Alberta, it is not uncommon to see over 1,000,000 resting spores/gram of soil. With high levels of inoculum, of course there are yield reductions. There has been work on bio controls but once high levels of disease occur, the bio controls are not effective. Lower yields still result when resistant varieties are grown in highly infected fields as the plants still have to expend energy (metabolic cost of resistance). Each year there are new pathotypes found. Typically, CR shows up in small patches near the entrance of a field. What can we do when we have the first glance of disease? Currently, CCC recommends keeping the infected area grassed and creating a new exit/sanitation zone. Scouting is very important and patch management should include:

- Pulling out plants in an outward circle to confirm if it's clubroot.
- If present, destroy clubs.
- Seed a grass crop over the area so no resting spores are transferred. Once established, you can move equipment over the CR areas.
- After 2-3 years, re-evaluate to see if spores are present.

Does lime work to suppress CR? Only at high levels (pH > 7.5) do we see a reduction. At 10M spores/g soil there is no suppression no matter how high the pH. Adding lime is a common practice in Europe and widely used for vegetables but several tonnes/ha are required to change the soil's pH. In Canada there are field trials underway looking at the use of different types of lime which are spread then cultivated to a 4" depth. It is important to test pH buffers to calculate the rates to apply, as pH may act separately from calcium. Cover crops are very important to stop the movement of infected soils and slow the germination of resting spores. Which grass cover crop works best? There were some differences seen with grasses screened; smooth brome grass showed some promise but was not statistically significant. How long to leave a grass cover crop in place? A 2-year break from canola sees a significant drop in resting spores but no advantage seen after 3-4 years. How many resting spores are there in a club? Hwang et al found 16 billion resting spores in one club while McDonald's work saw 3 billion spores/club at 5 weeks after seeding and 10-81 billion spores at 9 weeks. At 50-60 canola plants/sq. m, the number of resting spores can reach 600 billion to 4.9 trillion. These spores must be prevented from moving beyond the patch that they are in. What to do after pulling out infected plants? Infected canola must be destroyed and Brassica weeds must be controlled. Merely killing the plant tops by mowing or spraying does nothing to kill the pathogen. Roots may die off but resting spores remain in the soil. Even burning the clubs with gasoline was investigated to see how viable the spores were after "roasting the root" or having a "CR campfire". These burns have to occur over a certain length of time to be effective.

Patches must be managed! Scouting and pulling plants is very important. If CR is found, apply lime and grass the area for at least 2 years. It is all about the numbers – everything should be done to keep numbers low to manage clubroot!

Questions & Answers:

Q. Has anyone done any work looking at effects of companion/cover crops on resistance numbers, and pathotype growth rate? Especially with cover crop “cocktails” like radish mixes.
A. There has been interest in looking at mixes. Some tillage radish cultivars were screened for common pathotypes and none developed CR, but this does not mean that they’re resistant. We’re also looking at rotations with wheat, beans & peas to see if using these crops as a rotation crop will reduce resting spores in the soil.

Genetic Resources for Pest Management

Dwayne Hegedus, AAFC Saskatoon

We have an ideal prairie landscape with clean fields – “fields of dreams”, but with so many pests and pathogens that can affect it, it’s a wonder that we can grow canola at all. Lygus bug, sweet midge, prairie midge, aphids, grasshoppers, flea beetles – any one of these pests can cause issues and cost money in terms of control or crop losses.

There are two types of flea beetles on the prairies – crucifer and striped, which historically have been controlled by different pesticides. Since the ban on neonicotinoids in Europe, beetles have been on the rise. There has also been an unintended consequence as result of the use of more aerial/foiar spraying – beekeepers are having a hard time finding clean canola fields.

Research at AAFC has looked at suppression in flea beetles due to trichomes. Wild species of brassica have hairs on leaves while ‘contemporary canola’ has few hairs. This led to work to see if perhaps “hairy canola” could control flea beetles by disrupting their feeding. It was found that a flea beetle will circle until it is comfortable and then it will start to feed. If this habit of circling is interrupted, then the beetle will leave the plant. In field experiments, hairy canola performed very well when compared to treated seed.

How was this ‘hairiness’ achieved? In the leaf there are 2 types of cells that produce hairs.

When certain proteins were brought together and hormones were introduced, epidermal cells were turned into trichome or hairy cells. The GL3 protein from *Arabidopsis thaliana* was used but this resulted in severe growth impairment to the plant, as GL3 is involved in other areas of plant growth and development such as root hairs, mucilage and flavonoids/glucosinolates. The ratio of GL3 and TTG1 was adjusted and this repaired the wild growth phenotype of hairs.

Why is this not in farmer’s fields? There are 3 reasons: two transgenic events are required and these are complicated and unstable; the patent for GL3 is at Texas A& M; and issues with major breeding companies as there are regulatory costs as well conflicts between internal business units.

What became the next step? One thousand lines of various Brassica species were screened for hairiness. A small subset was found to be naturally hairy – *B. villosa* is entirely covered with trichomes. Researchers began to look at ways to access this trait. They examined the GL3 gene and introduced it into non-hairy canola but there was a developmental impact. Crossing has continued with naturally hairy line to see how this trait can be passed along – there seems to be a single dominant gene, but other genes may influence trichome numbers. Interspecific crosses

are difficult so they have tried to move the trait into a genome background that might be more amenable to crossing. An extreme range of phenotypes have resulted, from those with hairy trichomes to those with white flowers. Work continues to map and move hairy trait into a canola quality background.

Questions & Answers:

Q. How big of a growth penalty are we talking about?

A. There's a growth penalty when you overexpress the GL3 gene that induces the formation of trichomes. It can be overcome when you reduce the expression of another gene but the combination to develop the right ratio is complicated. If wild type *B. napus* are used, we don't see a growth penalty - so the ratios must already be corrected to produce abundant trichomes. To introduce this trait into canola more attention should be paid to the wild and hairy type brassicas and the use of traditional breeding methods instead of a GMO approach.

Q. Are you checking to see if bees have issues with visiting the hairy flowers?

A. *B. villosa* has trichomes on the flowering parts of the plants, but the petals themselves aren't hairy so there is no problem for bees.

Biotechnologies Role in Integrated Pest Management

Steve Whyard, University of Manitoba

The current method of control is pesticides and there are two major problems associated with their use – increasing resistance and off target effects. Can we try to control these pests and pathogens in a more sustainable manner? We may be able to lower the use of species-specific pesticides and reduce harm to beneficial species by looking at gene specific double stranded RNA (dsRNA) in these pathways. Can RNAi (interference RNA) and silencing a gene using siRNA be used to target and kill pests? If dsRNA is fed to an insect, ingested dsRNA will leave the gut, spread and silence genes in other tissues.

Research was conducted using the striped flea beetles since the cruciferous species is too difficult to grow under lab conditions. Beetles were collected using sweep nets, colonies were grown in the lab and were then fed dsRNA leaf discs to access mRNA knockdown, mortality of the beetles and leaf damage. It took up to 2 weeks to kill the beetles but leaf damage was lowered after a couple of days. dsRNA target genes found in the gut were screened to see which worked best. Flea beetle RNAi insecticides are species specific – striped flea beetles were not killed and 5 different predators of flea beetles were also not affected, even with high doses. In order to obtain a 100% kill rate, best to mix half doses of 2 dsRNA, create a more stable structure so you don't have to apply as much and improve the formulation to adhere to the leaves & stay bioactive. There is the potential for different delivery approaches including transgenic plants, foliar sprays, root delivery and stem injections. When comparisons were made between transgenic material and foliar treatments, there was less leaf damage with the foliar spray. Is the technology affordable? You could use microorganisms to produce dsRNA. There are now commercial producers developing this with the intention of larger scale use (1mg can kill about 100,000 flea beetles).

There is also work looking at anti-fungal dsRNA to target *Sclerotinia* – using the same approach to control with RNA. Two methods include transgenic plants expressing dsRNA and foliar dsRNA

sprays. The disadvantage of transgenic plants is the public perception (especially in Europe) but the plant is protected all the time. Foliar sprays are easily transferrable to more crops but can be costly with multiple treatments.

The technology can be applied to other fungal pathogen, for instance some of the same genes targeted in Sclerotinia can be used against Botrytis. The use of qRT-PCR can confirm that fungal transcripts and fungal loads can be reduced. And when you combine dsRNAs in half doses, it works better and the reduction in lesion size is much greater.

What does protection look like on transgenic plants? Many lines of dsRNA expression were produced & screened, and lesions were much reduced on leaves and stems of the transgenic plants. In terms of whole plant protection, the transgenic plants produced more seed and fewer sclerotia/plant were produced. The sclerotia produced actually showed less pathogenicity when re-used in the next trial.

On-going activities include:

- looking at the lasting effects of the foliar sprays in the environment
- testing the best foliar treatments in the field
- examining the effects of dsRNA on other fungal pathogens

RNAi shows good promise of species specific control of pests and pathogens as both foliar sprays and transgenic plants are effective at controlling flea beetles and Sclerotinia. Different markets can be offered different approaches depending on their needs, with future field trials conducted to provide more information on this new technology.

Questions & Answers:

Q. Are there any multiple effects of those specific RNA's, like one on botrytis and one on sclerotinia? Is it possible that one will do both diseases, or are they are specific on one disease?

A. Currently focussed on specific disease only. There's a possibility that you can design some dsRNA on 2 pathogens as long as they're closely related.

Q. Is it possible to mix RNAs so that you can "tank mix" them and control multiple diseases?

A. That's the goal. It's easy to mix and easy to switch to a new target. This technology is very adaptable compared to development of other modes of action.

Q. Any thoughts on potential of resistance in flea beetles?

A. No matter what we throw at nature, resistance is inevitable. We are thinking about resistance and have tried saving some insects that survived treatments and found they were sterile. If resistant to one gene, it's easy to switch to a different gene. If resistant to uptake mechanisms, then alternate means will be researched. We are already anticipating how to counter the resistance mechanisms.

Canola Research Hub

Taryn Dickson, CCC Resource Manager

Many steps are taken towards discovery in research, including positive/negative/null results, new methods, and new conditions or environments. Discovery is a piece of the puzzle that will help explain the big picture of canola production. Each step allows us to be more efficient with time, energy, and funding, and keeping good records is important to prevent duplication. Today

we heard about many research projects that will lead to more sustainable and profitable canola production in the areas of IPM. Many projects focus on fertility management, plant establishment, harvest management, and genetics, and are funded by universities, government (AAFC, provincial), and industry (not for profit, private). Programs such as Canola Agronomic Research Program (CARP) and Canadian Agriculture Partnership (CAP) funded through the CCC can provide useful information towards understanding canola production in Western Canada and improve recommendations based on scientific evidence we have at that time. However, these results can only be used if they are accessible to growers, agronomists, and researchers to make canola production more sustainable and profitable. The CCC created the Canola Research Hub (canolaresearch.ca) to provide a variety of information sources online at varying degrees that everyone can understand, from podcasts to video interviews to full reports. They are improving functionality of the website by adding more interesting research, incorporating user feedback, highlighting timely canola topics, and better integrating research findings into best management practices. The website will re-launch in 2020.

