2015 Canola Discovery Forum
Meeting Proceedings
Coast Canmore Hotel & Conference Centre Canmore, Alberta
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WELCOME AND INTRODUCTION

Meeting Chair: Brian Chorney, Secretary, Manitoba Canola Growers Association; Director, Canola Council of Canada

The Canola Discovery Forum is an important part of our research program and provides an opportunity to ensure that the canola industry understands the issues limiting canola's potential. It is an opportunity to exchange ideas and to coordinate both industry and research to reach canola's potential. It is a chance to talk about the research needed to increase yield, profitability and sustainability. Important to increasing productivity and profitability are the Canola Council of Canada's (CCC) utilization and crop production pillars, crop establishment, integrated pest management fertility and harvest management along with research and big data. This is also an opportunity to help farmers understand big data: to determine which big data is relevant and how it can be used. It is important to come up with the right variable rate prescription and to have a well-researched approach to using the data correctly. There is no average year, just a mix of extremes; for successful crop production there is a need for researchers and technology to figure out how to best deal with the extremes.

GROWER DIRECTED RESEARCH AND VALUE ADDED

Daryl Tuck, Region 4 Director, Alberta Canola Producers Commission

Alberta Canola Producers Commission (ACPC) has an Agronomic Research Committee that focuses on crop production and a Market Development and Promotion Committee that deals with research concerning new uses and products from canola seed, oil and meal. ACPC looks for projects that fit three basic goals: better ways to grow canola, better ways to provide pest control, or ways to increase demand for canola. With the government support of agriculture on the decline over the past decade, grower directed research is even more important today. The forum is a great way to review completed research and to explore new ideas for future work between growers and industry.

Wayne Truman, Director, SaskCanola

The Canola Discovery Forum helps bridge the knowledge transfer gap between research and industry and extends the research that producers and industry have invested in. Research is vital to the growth of the agriculture industry. Since 1991, SaskCanola has funded over 315 research projects related to agronomy, disease, best management practices and utilization of canola oil and meal. Examples of funded research projects include: Ecology and Swede Midge Host-Plant Interaction; Germination Effectiveness: Understanding the Role Dormancy plays in Canola Seed, Seed Vigour and Stand Establishment; Integrated Approach to Flea Beetle control: Economic Thresholds, Prediction Models, Landscape Effects, and Natural Enemies; Understanding the Mechanism for Race Specific and Non-Specific Resistance for Effective Use Of Cultivar Resistance against Blackleg in Canola in Western Canada and Characterization of New Strains of Clubroot Pathogen in Alberta.

Canola has the amazing ability to come back from adverse conditions. The importance of stopping the practice of consistently spraying just one herbicide was noted, as was the importance of controlling volunteers before seeding; the need to continually scout fields and the need to keep safety in mind.

“PLANT ESTABLISHMENT” PILLAR PANEL
Overview and Best Management Practices
Justine Cornelsen, Agronomy Specialist, Alberta South, Canola Council of Canada
How will canola stand establishment get to the level of “plant one to get one?” Two of the biggest limiting factors for stand establishment in 2015 were moisture and machines. There are five CCC crop production pillars to reach the industry supported goal of 52 bushels/acre by 2025 and these are: genetics; plant establishment; fertility management, IPM and harvest management. The goal is to get an extra 3 bushels/acre in plant establishment. A poll conducted in the *Canola Watch* asked growers to identify the biggest reasons for poor establishment: moisture and early frost were given as the top two reasons, with flea beetle pressure a close third, followed by seeding machine error. Weather cannot be controlled, but seeding practices can. **Key messaging** for plant establishment is to start strong: target a uniform 7-10 plants/square foot stand, seed shallow ½ - 1 inch, seed slow and into warm soils of 8-10 degrees, check the integrity of seeding tools, ensure fields are cleared of weeds early, and know your herbicide residue risk.

Soil Moisture Trumps All Factors for Good Stand Establishment
Dr. Neil Harker, Research Scientist, Weed Ecology and Crop Management, Agriculture and Agri-Food Canada
Why worry about emergence? Optimal emergence relates to optimal yields and profits, buffers against frost and flea beetle damage, reduces the necessity for a second in-crop herbicide application (cost and weed resistance management point of view), leads to earlier and more uniform maturity, better seed quality (less green seed), lowers harvest losses and mitigates against negative coffee talk shop. There is a need to worry about emergence.

AAFC research scientist Julia Leeson’s survey of canola plant stands in the Prairies revealed that many are not reaching the target of 7-10 plants/square foot: over 30% of growers had less than 4 plants/square foot. Five plants is the minimum number to achieve full yield potential, with a variability that ranges from 80 – 100% of possible yield.

Managing residues before the season starts can have a huge impact. Planting enough seed is the most obvious solution to poor plant establishment. Normal is 5 lbs of seed per acre with a 5 gram per thousand seed. Emergence can vary from 50% to as high as 98% in the case of hand-planted and irrigated conditions. Seeding is not cheap. Although both are important, depth is more important than speed for planting. Go slow and shallow.Too much urea in the seed row also negatively impacts emergence.

Does bigger seed have an effect on emergence? Year one of a study that looked at 9 sites using 4 different seed sizes and 2 different rates showed that there was no emergence or yield effect from bigger seed, but there were shorter days to flowering, shorter flowering periods and more biomass. The following two years of the study looked at 5 seeding rates and 2 seeds sizes. Rates of 50, 100 and 150 seeds showed bigger seed resulted in more plants/square foot. The most noticeable observation was that larger seeds were better able to handle stress with all three seeding rates. Under severe conditions, deeper seeding helped.

Soil Conditions and Secondary Dormancy
Dr. Sally Vail, Research Scientist, Oilseed Breeding Agriculture and Agri-Food Canada
Seed dormancy is when viable seed should germinate under ideal moisture and temperature conditions, but it does not. What role might dormancy play in stand establishment? Is the seed being exposed to conditions that could trigger dormancy and can this affect stand establishment?

Seed vigour is the measure of germination speed and biomass accumulation prior to emergence, two very different physiological processes. It is possible that germination speed is linked to dormancy, according to some work done in Germany. Dormancy in canola can be caused by endogenous factors (conditions within the embryo), exogenous (conditions outside of the embryo), or a combination of both. Physiological maturity is reached when the seed is ready to germinate. This happens before harvest maturity.

Primary dormancy occurs while the seed is still on the plant and it is selected for because it prevents germination while still on the plant (vavipary), or pre-harvest sprouting. Secondary dormancy occurs only with mature seeds. The seed is ready to germinate, but may be exposed to stress (temperature, moisture, lack of oxygen) that induces dormancy. This can be triggered by abiotic factors such as seed age or genotype. In canola, larger seeds have a higher dormancy potential. Genotype is the largest contributor to the amount of secondary dormancy observed. There is also higher dormancy potential and a wider range of dormancy potential seen in spring types of oilseed rape. This is a multigenic, complex trait, making it difficult to characterize phenotypically. It is possible that selection against vavipary has created an inadvertent bottleneck. The use of Nested Association Mapping Population