DAY 2 Thursday, November 14th

Current IPM Strategy for Canola Production

Warren Ward, CCC Agronomy Specialist

Yesterday we spoke about the various pillars that we want to use to reach 52 BU by 2025. This year we want to focus on IPM. It is a broad topic with many challenges including diseases, weeds and insects. There are main diseases but other like aster yellows present new challenges. We cannot become complacent with weeds as there are issues with timing of weed control as well as loss of options. There is the impact of beneficial insects, again the loss of options and the cyclical nature of insects. The number one IPM practice is scouting or “boots in the field”. We need to utilize economic thresholds to properly use controls. We must use an integrated approach with more than one option for controlling and managing pests. With our industry under scrutiny, we must use products as intended. This is key to remaining profitable in our production. There is a broad range of crop rotation options – economic vs. agronomic, continuous canola to ‘1 in 4’ and other consideration since not all regions are similar. We will look at measuring IPM success and the farm gate experience – what challenges are faced, what BMPs to use, what works and what could use with improvements. Clubroot presents challenges – pathotypes influencing management decisions; what about all those letters and numbers; soil testing and what do the results mean? We will discuss emerging threats and regulatory changes that impact industry. And in a world with increasing scrutiny, we will examine market access and available options using IPM technology.

Transitioning into Stronger Crop Rotations

Crop Rotation and Insects? The mysterious case of aster yellows

Tyler Wist, AAFC Saskatoon

Using crop rotations, we can control insects. Crop rotation affects both harmful and beneficial insects. Aster yellows is known to be vectored by aster leafhoppers and can only survive in the leaf hopper or within the plant. Aster yellow phytoplasmas affects the plant hormones and transforms the floral organs into leaf-like structures, causes bladder-like pods, germination in the pods, flattened or malformed stems, and malformed “pepper” seeds. Once infected, plants and insects are infected for life, and the only option is to control the vector. There is no chemical to control the phytoplasma, though insecticides or uprooting perennials can be used to control the vector. While leaf hoppers aren’t cold hardy for our environment, they are migratory. Initially it was thought that aster yellows were migratory too, but it now seems that crop rotations may be influential. In 2019 there have been observations of unusual plant symptoms resembling aster yellow symptomology, and upon testing found the plants were infected at a low level. The question became, are the leaf hoppers picking the vector up locally or bringing it in? There are areas in the province with aster yellows, but not a lot of leafhoppers. Found that a field of alfalfa was vectoring aster yellows and there may be a disease reservoir in the province hiding in forages and alfalfa.

Questions and Answers

Q. Perhaps we need to make sure our RMs keep ditches well mowed late in the fall to eliminate some of the feeding? Is there anything else we could do other than that?

A. Control measures are yet to come but mowing is a good idea. Won't be easy to convince people not to grow alfalfa.

Q. They've also detected phytoplasma in bromegrass and cereals etc., so what is the possibility of it overwintering in winter wheat/bromegrass crowns? Is there a number of different green bridge reservoirs? And, when you have aster yellows at a light rating and only one part of a flowering raceme affected, if you tested the plant would it be positive in that raceme, but negative in all other racemes in the plant?

A. Aster yellow phytoplasmas don't reproduce well in cereal crops, they can get affected and get symptomology, but the disease doesn't reproduce well. Aster yellow also can't pick up phytoplasmas from barley, but it may be a problem. Phytoplasmas can be hard to find. Found that if they just took leaves, the threshold of detection wasn't great. The best place in wheat that they found was right below the heads on the stems. In canola, they look for the most damaged racemes and they always tested positive. But an asymptomatic plant can still test positive. If you look in the wrong place on the plant where the phytoplasmas aren't, you can mis-test.

Biologicals: Emerging technologies for growers

John Kruse, Plant Response Biotech

Plant Response Biotech is based out of academia and looks at genetic, cellular, and whole-plant modes of action and finding technology to understand how they work. A lot of work on biologicals comes from Europe due to the pressure on their synthetic products. Biologicals have been around for a long time but there are still many unknowns and misunderstandings. The biological market benefits the agricultural industry with \$6.75 billion in 2018 and is projected to grow 13.8% from \$4.5 billion in 2014 to \$14.65 billion by 2023. Retailers feel the pressure to expand their portfolio and differentiate them from competitors. Biologicals are naturally derived products that elicit a beneficial or protective effect in a plant against abiotic and biotic stresses. They represent an environmentally friendly alternative to chemical products, and the regulatory process can be accelerated in comparison to chemical products. The four main categories of biologicals are biocontrol (act on a weed or pest), biostimulant (improve crop performance), biofertilizer (microbial supplement to increase nutrient use efficiency), and macro organisms (beneficial insects). There is a regulatory challenge with products that fall between fertilizer and crop protection. There is still grey area, but the EU and USA recently passed descriptions on clarifying biological terms, yet Canada seems to be ahead of the game with clear timelines, requirements and classifications. There is discussion around whether or not certain biologicals would be considered plant growth regulators, and what happens if you combine a biological with a micronutrient. Biologicals are emerging as BMP, are becoming more science based, and have the potential to integrate into IPM and offer alternatives.

Crop Rotation Decisions - Dollars and Sense

Murray Hartman, Retired Oilseed Specialist

An economic value cannot be put on the many factors that influence IPM strategies. The rotation benefit hasn't been partitioned for individual factors which creates grower uncertainty in the monetary value of IPM practices. A canola production survey in Alberta in 1991/1992 showed that 90% of respondents had a 2 year break or longer from canola prior to herbicide

tolerance and hybrid adoptions. In the last 30 years there has been a rapid increase in canola acreage. As a result, short term rotation studies were created to study impacts of pests, but small experimental plots may underestimate rotation effects due to disease, weeds or insect trespass between plots or from the same crop bordering the experimental area. In a long-term rotation plot in North Dakota they try to reduce contamination from plot to plot with separations, but what is a good separation distance to minimize pest and contamination impact between plots? If it is difficult for sanitation in small plot research, how can it be feasible for larger scale operations? We know that with a longer rotation there is lower disease incidence, lower severity trends, and lower yield loss response, but there are many unknowns that have not been economically assessed. Short rotations with fewer crops may be easier to manage, but they increase the risk of pesticide and genetic resistance/degradation. The rotation-yield benefit isn't fully understood but new scientific methods may fill in the gaps.

Questions and Answers

Q. BL pathogen isn't static in a tight rotation and begins to adapt to the resistance and may be more of a contributor to yield loss. BL dictates the rotation that the grower used. It's interesting in terms of what happens under the soil and potentially contributing to differences in yield, but worries we're basing our rotation on the effective sources of resistance, and how long can we do that? Is there an unlimited resistance to BL or will we empty the cupboard out?

A. Unless we can put a dollar figure on it, how can we incorporate risk management into grower programs? Producers have a stronger faith in science and technology now to handle these problems in the future. So instead of relying on the rotation, they just hope for science and technology to help them. Some growers don't put a dollar figure on the potential to lose BL resistance. There's a divide on what the risk really means to the individual farmer, and what the value is.

Q. I don't often see people talk about grade loss risk in growing wheat. Everybody likes to contract wheat, and sometimes something happens that knocks you down significantly even though you pick prices based on higher grading wheat.

A. There are many pieces to the puzzle. Why did wheat previously go down when canola went up? It was due to BSE. There was also canola planted to easily spray out weeds after forages once the technology to get a clean field was provided. There are many other pieces of the puzzle that need to be considered.

Producer Panel: Measuring IPM Success

- Scott Keller, Camrose Alberta
- Troy LaForge, Cadillac Saskatchewan
- Shane Friesen, Rosenort Manitoba
- Dana Maxwell, Minto Ag-Quest
- Moderator: Daryl Domitruk, Manitoba Pulse & Soybean Growers

Each producer gave background information before questions were taken.

Scott Keller: Scott studied Agronomy at Old's and worked as an agronomist in 2010, and is now a full-time farmer. When working as an agronomist, 2 different customers brought in plant samples. It was thought that CR was an Edmonton problem and that the closest field with CR was about 50 miles away, so it was felt that it was not an issue in their area. But then it was confirmed as CR and now he really needed to take the disease seriously. They found by experience that they were bad at detecting it at low incidence. By the time you find it, it's already a large patch. Scott is in a predominantly W-C (wheat canola) area and on his farm, it's a '1 in 3' rotation: malt barley, wheat, and canola. There are farmers that are growing canola every other year for 20-25 years. It was easy to adopt R varieties even before seeing patches in the field but it was the only IPM tool that producers implemented. So he decided to start using CR resistant varieties, while others brought in the R varieties only once they found CR. Just because you haven't seen it yet, doesn't mean you won't get it. The county has surveyed every canola field over the last 6 years and you could correlate where it was popping up by the products they were buying. In his area, there was a quick adoption of R varieties but what didn't change was the rotations. Those who were malt barley growers had their 3-year plan going, while W-C producers kept doing what they were doing. This was 10 years ago and now they are dealing with new pathotypes due to broken down resistance. Agronomists are finding a lot of dead patches in fields where all they did was adopt a resistant variety, especially in the wet patches. There are some issues with the '1 in 3' farmers, but much fewer compared to the growers who won't stretch out their crop rotation. The R varieties are not useless yet but the resistance breakdown is having an impact. Used to be the county policy that if they found 1 gall in 1 plant, you couldn't grow canola for 4 years, but now that policy doesn't exist. Scott however is now seeing great yields and doesn't have problems with blackleg due to '1 in 3' rotation and using different seed company technologies; BL hasn't been viewed in the field. As they stretched out their rotation by adding pulses, he is not dealing with the same weeds and they're able to use the single pass spray. Canola is our most profitable crop and CR is the biggest threat to the farmer's whole bottom line.

Daryl Domitruk (moderator): What we've heard from black soils diverse rotations in AB, genetic resistance is a good key, but you will lose that genetic value if overused.

Troy LaForge: Southwest SK is low in organic matter and has limited moisture to work with, different from black soil zone. They need to be flexible from year to year and typically try to pick ~ 3 majors out of a crop group. Troy is a big believer in time and intensity in crop rotations. At times he will double stack some cereals, but then return to stacking pulses and oil seeds, and then go back to broadleaf-cereal rotations to try to solve issues. He is very interested in intercropping as IPM (illustrated by showing a photo of chickpeas and flax in the same field). There are lots of cons but also lots of pros moving forward. Troy works with an agronomy background (Ultimate Yield), and believes in diagnostics first. If you're going to use an IPM tool, the problem should be diagnosed first before using the tool – this will give the greatest return for the cost outlay. Too often IPM tools are being used that don't even suit the farm. If a tool is needed, don't look for the cheapest cost, look for what will get the greatest return. His agronomy group has a research side and looks at water use effectiveness (WUE) data. If he's looking at a new tool, he likes to compare it to WUE data. He's looking to maximize economic

return and what IPM systems should he employ to be the most profitable. He plants at narrow row spacing (i.e. 7.5" in barley). After 3-4 weeks, the barley crop is starting to get canopy closure, which means it is competitive with the weeds. If it was 12 inches, it's another 2 weeks to close it up, and in a moisture limited environment, you want to cover the exposed soil to reduce evaporative losses and improve biology of the soil to cycle nutrition back to the crop. He uses a no till disc drill, diverse rotations and scouts. He also employs a 6 factor agronomy plan (crop rotation, soil & tissue samples are tested for balanced nutrition, uses insect tolerant traits, seed treatments for insects, minimizes fungicide use in pulses for aphid control). He is big on balanced soil nutrition as a massive contributor to yield. For seed treatments for insects, he uses indicator species like wireworms/cutworms to check that their no-till high-residue crops have a good environment (moist and cool). Aphid control happens naturally in the crops, but when you apply certain fungicides, you kill the fungus that control aphids. He minimizes fungicide use in their pulse crops. He's found that farmers who spray fungicides have twice as many aphids as those who don't, which is why he doesn't apply fungicide. Troy feels that the ladybird beetles will do a lot of the work for you. His questions moving forward are about intercropping. He would like to grow flax-chickpeas more often because they have to spray less and fertilize less but crop insurance cannot cover his risk on the crop. Resistance traits and all-in-one seed treatments are band-aids to a broken system. Intercropping is a great concept but a risk management program issue and cost issue. All in one seed treatments are not very targeted to exactly what you need in your system.

Shane Friesen: Comes from a high moisture area and uses a diverse rotation. We should ask the question "what works on my farm". Of course whatever a farmer does is what works! "What I do is right". Shane looks at the use of weed science to see how he can grow the strongest crop. How can I grow the best crop, because if the crop is there, the weeds aren't there. Shane likes to plant early canola (gets higher yields and early emergence competition against weeds), and doesn't use too little seed (price of seed goes up so producers start to use less, and as price goes up you start to wonder if you can use less. People in his area are considering 15-22" rows to save on seed costs but this leaves more space and time for weeds to fill the gaps and then leads to increased sprays. Rotation is a good idea, but the biggest weed problem in a canola field with a tight rotation is canola. This can be solved very readily; technology is available to solve this problem. As for future research we should be looking at controlling volunteers and herbicide resistance. Hopeful that Canola Council can take a leadership role in extension and look at the Australian example where they had a better resistance network connecting farmers to the University/research to answer farmers' questions. Companies are starting to stack traits, soybeans especially, but how are we going to control those volunteers?

Dana Maxwell: Dana manipulates IPM for contract work at AgQuest to test out pests and pathogens for clients. AgQuest has 5 research stations across Canada, 24 research associates, and does a variety of research, efficacy research, and glp residue testing. They operate in a lot of environments across Western Canada that companies plan to deploy their products in. Certain regions/environments are used for certain tests – for example MB or SK can be used to test for sclerotinia while Alberta is not used. Blackleg trials may be better elsewhere where a certain level of the pathogen is needed. Dana needs to think on what is needed to manipulate

IPM to obtain the right condition for testing: picking non-resistant varieties, tight row spacing, reducing airflow in the canopy, adding inoculum, tight 2-year rotation, adding more water and mist irrigation to get the crop infected. In fact, it's getting harder to infect canola with sclerotinia due to better breeding from seed companies. Different fungicides are applied to try to find statistically significant differences with sclerotinia, as well as with FHB in wheat and barley. For blackleg, AgQuest runs tight rotations and introduces inoculum at high densities to obtain high infections for pre-registration testing. With insect studies, they scout a lot and vary the time of the day as there can be a lot of damage and the loss of data points can be very important for the client. In yield trials they have to implement a longer rotation so that the genetics of a variety are studied, not the genetics of the volunteers – this will impact tolerance levels and other results. AgQuest uses many strategies with IPM but not in the way that others use them.

Questions & Answers:

Q. What IPM strategies do you find too difficult to implement in your operation?

Scott: From a CR standpoint, he doesn't think he has time for sanitation and doesn't think he has a bad enough infection on his land to implement that. He thinks having a longer rotation will have more of an impact on managing the resistant varietal strength. We know now that a 3 year rotation impacts CR, so Scott knows if he does a good job elsewhere then he can skip this one. It works where he is but it may be harder in MB because tillage is more prominent and it is wetter in MB.

Dana: Sanitation is really important in her situation, and not within the research station. It's more troublesome when clients visit the site and you don't know where they came in from last. She has emphasized sanitation in her program even though it costs in time for cleaning of equipment, it's worth the push to implement it.

Troy: They only pick the 3 crops every year. It's a lot of work having a diverse rotation because you need a diverse marketing strategy. And because they have a seed growing program it's also a lot of extra work cleaning between varieties - cleaning the drill and combine out.

Shane: Are you going to take 3 hours to clean out equipment? He has an implement that picks up so much dirt that it's not possible to sanitize. There are also municipal problems - the RM uses equipment in ditches – where have they been? Long rotations are important - there has been a lot of talk in MB about changing funding structures for crops. Would love to grow other crops like flax - could we offer more support to other oilseed crops to develop more rotation options for growers?

Q. For Scott - Are you concerned about CR and your neighbors? Is there potential for carryover?

Scott: You can do everything right on your farm and wonder - are the neighbors going to wreck it for me? It really is a disease that even if you do everything you think is right on your farm, it can still come. But it's not going to move into your farm like kochia blowing in. Doing at least a '1 in 3' rotation you really mitigate the chance the spores will stay alive. When you drive around you can tell which farms have CR because they're ALWAYS in a '1 in 2' rotation.

Q. For Troy – You mentioned that you intercrop with chickpeas and flax, and there's a benefit on ascochyta. What is your primary goal in terms of intercropping?

Troy: Intercropping is about maximizing returns, not cutting costs, and minimizing risks. Just having the physical crop barrier of flax growing between chickpeas minimizes the risk of the ascochyta movement. Flax needs N inputs but growing chickpeas between helps to keep costs the same without losing yield. We are also able to increase the ‘standability’ of peas in canola and increase the yield of the peas.

Q. One of the objectives of the forum is to identify areas of discovery. If you could ID one tool that you need to be successful with IPM, what tool do you need to be developed?

Scott: Any IPM starts and ends with rotation and picking which crops you are going to add to diversify that rotation. In Scott’s area, they’re a little limited on the crop choices but they have options even with the shorter growing season. It’s a learning curve. It’s simple to manage if you only have two crops but you can have a diverse rotation and make all those management decisions right now. He’s already got his crop rotation and herbicide rotation figured out now. All he’s looking for in June is “time” – when to spray depending on weed sizes, since he already know what weeds he deals with on an annual basis. He’s not shopping for herbicides in June and making decisions unless something comes from left field.

Troy: In terms of research, you look at a systemology or “all-phases” system. What would you actually put into a 50-70 bu system given the WUE? The 50 versus 70 systems are very different so you have to account for all different phases involved.

Understanding and Interpreting Clubroot Testing

Clubroot Pathotypes

Keisha Hollman, University of Alberta

The first cases of clubroot in canola were identified in 12 fields in 2003 and has increased to 3351 fields across the prairie provinces in 2019. Some of the most severely infested fields were planted to clubroot resistant canola. Resistance has degraded in Alberta, Manitoba, but not Saskatchewan. Pathotype shifting is common when one pathotype population is reduced which allows other pathotypes to dominate. Based on the current pathotype classification system, “new” *P. brassicae* strains that overcome resistance cannot be differentiated from “old” strains. Pathotyping is a long process that takes several months to complete but helps determine the best farm management plan and smart genetic deployment schedules. It is also helpful to determine the spread of new pathotypes, and pathotype diversity. With the Canadian Clubroot Differential (CCD) set, populations from fields with resistance issues are tested for designation on the CCD, with unique pathogen virulence assigned to different letters. The set has 17 distinct pathotypes, but 19 new ones were discovered this year, 10 of which are from single spore isolates, which brings us to 36 unique pathotypes. There is diversity in virulence, and the CCD helps to further identify a pathotype’s unique virulence pattern to accurately focus on breeding efforts. However, genetics may not be an option for breeding for resistance since there are so many new pathotypes, so an IPM approach will become more important through reducing spread to other fields, liming, or patch management.

Questions and Answers

Q. Interested that the rare pathotypes are showing up in clusters. Are we seeing them clustering and that they’re moving to a new central location?

A. Almost all of the new ones were in clusters in various places. A lot of the new ones were found in one field, a few others were in multiple (2-3) fields.

Q. Because we know that lots of clubs contain more than one pathotype, your genetic testing material may be quite diverse. Do you expect we will consolidate down from the massive new amount of genetic diversity?

A. It's hard to say given the trends because we didn't see so many pathotypes in 2014-2016 but suddenly we're finding many new pathotypes in the last 3 years.

Clubroot Soil Sampling

Kim Kenward, 20/20 Seed Labs

20/20 Seed Labs offered the first clubroot test in a lab. Clubroot root galls can release 16 billion spores per infected plant. Clubroot was first detected in Sturgeon county in Alberta in 2003, was declared a pest under Alberta's *Agricultural Pests Act* in 2007, and varietal resistance was first observed in 2014. Clubroot moves by machinery, water, wind, and seed, but is not necessarily distributed evenly around a field - most incidence occurs around field entrances in addition to low spots, water runs, and old gardening sites. Testing plants with clubs can get positive results, however the soil around it may not test positive – the bulk of the pathogen is where the bulk of the root mass is. However, no test can compare to just looking at the crop. To submit a test, a 2-cup sample must be collected using a W shape scouting pattern in the field, targeting the site where higher incidence would occur. Soil must be taken from the top 5 cm of the A horizon without taking the B horizon and should be air dried. It is best to wait until the galls have decayed back into the soil, or to bring in an intact canola root. Dilution of a positive soil sample with clean soil can result in loss of micro-organism detection. It's important to recognize that spore load can be reduced by 90% after a 2-year break from canola.

Emerging Threats: Farming in a Regulatory World

Crop Protection in a Changing Regulatory World

Alan Schlachter, Crop Life Canada

Plant science solutions are recognized as an integral part of sustainable agriculture, food production, economic growth and healthy communities. Currently some topics of interest include the protection of modern ag tools, re-evaluation, water monitoring, 2020 review of the *Pest Control Products Act*, MRLs, resistance management, and emerging technologies such as RNAi, precision ag, and drones. A graph was shown depicting that populations, cereal production index, and cereal yield index are increasing, yet land under cereal production index is mainly static. Regarding the protection of modern ag tools, glyphosate is under attack for a multitude of reasons, and a current re-evaluation program is being implemented and is strongly supported by Crop Life. The PMRA capacity and current resources cannot meet current/future needs – reviews occur every 15 years but reviewing as fast as possible means all products are assumed to be safe. PMRA pumps out decisions as quickly as possible and makes overly conservative decisions for post-market evaluations that results in cancellation of uses that would otherwise have acceptable risk. Crop Life is advocating for this part of the analysis, not only for health and safety, but for Canadian competitiveness, investment, and international

trade. Crop Life is also intervening with PMRA's challenges with THX and neonics. Finding pesticides in water doesn't mean there is a risk, and PMRA doesn't have the data they would need to refine those assessments. Crop Life is developing a national standard for greenhouse stewardship, since there isn't one yet, and participating in the 2020 legislative review of the Pest Control Products Act. The "Manage Resistance Now" website has a mandate in the protection of human health and environment. Regarding drones, there are huge opportunities blocked by the regulatory environment. Regulatory environments are complex, and new technologies such as RNAi will face more regulatory challenges in the future.

Questions and Answers

Q. If EU bans Matador in March, and PMRA releases final decision of Matador in January, and they approve their registration, does that mean EU reviews Matador in April or March?

A. It's complicated. If the EU or other country bans a product for use due to human health concerns, then PMRA is obligated to initiate a special review. It depends on why they banned it if they initiate the special review. PMRA has flexibility of when they initiate a special review, so if they've done it, or did it recently, they're no longer obligated to initiate a special review. If it's human health reasons they're obligated to initiate a special review. With PCPA Act, they're obligated to initiate but there's no time frame/no obligation to finish.

Canola Industry's 2019 Neonic Water Monitoring Program

2019 Neonic Water Monitoring Program of Prairie Pothole Wetlands

Mark Walker, Canadian Canola Growers Association

The Canadian Canola Growers Association (CCGA) has policy and government relation teams in Winnipeg and Ottawa that work on issues around trade, environment and sustainability, transportation, business risk management, crop inputs, biodiesel and marketing. In August 2018, the PMRA proposed banning all outdoor use of seed treatments due to unacceptable risk to aquatic invertebrates, as modelled by PMRA (i.e. Poncho, Prosper, Helix, Cruiser Maxx). If PMRA moves forward with a phase out, the products won't be available until after 2024. Factors involved in the model that PMRA used were from Eastern and Western Canada, which doesn't work for the middle prairies. CCGA proposed a special review based on the chronic endpoint - the level at which chemistry must be present in freshwater to cause breakdown of cellular structure of brains of midges and mayflies after 21 days or more. CCGA studied 17 wetlands in Alberta and Saskatchewan, took 157 samples over 3 months, found 18 detections of Clothianidin, 10 detections of Thiamethoxam, and 125 detected no neonics. No samples met criteria for chronic or acute events. The data also showed that detections dissipate quite rapidly after weekly sampling events, resulting in low levels of neonics. Detections mainly happened after rainfall events and are very low. Thus, the research here doesn't support phasing out these products due to aquatic invertebrates and doesn't support need for regulated mitigation measures. These results were submitted to PMRA and presented for review, and the CCGA wants to move it towards decision makers in Ottawa.

Questions and Answers

Q. Regarding the review of some of these risks of pesticides, do they take into account the discovery of compounds over time or just acute events? Obviously, the biggest risk of finding a

seed treatment would be if you planted the crop into the field this year, especially in the case where you showed the wetland grew into the area seeded, you can expect higher product concentration in that place. But do they even look into that same area at different stages later on to determine if the product breaks down over time?

A. They look at both the acute (one-off event) and chronic (if it's present for 21+ days) endpoints. Where they did see any issues/detections, they were broken down quickly. No persistent levels of chronic events.

Q. Can you provide more background on why the levels in the East are so much higher than what you were finding here?

A. Likely different tillage practices, but Mark wasn't familiar with the areas where the studies were done. There's one area around Levington with lots of greenhouses on it, and that area/those levels were assumed to be quite typical for the area, so those practices went into the model. Of the studies that came from the East, two were from Environment Canada and could have been more robust.

Q. Is the proposed ban from PMRA based solely on an intended impact on aquatic invertebrates? This topic was previously discussed around bees in Ontario and particularly in Europe, but now it's become a problem in the UK with foliar. Is it still about bees?

A. 99% certain that PMRA said neonics on canola is not harmful to bees. There may be some foliar applications that may be questionable still. But currently at this point it's for aquatic invertebrates, not bees.

Q. Do you have any recommendations or thoughts that you want farmers to collect on their own in some way or something that if called upon really quickly, we would have that network or data ready for them?

A. We've tried to work with PMRA about finding out what active ingredients are coming down the pipe, and that they don't have information on. Now a large part of efforts is trying to find where the data gaps are and try to be ready so that we can take it at a more regular pace. This is ultimately what allows us to keep these products.

Q. If you think back, right now we're at a watershed around continued water monitoring. In past years, provincial resources, jurisdictions and grower organizations came together to fund most of the sampling over the years to put together a robust dataset. Is there merit in continuing to monitor wetlands and flowing water in years to come with cropping system data, and store samples at AFC or somewhere to look at historically to prove we're following good stewardship, or do we just drop what we've built and leave it.

A. Growers funding this work for the next 10 years is not okay. Government needs to find a way to collect this data because farmers can't fund this forever. We need a plan and a system in place. There was one ~13 years ago and it was cancelled.

Market Access: Stewardship of IPM Technology

The Path to Production

Jennifer Marchand, Cargill Ltd

Cargill's primary goal is to feed the world in a safe, responsible and sustainable way. Together we can help the world thrive. We are uniquely positioned to deliver solutions by connecting people, products and the planet. Our priorities include human rights & inclusion, food & nutrition security, farmer prosperity and enriching communities. Cargill collaborates to protect natural resources and address environmental challenges. We create innovations that drive sustainability. We have the benefit of operating an integrated supply chain - sourcing food and moving it around the world, producing thousands of ingredients that go into the food you eat every day. Innovation is the answer – how to do more with less. Innovation requires time, investment and strict processes and protocols. With the increase of affluence there is an increase of consumption – which requires more regulatory approval. Authorizations in each country varies. Serious trade disruptions could be reduced if all countries could provide authorizations simultaneously or if there were international governmental consensus on the elimination of zero tolerance policies – however this is not the case.

The introduction of a new plant biotech trait costs \$136 million US and it is not a fast or an uncomplicated process. The time associated with registration and regulatory affairs has increase from 3.7 to 5.5 years and regulatory accounts for the longest phase in product development, 36.7% of total time involved. Cargill is in the process of obtaining regulatory approval for canola with an oil profile that will support the aquaculture industry. This is an exciting opportunity as only 2% of food produced comes from the ocean. There's a lot of effort in our value chain to ensure the integrity of Canada's supply chain and our markets stay accessible. Responsible commercialization of this canola, done at the right pace, is critical so that the market is not put at risk. There will be pressure to scale up but this must be done sustainably. Pre-harvest will select the right growers and will support the grower network. Cargill will start with a very concentrated geographic area in the US and seed will be kept separate from their base business, with dedicated facilities in production regions. There will be strict containment protocols to ensure no on-farm comingling, inspections of all storage locations and strict containment protocols. Post-harvest, stewardship extends beyond the crop year and into the future including rotation protocols and monitoring & control of volunteers and dedicated storage with inspection & release controls. Grower support is critical and this includes audits throughout the growing season, communication to growers of compliance to protocols and all components of stewardship documented. Investments and procedures will ensure stewardship at the processing facilities and safe segregation of EPA/DHA canola from other products. Meal from crushed canola will be sold as a commodity in the USA – it will be channeled and trace to specific buyers to ensure that it has a domestic end-use. The system must be strong to ensure success and Cargill's stewardship team will work closely with growers, with many opportunities per season to visit farmer/fields. At Cargill we take our role as stewards of the supply chain very seriously and in order to avoid market loss and impact to all stakeholders, the vigilant and transparent stewardship of traits that have not been de-regulated in all major markets is critical. Everyone in the value chain must work together.

Questions & Answers:

Q. How competitive can you be to what CSIRO has done with its development, and is the strategy different?

A. Will connect people with the right colleague → There are other organizations working in the industry to bring this technology forward. The breeding strategy that CSIRO use and the one Cargill uses to develop this product are the same. Don't know enough about the specifics but they're the same.

Q. Is this food grade canola?

A. We process our canola as it's intended to go to human use. This is solely for animal use and is processed in a safe way under all protocols and SOP's like we process any other canola but the destination will only be to the aquaculture market.

Gord Kurbis, Canada Grains Council

Canada's Pest Management Regulatory Agency (PMRA) is doing a good job but they have few resources. What happens if there are import restrictions in our main markets. Unfortunately, the risk is that things will get worse before they get better. As Canadians we've had an aggressive free trade agenda in the last few years. As we see free trade agreements place disciplines on trading partners on how tariffs can be used, the more we see tariff disciplines go down. The Canada Grains Council is setting forth a new domestic stewardship policy that's nearing final approval. The CGC's member organizations are very diverse and go across all crops. Our priority is to focus on systemic issues across all crops and all areas of the value chain such as chemistry and maximum residue levels (MRLs) and taking into account domestic policies which can result in higher level of profitability. Why does CGC focus on MRLs as a priority? Tariff related trade barriers are going down, exports are going up and new MRL notifications are going way up. This is not a food safety issue – that falls to the CFIA. Trade is getting more complicated with 294 free trade agreements as of January 2019 and a 3X rate of growth in global agricultural trade since 2000. Data from the Association of South East Asian Nations (ASEAN) shows that applied tariffs have decreased by roughly half while non-tariff measures have tripled. A NTM becomes a NTB when it is not based on science or used to protect domestic producers. Grain Trade Australia's survey shows NTMs by type with Sanitary & Phytosanitary at 61.1% ... 33.3% of represents plant health issues (disease, pests, weeds) and MRLs accounts for 36.4%. The CGC is a member of the International Grain Trade Coalition (IGTC) where 3 out of 6 focus areas of its policy advocacy deal with innovation and market access. More countries are moving away from Codex deferral of MRLs towards national lists of MRLs which means more missing MRLs. Residue testing is now more sensitive which means that you "can find anything in anything". In some cases, this is not a problem. India, for instance, now test for pest residues, has domestic compliance and have released a report.

Other countries are looking to the glyphosate lawsuits in the USA and the large awards. The EU is "marching everyone up to the cliff edge and threatening to push us off" as they will eliminate registrations for a number of chemistries that farmers will no longer be able to use. This has motivated governments around the world to approach the EU to notify them of the impact. The issue of MRL noncompliance hits many countries – presently there are 7 countries (with Korea now the 8th) that report publicly. When we talk about innovation and trade policy, we think that we can have innovation-friendly policies that approaches trade companies. The proportion of the zero tolerance (no MRL or default) is 87%. The max residue level is not a food safety issue –

the perception is if you exceed MRL you have a food safety problem – this is not true. Stewardship comes down to figuring out which crops, if commercialized, would be difficult to trade. CGC's value chain stewardship looks to standardization, provide predictability and the maximum amount of innovation. There is a policy for what goes into the recommendations. This has been approved by CropLife Canada and Western Grain Elevator Association and most national associations CCC and Pulse Canada and Cereals Canada. The CGC's Domestic MRL policy has a 3 step risk assessment and is transparent with the value chain showing clear direction for growers. To conclude – trade is very complicated with constant new risks. A value chain consensus policy on MRLs and responsible commercialization has been approved by most companies and is expected to be ready by this December.

Questions and Answers:

Q. Was there an insect shown on your slide of quinoa?

A. In Peru, they used to grow quinoa in the highlands where pest pressure was minor. As demands for quinoa got higher, they had to take it down in elevation and faced new pest pressures. They began using pesticides and had major trouble going into the US market.

Recap and Planning for the Future

Curtis Rempel, CCC Vice President, Crop Production and Innovation

IPM is using all the tools we have available to manage pests while reducing ecological footprint or environmental impact. Scouting and knowing what you have to manage in your field is important - speakers reiterated that. If you scout and find CR, you can find patches early, and you can remove the plants early to save inoculum pressure. Patches can be squared off and limed or planted into perennial grasses. If we are planting those patches to perennial grasses, incorporate a pollinator mix that wouldn't reproduce CR spores. Sanitation should be used to ensure no soil is sticking to equipment, and weeds should be controlled. Around volunteer management, the Green Bridge was interesting. How many volunteer plants do you need in the year following canola to keep your green bridge going? Maybe it's only a few, but it's worth thinking about.

Hairy canola is another way to equip the "toolbox" of innovation using IPM. It was learned that flea beetles do a "dance/shuffle" before feeding. If they're going to shuffle, is there something else we can do to interrupt the shuffle? What happens if you spray some white talc using a spreader, would it confuse the flea beetle enough to stop feeding? It's simple and complex to get hairy canola expression. With new tech like CRISPR there's an interesting future.

RNA interference for mosquito control and malaria abatement would be interesting and targeting flea beetles and sclerotinia reduction with the dsRNA was useful. Both agricultural applications have regulatory challenges and the scientists will be meeting to discuss them next week. This innovation is very specific to targeted pests and by mixing two different half doses to different RNA's, efficacy is increased, and resistance is decreased dramatically.

Part of the mandate is to look for threats. We know pollen beetle is present in Canada and has the potential to spread, and looking at the changing climate maps, we may be moving towards

a future situation where pollen beetle is a problem in canola production. It is very important to start monitoring for this pest in the future.

Regarding the importance of the “green bridge”, we’re supportive of perennial crops but if you have alfalfa, the aster yellow phytoplasma may be able to overwinter and transport the disease. In the past, aster yellows were present all the time when they were growing alfalfa. There may be something to the green bridge that we should pay attention to.

Pesticides are under significant pressure due to consumer fear, and biologicals may have to do some “heavy lifting” in the future. What is the MOA of these products, what will they do for us on the farm, what is the efficacy, what specific problems will they address, what are the negative results of using these products, and what will they look like?

It’s hard to quantify economic value of crop rotation. Looking at the steep adoption of canola between 2000-2010, this isn’t the entire story – there were other factors that played into this (such as convenience), and producers don’t monetize these factors in their mind. Scientists asked if you’d monetize the risks. But do growers monetize those risks into their mind? How can we effectively get a 3 or 4 year rotation established across the prairies?

Successful IPM is making a plan during the winter then executing the plan in the summer. The importance of understanding the green bridge and beneficial insects was brought home. Growers using fungicides more frequently had to use more and more insecticides to control insects, showing that the tactics used now may have implications 3-4 years down the road. Intercropping has enormous potential in the prairies and can develop rewards and risks for the future. Diversification adds resiliency to systems and in the long run, resiliency adds profitability. But when you add more crops to rotation, you also add more logistical challenges with marketing and storage, etc.

Why do we not have detections in wetland monitoring? What are we doing right? And when we do have detections, why do we?

Lastly, coordinated market approaches were discussed. Cargill, a core funder, has a committed relationship with not putting markets at risk. Finally, complications behind the pesticide stewardship story were discussed. Pesticide stewardship is a continued focus of our canola industry.

The next pillar is fertility and there is no shortage of topics to discuss on this.

CLUB Day 2019 Friday November 15, 2019

Creating, **L**earning, **U**nderstand and **B**ettering clubroot messaging research and extension.

Panel: Fengqun Yu - SK AAFC | Stephen Strelkov U of A | Scott Keller AB Farmer | Errin Willenborg FCL | Barb Ziesman SK Ministry Agriculture | Venkataramana Chapara NDSU | Shaan Tsai Canterra Seeds | Dilantha Fernando U of M | Dane Froese MB Agriculture | Dan Stanton - Farmer from MB and Pioneer seed dealer | Stephen Fox Canola Breeder DL Seeds

Topic 1: Deploying a Resistant Variety ahead of Clubroot (Dan Orchard)

Understanding the risks and challenges associated with using susceptible vs. resistant varieties.

When to deploy? Symptoms appear below ground long before above ground. The crop can still be green with CR.

Current messages:

- Deploy R-varieties before CR arrives
- Use R varieties if CR is in your community (CRE Steering Committee). The county size is discretionary and depends on the grower's accepted risk level.

Other countries do not have the same message and wait until CR is confirmed before using resistant varieties. They do not have good resistant varieties and not a wide range of resistance so there is a significant yield penalty and quality is not there, so products are difficult to market. In other countries, on smaller fields, it's also easier to find CR where they might see every plant i.e. cauliflower. This is not feasible on the prairies.

Surveys don't often find CR; it is farmers or agronomists who find it. Often heavily infested fields are first found in non-CR areas. The ability to detect CR early before it becomes a problem is the biggest drawback. The default is to just grow R varieties.

For those not growing R varieties, there may be an argument that you can use a susceptible variety if you have scouted crops, sent in soil samples and they tested negative, neighbors don't have CR, haven't heard of CR in community, and no outside traffic has entered field.

There are resistant varieties available with Brett Young, Dekalb, Proven, Cargill, Canterra, Pioneer, Corteva, BASF.

Topic 1 – When to deploy resistance (Panel discussion)

Clint Jurke - Moderator

Scott – We should absolutely be deploying resistance ahead of CR because of what Dan pointed out – we're terrible at scouting for it. Deploying once you see it is too late. By deploying it when you find it, you're pointing out your scouting is perfect and that's not even true.

Venkataramana – In North Dakota they're trying to collect over 100 samples from farmers to send to the lab. When seen in the soil samples it could be too late. Before getting the galls, they can detect it in the fields before seeing it in the fields. Suggested using R varieties. If you're in a C-W rotation, seeing spores before symptoms appear, that will be good for us.

Dane – 36 fields in MB with symptoms, 296 fields have it in areas spread over 30 municipalities. Most of the fields that tested positive for DNA are not symptomatic at this point. Staying proactive with resistant varieties is favourable.

Barb – In SK they suggest use resistant varieties early. It's a number game – probably much wider spread than what you see. The pathogen may be present in a field, but by using resistant varieties and rotating properly you can manage the disease. If we use R early but don't extend rotations, it won't be as effective - we need to marry or combine those two messages together.

Stephen S – Agrees with the other messages. If we wait to deploy resistance when there's already pathogens, you're essentially reducing the resistance strength because you're exposing it to that much more pathogen if you introduce it to a very infected field. We must work to keep ahead.

Dilantha – Agrees with deploying early. It's important that resistance is deployed in rotation. Need to study the pathogen more to see what ways it can break down resistance. Most of the time we can give the option of rotations in a crop but that may not happen in a farmer's field. Resistances are important.

Stephen F – If you put out a resistant hybrid you STILL have to do the same jobs. It all comes down to how you're going to manage the pathogen and how you're going to manage your resistance.

Shan – On paper it makes sense - if you don't have CR in the field, there's no pathogen to select for, and therefore minimal or zero risk for pathogen resistance to the technology. You can scout but still miss the pathogen. One potential solution is to accompany it by extending rotations and frequent and thorough scouting.

Erin – We all agree that deploying resistance early is important but we also need to agree that we have to make the message joined with the extended rotation. That is hard to make people listen to the rotation part.

Fegun – She met a farmer who was frustrated with CR, she asked if they grew R varieties, and they said they "should". Don't wait to use resistant varieties.

Q. We all agree using resistant cultivars early, but should we be using a 1st generation resistance, 2nd generation, stack some resistances?

Q. The cow is out of the barn – should we recommend resistant varieties?

Q. There are lots of acres in non-resistance varieties. What do we recommend?

A. Stephen S – If the field already has severe CR, planting non-R would be useless, the farmer has to proceed with caution because they should wait a few years before attempting again.

Q. Can we have different messaging for those who haven't had CR in their field versus those who have lots of CR? The different messaging is concerning.

Stephen F – It's there, you've been exposed to CR and you should treat it like that. Messaging should be across the board.

Dan S – maybe the message of the 2 year break is okay for those who have clean fields, but someone with lots of pathogen needs a different message.

Q. In many situations, deploying resistance early is important, but what would you recommend to a producer with high pathogen infection? Should we recommend using R varieties or are you risking breaking R pathotypes?

Scott – The message has been so ambiguous to farmers, that the variety list for the zones in areas with heavy incidence is that 10-20 % of the acres still aren't seeded to an R variety. Why aren't farmers in cautionary zones getting the message? We need to expand "community" to "the Prairies". Within 3-5 cycles of canola (6-10 years), resistance will break down if you introduce R varieties in an already-infected field without extending the rotation.

Dan Orchard – If the best management practice is to use R varieties, we need to strive with this.

Q./comments: Europe has been more reserved on using R varieties. CR is more of a soil borne problem and has limited means of disseminating it as opposed to the airborne types of diseases. There are 36 potentially virulent pathotype strains already out there. So how do you deploy- should you use 1st gen or 2nd gen? It's starting to get complicated at the farm level at this point. We should look at reduction of inoculum first before production of resistance. This will make resistance more effective and durable.

Murray – It's a different story in Europe - the EU probably has <1% of R CR varieties so we need to understand the reasoning there. And in Canada, we ideally would seed entirely R varieties but where are you putting these varieties 'strategically' - where is the most optimal place to have the resistance? Take into account what the CR intensity is in your area. It's ideally in areas that have already gotten CR.

Venkataramana – Are we forgetting pH range and what is the cut off range to cut off resistance? We've seen CR at pH 6.7 so far. But if producers had pH below 7, I would definitely suggest R varieties.

Barb – We need to be strategic if we have limited seed for R varieties. If farmers are already in an extended rotation, are in an area that is clean, we say hold off the R varieties. As far as pH,

they saw 4.5 pH in a patch, but the field entrance was pH of 8. This means you can't make recommendations based on pH.

Comment: There is the potential for dust dispersal. Looked at wind trajectories that moved into E AB and W SK, and checking for soil movement on equipment may not be enough. We may have a larger problem than we think. There is lots of potential with conventional tillage vs. zero till. Anything that moves the soil and disturbs it so that there are dust particles in the air is a risk. We may want to consider using R varieties even though you may think you don't have it in your area.

Errin – We need a very clear message. Every farm is different but today it needs to be a crisp clear message. Doesn't think the message should be "we should use susceptible varieties until it's ready".

Shan – Agrees with blanket approach with using R varieties. But have to keep in mind different farms have different priorities, such a BL. Not all varieties are created equal - S varieties may be S to CR but you have to also address other agronomic issues.

Dan S – Found CR on his farm last summer. He used conventional tillage and the locations were not necessarily at field entrances, so there was a lot of surprise still given the information that industry gave them. Moving forward, if you don't think you have CR you probably do you just haven't seen it yet. Use rotation, use R varieties. In his area, minimal tillage is not feasible. The R varieties are a no brainer. There are lots of non-R varieties but they'll yield very poorly when you get the problem.

Errin – "only YOU can prevent CR".

Fequn – "Don't wait or it will be too late".

Clint – Everyone recognizes that the goal is CR R on every acre. We don't have it on every acre in 2020 but the industry will be best served in the long term knowing this goal.

Barb – How do you tie rotation back into the message because it's often overlooked and extremely important?

Clint – Tying it back to the recipe, to control CR you need a recipe of management practices.

Stephen F – There are great tools but you have to use them properly. If you don't, we're going to lose them. We must rotate.

Comment: As an industry we need to collectively communicate the importance of integrated approach. Goal is to make every acre a CR R acre.

Q./comments: There's a message of deploying R early and being proactive. But what about those with really high spore levels? When should a producer go back and integrate an R variety?

Comment: It's an important part of protecting the R varieties.

Wording messages:

Don't wait it will be too late.

Only you can delay CR.

Deploy resistance early

Farm like you will lose resistance.

Comment: People are good at deploying resistance but not at stewarding resistance.

Dan (CCC) – Our message currently is to deploy CR R varieties when CR is in your community. And the panel discussed that we need to clarify this message better.

Clint (CCC) – So the message should be: Deploy CR R varieties as part of an IPM practice for the prairies.

Scott - Canola growers should deploy R varieties. Seed companies have been slow to produce R varieties but if they get the demand from producers, seed companies will figure out a way to fill the demand quickly.

Errin – in 5 years when all varieties have CR resistance, then we'd have to fill the demand.

Comment: We will need more buy-in by the growers.

Topic 2 – Naming of Varieties

Creating a consistent naming system and understanding the various sources/generations of resistance.

Naming Clubroot Resistant Hybrids (Leighton Blashko, BASF)

Sustainability is the key driver in managing clubroot. BASF wants growers to integrate an IPM plan on their farm, including the usage of clubroot resistant hybrids. Genetics are only one part of the strategy and can't be relied on as a single strategy. Recommended growing 1st generation clubroot resistant hybrids for 2 cycles OR until clubroot symptoms appear, then switching to 2nd generation resistant hybrids. In 2012 BASF first introduced InVigor L135C clubroot resistant canola. Their naming convention for "clubroot resistant" started with the letter C. Once they saw breakdown in hybrids, InVigor L234PC was available as their first 2nd generation clubroot resistant hybrid. First generation hybrids contain resistance genetics initially used to combat clubroot for InVigor hybrid canol. Second generation hybrids contain the same resistance genes

as the first generation, plus additional sources of resistance with multiple genes so they are effective against a wider range of pathotypes.

Clubroot Discovery Forum (Dan S, Corteva)

Management is key importance as a seed developer. If resistance breaks down there won't be anything left. Putting the same resistance gene in front of the same pathogen repeatedly is a recipe for breakdown but implementing IPM strategies is a key for managing clubroot. The goal of breeding is to stack genes for overlapping resistance that will prevent race shifts, giving the hybrid a good chance of maintaining low spore loads in the field. In the future the aim is to prevent virulence shifts. In Corteva they label their hybrids CR1 CR2 and CR3. It is important to deploy and rotate effective resistance and manage the spore load level to ensure virulence shifts do not occur.

New Panel Members: Rudolph Fredua-Agyeman U of A | Jed Christianson Bayer | Eric Gregory Brett Young Seeds | Igor Falak Corteva | Norm Boulet M.D. of Smoky River No. 130 | Yu Chen Cargill

Moderator: Gregory Sekulic

Scott – As a farmer and agronomist, he is confused listening to these presentations and makes a prediction that if a farmer hears “this is 1st gen clubroot resistant and this is 2nd Gen” then the seed companies are “fixing clubroot” and think “now I don't have to do anything on my farm, there are already new varieties to fix what I'm doing now”. If we don't know what pathotypes are on our farm, it creates a false sense of security. Scares people towards “new variety, new genetics, go towards this”.

Dilantha – Agrees with this statement. Make a strategy meaningful. Jumping to make a quick fix isn't going to work. We've learned from the BL situation to make simple language for the farmers on the labelling, but even that has challenges. He strongly cautions that getting to the “Clubroot Resistant” in a haste may not pay off in the long run, he has seen this in BL. It should be a cautious approach. We can learn by the ways we approached BL.

Jed – The information out there is confusing. There was a widely accepted nomenclature in BL resistant genes. Industry can understand what it means. With clubroot we don't have that nomenclature. If it's confusing for growers, it's confusing for genetic researchers as well.

Dilantha – PG2, PG3 and PG4 with BL is similar to what we have now with clubroot. It's a great initiative but it may be too premature to introduce it to full scale.

Dan S – If you have 36 things it's resistant to, it discourages rotation. Need to find a labelling system on how to differentiate things without making it look like the “best” product but making sure it's the most effective.

Eric – A couple years ago they added the “defender” platform and use it to ID newer and better products with disease resistance. Adding 1st gen, 2nd gen etc. is just adding another label which

will be more confusing to the grower. The only way we can explain this is by IDing the major genes in the product. There may not be enough diversity or understanding of the genes to try to describe the genes on the label for clubroot yet.

Gregory – Are we far too premature to even suggest consistent nomenclature across platforms?

Errin – When we look at the original resistance it's all resistant to pathotypes 2, 3, 5, 6, 8. Could we call that one thing like "R" or "base" and clump it into one thing?

Leighton – 2, 3, 5, 6, 8 have now become something else because it's a continually evolving thing. As a farmer you like to have linear thinking and simple steps to strategize your farm.

Scott – Would it be more useful in the message that farmers hear if the variety said how many pathotypes it was resistant to? Some genes are resistant to 5 out of known 36, and 2nd gen is 7 of 36, etc. Would that portray to the farmer that this is only a small piece of the problem? Want farmers to get more rotation and less adoption of R varieties.

Dan O – We need to rotate resistance, but we don't know the resistant source. We need people to understand how to rotate resistance but if there's not proper labelling for resistance, then it will be difficult to understand how to rotate.

Igor – Unfortunately, Scott's situation is a reality. There is a big issue and it's about rotations. Canola-Canola is not a rotation. We need to get into rotations. The genetics are getting to be more complex. How can we reconcile this as industry professionals?

Q: To add to what Dan was saying, if producers don't know what pathotype is in their field, how do they know what variety to be using? There is no commercial testing available. Is that something to look into in conjunction with labelling varieties?

Igor – There needs to be more research and investment to know what profile you have. It will be very helpful to match the elaborate pathotype table to what you have in your field.

Dan S – We know gen 1 is all the same and there is a lot of assumption that gen 2 is the same but we have 7 or 8 different types. Gen 2 has 8 different resistance sources compared to gen 1, so we need to get away from calling it gen 2. There's a lot of information about resistance rotations out there and you can't rotate gen 1 and gen 2.

Yu – Seed companies are still in the early stages. Need more pathotype ID. CR1 versus CR2 vs CR3 doesn't mean much to the grower, especially when you tell them to rotate. Later it will become easier to understand with the letter families with clubroot and rotations. Follow the BL gene route to be simple for growers

Q. A rotation should really be about crop rotation rather than genetic rotation because it gives you a false sense of security.

Greg – Rotation is not happening properly.

Errin – Propose that we should remove 2, 3, 5, 6, 8 labels and have it labelled as “base” resistance.

Dan O – Table this and work on it later.

Topic 3 – Using Various Sources/Generations of Resistance in Rotation

What is the most durable way to use the current sources and generations of resistance?

John Guelly (AB Canola) was added to panel.

Moderator: Rudolph Fredua-Agyeman

Rudolph – We only have a finite combination of resistance genes. If you look at the chromosomes of *B. rapa*, they’re named the same. By looking at the physical position of the genes, they’re basically the same gene. There are 5 resistant genes, called by different names by different groups just because they’re getting the resistant source from different species. We are likely dealing with the same source of resistance.

In 2003, there was no CR until we found the first case. There were 5 main pathotypes identified. Resistance was derived from *B. napus* cultivar “Mendel”. When we talk about Mendel resistance, it’s located in the bottom half of the A03 chromosome.

In 2013, there were more pathotypes found and second generation CR R cultivars were developed. The designation 5X was used because they didn’t know what it was. Some researchers used combinations of Mendel and Rutabaga resistance. It becomes very complicated if we try to label our hybrids based on pathotypes.

There has been a shift in pathotypes. In 2003, the predominant pathotype was 3H. Now it’s shifted to 3A followed by 3D with 3H accounting for 16% and 5X is less than 1%. Between 2012 and 2016, 11 new pathotypes were identified. With new ones found, there are now 36 pathotypes – 19 new ones. Even at the scientific level there is not consensus. Researchers and breeding companies need to be sure that we understand all of this and make it a little easier for farmers. Scott Keller had a successful story with resistance by rotating crops. What deployment strategy will bring the spore load down and what genes should be used?

Dan O. – This slide makes 3H look small and underrepresented even though it’s the most known pathotype.

Rudolph – If we grow Mendel cultivars, what pathotype is going to increase and what happens to spore loads?

Comment: You can't say that just because genes map to the same location it makes them the same. For example, R_{Lm4} and 7 are the same sequence position but they work differently. We don't have the research base to determine which genes are the same and which are different. It will be a really challenging discussion on spore loads because research is just starting to form.

Fegun – It's very hard to simplify Mendel or rutabaga resistance. CR resistance actually is derived from turnip "B. rapa". It's a turnip crossed with B. oleracea. Pathotypes 3,2,5,6,8 ... Genetics aside, they're still in the early stage compared to BL. CR is more complicated than BL but we are really behind compared to BL. In BL we can pick up single spore from a culture, but working with a CR single spore is very difficult. One gall can contain many different races. There is lots of research to be done.

Dan O – Ideally what controls the most pathotypes should be the most used. But we don't have the seed to do that for 1st gen, let alone this new thing with many pathotype resistances.

Dan S – Looking at situations of antibiotic resistance in people - it's caused by putting the same pressure on the same pathogens at the same time. We stack genes together because we're dealing with trillions of spores, but the key is to find where the differences lie in our genetics. If we can take new resistance and deploy it, we'll be in a better place.

Normand Boulet – We need to dumb it down completely. As a field man I need to talk to my farmers about how to manage the disease. We've already seen with two companies that there's a discrepancy in labelling, never mind introducing more companies into the picture. We should use the 4 R's – rotate crops first, then use resistant crops next, then rotation of resistance and then reduce spore load.

Q. We can all agree the 1st gen is applicable and easily understood. 2nd gen is significantly different than this and should be called "next gen" instead. Rotate your crops is really good advice. After two crops, you rotate to next gen resistance.

Clint – The pathogen is dynamic and works differently. When you have the infected root, you have many pathotypes. So what's better, to rotate from one source of resistance to another or should we stack resistance? What's the better approach?

Stephen F - If you get CR in your Gen 1 hybrid, and it's 3A dominant pathotype. If you wait a few years and grow canola again, it will still be the dominant pathotype. After a few years, it may be a different pathotype. Shouldn't be in a hurry to climb the resistance ladder.

Jed – On stacking, we are up to 36 pathotypes. Does CR have the capacity to generate new diversity? We don't know. If a gall has ~20 different pathotypes in it, and you stack genes

against this, does stacking help? Do we keep building? Does CR go through sexual recombination? We don't know yet.

Gary Peng – We're just starting to accumulate data on stacked genes. But the key factor is spore load. After 5 cycles of exposure to the same pathogen, you can see the start of resistance erosion. Stacked genes seem to delay that a little bit, but they've only done that a little bit. If you can reduce inoculation level by 100-fold, Mendel R genes will still hold well. So, holding R earlier at a lower level of pathogen, you run a lower risk of resistance erosion. He likes the gen separation style of naming – probably more practical.

Stephen S– Spore management is the key. So many things that work in a field fall apart with greater spore loads. Genetics are very important but they're just one factor and we lose the ability to control things as the situation comes out of control.

Venkataramana: CR has a half life of 4 years. If we mandate 4 years of resistant crop rotation – will that work?

Rudolph – It has been shown that after 2 years the pathogen goes down 90+%.

Dan O – Half life came from before they were able to detect viable spores. We need to abolish the 4-year term from our memories. 99% of the fields would be fine if we deploy the 4 R's. For the bulk of the prairies, following the 4 R's will work now. You need to use them until they're not working. 1st gen until you notice a problem or 2 cycles. We all know there will be exceptions and thus won't hold true. But it's rare. We need to stick to the message and strengthen rotation.

Dan S – 1st gen is risky to use because it's the most used. How about a resistant source – not gen 1 or 2.

Dan O – Some farmers aren't using it and would hate to remove it without trying this first.

Igor – When you see the problem it's too late.

Dan O – Need to work on extension messaging.

Summary on flip chart:

Deploy Gen 1 resistance

Reduce/Manage spore load

Rotate crop and extend rotation

Gen 1, then Gen next.

Topic 4 – Pathotyping and Naming Pathotypes

Is the Industry able to support a change in naming pathotypes, or are we already too familiar with the current system(s) to risk changes?

Pathotype Labeling of *Plasmodiophora brassicae* - Stephen Strelkov

Different forms of *P. brassicae* have been called races, pathotypes or strains. The terms are used interchangeably but they carry different connotations. Race, pathotype, and strain are often used interchangeably but are not exactly the same. Race implies the presence or absence of specific virulence/avirulence genes in the pathogen that interact with matching resistance genes in the host. Pathotype is a looser term than race. It's a phenotypic definition of a group when the genetic or molecular basis for the pathogen is unknown. The concept of pathotype fits well with the clubroot system. Strain is the loosest term. It implies that groups of a pathogen are different in some way and not necessarily defined by any agreed upon or consistent system. Numerous systems have been developed for clubroot pathotyping; in Europe it is the European Clubroot Differential, in North America it was Williams but now is the Canadian Clubroot Differential (CCD) set, and in Asia they use various systems, including Williams and some specific types for Chinese cabbage. In nearly all the systems, pathotypes are labelled with numbers – CCD is the sole exception. Unique virulence patterns are assigned different letters. If it's 3A, the 3 is from Williams, A from CCD. With new pathotypes, two letters were used to designate new virulence patterns after running out of single letters. Including both Williams and CCD designations on labels has pros and cons - pros include an immediate Williams pathotype designation, a link to the older system, and greater familiarity with combined labels. Cons are that this may imply a closer relationship between pathotypes, Williams isn't providing additional information, and overall provides confusion.

New people on panel = Rene Mabon from Brett Young

Moderator: John Guelly

Dan O - Do we need the number in front of the letters or not?

Leighton – To him, simplifying things and avoiding confusion is important. We need clarity. Suggest we move to CCD. We may need to shift once again. Mixing nomenclature is not helpful. People are using 2 systems without telling the farmer they're the same system. What does knowing the pathotype help the farmer?

Dan O – Understands that some of the labelling confused farmers. When 3 is the same as 3H and they list both, it gets confusing. Not being able to understand the difference between 3 and 3H is the source of confusion. Is there any international collaboration that would be lost by removing the number?

Stephen S– No, it's not a concern from a scientific perspective. It's more if it's causing confusion on a broad level in industry in a discussion like this about clubroot pathotypes.

Scott – Agrees that the number + letter combination is confusing. Why adopt more letters when we will run out of letters? Numbers can go on forever. Letter system will be confusing years from now and will likely lead to remaining in the future.

Stephen S – What is confusing in scientific level is that the older systems have all used numbers. Williams has used pathotype 3, and another has used a number 3 but it's not the same number 3.

Rene – Brett Young is one of the companies that has used 3 and 3A etc. and it reflects in the varieties brought into the market.

Dan S– Do we want an acreage threshold before adding to the CCD list? There's x minor pathotypes but y pathotypes that have more, and we need a designation for those with more.

Stephen S – Some of the pathotypes are rare and may be in specific fields nobody is working on, but it may just be tough luck for that field.

Dan O – if a farmer knows he has a letter in his field, he knows that's the pathotype from testing. If there's a letter assigned to your field somehow, and you sent a sample and know your pathotype, but your bag doesn't have the corresponding letters on it, then you're risking it.

Shaan – Leaning towards full CCD system. Majority of prairies are non-traditional CR areas, limited awareness on pathotype labelling system so new labels wouldn't phase them. However, in clubroot areas, labelling is more acute, and they would be influenced by treatments. There is a transition phase and at some point, they'll fully adopt the CDD, but awareness varies.

Eric – agrees with Shan. Awareness with farmers is low and even in retail community is also low. Do we categorize pathotypes in main groups and then sub-group in the future?

Stephen – There are lots of pathotypes, some are extremely rare, and some of this info is useful for farmers, but is maybe more important with breeders so they can prepare for this.

Erin – Absolutely keep it simple. What you want to call it in literature is whatever works, but what retail shares with farmers in the simplest way is the most important thing.

Fengqun– we're very busy on selection right now and have a selection of 1000 lines. Hopefully next year there will be results.

Dane – for ease of understanding we can make some form of formatting so that there is differentiation in letters (big 'a', little 'a', period or dashes between)

Murray – initially liked a number system.

Q. Alan Hampton - To keep it simple, why not call it Canada 1, Canada 2, Canada 3 etc.

Mary Ruth – Wanted to talk in favour of the number-letter system. It's useful to tie the letters back to the numbers. It's useful to know where it came back from.

Errin – is it useful for your academic perspective or from the farmer perspective?

Mary Ruth – it's easier to remember than a string of letter and especially now that we're getting into double letters.

Scott – What if we adopt CCD letter system and compare it varietal development with a serial number. What if we gave it a CCD letter we give it a variation but once it becomes a resistant variety the letter becomes a number? We know there's 8 pathotypes, so use those numbers and then use the letter to find out the background.

Igor - To avoid conflict around past systems, why not keep original 17 and start counting 18 and up moving forward. To kind of merge the problems while making it functional.

Stephen S – It's good to hear different perspectives and will take suggestions moving forward.

Stephen F – Your pathotyping bears no resemblance to what breeders are using. Which is a problem because you have large groups of things that can be grouped together but don't have the genetic material at your disposal. There is a huge disconnect because we can do it this way but it's difficult.

Stephen S – Long term this is good to think about.

Fengqun- suggested you stay consistent with 17 past pathotypes.

Discussion was tabled.

Topic 5 – Labelling Varieties According to Pathotype Naming

Should we be pushing for labelling bags (varieties) according to pathotype resistance?

New panel members added: **Yu Chen (Cargill) | Alan Hampton (Starland County) | Keith Kornelson (County of St. Paul)**

Moderator: Jed Christianson

In the early days all the growers needed to know was if the genetics worked - the resistance. But now we have 36 pathotypes to date and “alphabet soup” – tremendous diversity and multiple traits. The goal is to give farmers, agronomists, etc. the right information to decide what products to use on the farm. The desire is to keep it simple but there are huge areas of grey spots and unknowns that make it complicated. Even testing is not simple - there is a lot of variability involved. Just keeping up with pathotypes will be a struggle. What do we need to do to meet the goal of giving information to industry/growers to know what products to use?

Jed – So how should we go about labelling?

Yu Chen – Label resistant varieties. How can we verify what type of genes are on the bag to make it more understandable and transparent?

Alan – Labelling is definitely a good idea, but farmers at this point may not know what type of pathotypes they have. Is in agreement of labelling.

Dan S – Practically speaking, 36 pathotypes is just the tip of the iceberg. We need to know what the predominant pathotypes are and then make sure we're not putting everything into the same group. We want to have good rotation with the best genetics and make sure labelling isn't grouping everything together and limiting resistance. If we group the pathotypes it may turn into a "shiny new thing" for farmers and they'll want to stack over and over until they lose resistance.

Scott – It's one thing to communicate info, it's another to communicate it effectively. Farmers still don't understand CR and more information doesn't do any good if it just goes over their heads. With whatever system that we choose – farmers need to understand it completely.

Rene – Agrees that major predominant pathotypes should be ID'd and minor pathotypes can be grouped, but with varieties developed on previous systems, there will be a transition as you get to new naming systems.

Shaan – We are not quite at the place to ID genetic sources, so right now by labelling the pathotype we're doing the best we can. The more information to the grower the better so they can make informed decisions. The challenge is the proliferation of new pathotypes – we need to continue to test varieties.

Eric – The CEO of Amazon always has an extra chair at his meetings that sits empty that represents the customer. Customers are farmers and they want full disclosure. He acknowledges there are issues, pathotypes that may exist in a farmer's field that they may not know about – the goal is to know this information.

Clint – Need to provide information to producers. When next gen breaks down, we need some way of knowing the differences between resistance genes or sources so we can make more informed decisions about rotating.

Leighton – We don't have the information and it's a fundamental issue if we don't have the pure isolates or single spore isolates available. We're not able to provide full transparency on what they may be. He agree that this is a good goal to get to, and this would be considered in the future if the tech is available, however with single spore isolate not available, and using whatever nomenclature we decide, the goal is the farmer will use this info to pair with their field, but we know we don't have this information. It can provide a false sense of security to provide partial information.

Scott – Is it because we can't know 100% of the pathotypes we could be resistant to that we don't want to disclose the 3, 4, 5 that we know it is resistant to?

Leighton – Yes, the clarity just isn't there. Even in a small plot, you could have variation giving you different results within a trial.

Keith – We're working on something in the county in AB to find out what is prevalent in our area. It's a 3 year program and it's assumed it's the same pathotype. Farmers are already asking what race is there. Even if it's confusing at first, it's okay because it makes a farmer ask questions and that is healthy to do moving forward.

Leighton – I'm asked by farmers sometimes "do you control 3A" and they say the information they have is that they tested the hybrid and what they're told is 3A. The language is grey on purpose. It's a cautious approach and he has to remind every group of farmers that walks up and says "I have 3A", that they may have 3A but they may have other pathotypes than just the one that has been ID'd. They take the simplest approach and may not understand it fully.

Dan O – The CCC guidelines state that R strains need to be resistant to 2, 3, 5, 6, 8. So if we use the same approach for the new pathotypes which is in the WCC guidelines about what classifies resistance. For a tool that the farmer can use, we need to address the most predominant pathotype. Perhaps coloured coding?

Clint – The purpose of Club Day is to set a direction on how we want industry to communicate with producers. We don't have a complete picture as to how plant varieties and pathogens interact but we need to work together towards this – to get information out to producers.

Jed – We are coming to a broad consensus. But if you do 2 experiments that show your products are R then a third experiment doesn't, what do you want to say about your product? 36 pathotypes – should we test against all of them? Or just the ones that are found at 5-10% frequency?

Barb – Are we monitoring/scouting in a way that allows us to determine what the predominant pathotypes are? There are limitations in pathotyping – we should not shy away but explain to growers the limitations.

Leighton – If it were to come down to a liability, we're taking a caution approach in case they make a claim that isn't true. We probably have the same goals, but it's a risk tolerance.

Comment to Clint and Leighton: Farmers need to understand that R will fail – it is not a silver bullet and this message isn't clearly communicated. When talking about 3 and 4 R's, you need to add responsibility in there. It means stewardship and without this, R will fail.

Dan S – As industry moves towards 100% adoption of R hybrids, you need to strike a balance where you have IPM. Concerned some people will say it's resistant to these pathotypes and

then grow it over and over. Need to make sure that labelling system encourages rotation between varieties. Intermediate resistance (5x) got sales in the market. We don't want this advertisement to be the only thing producers rely on – we want to make sure there is IPM and reliability.

John Guelly – Hopefully someday we can send soil into the lab and be able to test pathotypes and re-evaluate yearly. But currently the more transparent we are, the better off we are for the industry.

Dan S – Pathotyping will give growers a false sense of security. If you test pathotypes before you find the patch and it's too late, it's not a valid solution. Rotations are key.

Dan O – The theme seems to be that people want to understand what's in the bag, especially farmers, agronomists, retail. Whether or not it's in the field, they just want to know what's in the bag so they can rotate their bags. Ultimately the goal will be that everything is fully labelled.

Topic 6 – Understanding Soil Sampling

Understanding the benefits and challenges associated with this valuable tool.

Moderator: Murray Hartman

Dane Froese MB Agric. | Yu Chen Cargill | Alan Hampton Starland County | Norm Boulet M.D. of Smoky River No. 130 | Venkataramana Chapara NDSU | Barb Ziesman Sk Govt. | Mary Ruth McDonald U of Guelph | Terry McIntee SGS-Biovision | Kim Kenward 20/20 Seed Labs Inc | Grant Woronuk Quantum Genetix SK | Keith Kornelson County of St. Paul

Soil sampling has some limitations because it can test negative even if there are pathotypes in the field, so producers continue to plant susceptible varieties. Is the soil sampling for research or for regulatory? From the standpoint of field sample collection – how many spots in the field should be taken, how many samples per spot, what is the timing, what is the volume of material, how many of those factors do you need to justify whatever your purpose is? We're under-sampling individual plots. Do researchers have the same protocols, so the results are comparable? The need for presence/absence of disease, versus number of spores is a good discussion to have. How comfortable will you be with saying that 10,000 spores are the limit? It could be plus/minus 5000 spores, what are the true limits? And there is variability in the field in addition?

Barb – There are different protocols and advice. Multiple individual samples (MIS) versus multiple subsamples that go into individual samples. MIS is better because you don't get the risk of multiple mini samples when you dilute the samples with others. Field will be classified as high risk (low spots, field entrances, water runs). Collecting 5 sub samples in the high-risk areas.

Alan – How reliable is soil testing? We know it can be in a tiny patch over here but not elsewhere. Would be better served to just test the clubroot plants?

Dan O – The most reliable source if you think you have clubroot is to pull the plant, the plant is the first to show it. Second most reliable is to pull tissue from the plant. Third is soil testing. There is variation between labs, some may say 20,000 spores and the next may say 40,000 and that may seem vastly different but they're not that different if you figure out how they got the numbers (subsamples versus individual samples). Sample affect future farm management, sanitization, oil and gas exploration, research plots.

Norm – From a qualitative point of view, he has faith. Important to hit big spots like the field entrance or other areas of concern. As long as you're down to 1000 spores/gram, it's positive. Quantitatively speaking, no faith.

Murray – If you have low levels of clubroot, and dilute it with soils, you lose the big effect.

Terry – Testing plant tissue is the best because it's easiest for labs. This also causes the same issue in the field because spores are from rotting roots. If you stick a core through the rotten root in the field, you get a great result. But 3 feet away you may get nothing in the soil.

Murray - It's the small-scale things that are a concern for researchers because you could miss the clubroot.

Terry – Is not finding huge spore counts.

Murray – Is there a difference between labs for numbers on soil spores?

Kim – According to literature it was 10^5 . They can test 10^3 (which isn't enough to cause disease). With qPCR in a clean spore solution with dilution curve and you're extracting that at different concentrations, you can do 10^3 but soil samples have errors. We don't typically see these 10 billion spores, mostly 10^6 and 10^7 . There's still distance in detection ability. We know we can detect more, but we're not seeing it in the samples. We're seeing it 10^7 on average.

Dan O – When someone runs into a dead patch people don't need to see tests to confirm, so that's why you aren't seeing 10B. 10^5 is an alarm because these areas aren't supposed to be so high in your area. 10,000-80,000 you may not know what to do with it. But higher numbers of spores are obvious in the field.

Barb – In SK they use it in surveys for detection. A positive is a positive, but neg is not necessarily a neg. Recommended using a GPS point to take soil samples from the exact same patch at the exact same time of the year. Numbers sometimes just give a value of performance.

Dane – What we're looking for in MB is that they're trying to find clubroot. He wants to be able to report to the farmer if they have a problem or not. They only have 36 symptomatic fields they're aware of. Producers aren't aware they have a problem until they get confirmation. If a soil test is what it takes to have confirmation, that may help.

Grant – The priority is on sampling hot spots for clubroot. When talking to farmers it's a difficult conversation. What does 10,000 spores mean? But just having **any** positive is a more actionable result and spore counts can be considered more for just trends and monitoring your field.

Terry - Spore number is a tool, it's not proof, but it tells you if you're doing a good job or a bad job. Could be very helpful for some and their management decisions.

Keith – A producer grew canola where he shouldn't have. County sought a court order to spray out the field and asked for a soil sample. The soil sample had visible galls, but the soil sample quantitative test was negative. The qualitative test was positive. So, the court situation was complicated because they had to explain the differences of this in court.

Mary Ruth – If someone is growing canola in the field with clubroot, if you disc it up or just spray it with herbicide, you're just returning it to the soil. 2-3 weeks of growth already has many spores.

Venkataramana – We need to walk in a W or X pattern to collect soil samples. How far in should we walk in?

Murray – Similar to regular soil sampling, except adjusted to be near the entrance. You follow the pattern but all ten don't have to be in the W pattern, you can identify 7-8 and then add some other strategic samples in low spots etc.

Yu – In terms of yield trial experiments, we are trying to avoid hot spots, low/high pressures of clubroot that will impact yield. We go to the hot spots for sampling. 6-7 samples are taken.

Barb – There's a federal level committee called surveillance working group. They picked 3 different pests to work on. Looking for anyone involved in clubroot surveillance, industry researchers and soil labs. Looking at sampling methods, in-field methods, etc.

Murray – Samples from seed cleaning and dust bins could be taken to determine if clubroot could be in that region or not, and avoid pointing fingers.

Don O – Or air filters on equipment.

Norm – Then you'd point the finger unless you were custom operator. Downwind of elevators could be another place to test.

Murray – What are the repercussions on the seed cleaning plant then. Once the seed was cleaned, the pathogen was cleaned out. But it's the dust bins etc that could be areas of risk.

Grant – Some value at the farm level if you can determine what amount of disease you have in your field.

Kim – Quantitative test results are reported in 3 ranges in the orders or magnitude that it's there. The degree of accuracy decreases with more concentration - there's variability with high spore tests.

Mary Ruth – It's fine because once you are 1M and above, you know you have it.

Murray – But if it's 10M in one lab and then do the recommended two sets of rotation and then send it to another lab that reads 2M, you may think you're improving, but it may be inaccurate.

Terry – We keep finding more because tests are becoming more sensitive.

Sheila – There needs to be a consistent protocol, so before looking at med high and low, we need to solve this first.

Q. Guo Xiaowei - We touched on reliability of some testing, qPCR and PCR are sensitive enough. There may be a problem with your soil sampling or sub sampling... With so many factors at play how can you end up without a false negative? How can you make the samples represent your whole field? The soil sampling in itself is full of variability. We need to standardize one protocol between MB, SK, and AB.

Dr. Peng – With qPCR, many have been adapted from Steve's protocol.

Bruce – The best soil sampling technique is just looking at the plants.

Dr. Peng – There is a thin layer of pathogen all across the prairies. Just because you test negative doesn't mean it's not there.

Murray – Are there differences contributing to differences on how we read results? Can we figure out how to report low medium and high levels?

Don O – There is a lack of knowledge and extension out there. We can discuss these topics at length, but the producers are not here to listen to it. And now it's important moving forward to develop better extension material and messaging around this to make sure they understand. We don't understand many things so it's important to discuss this in the future.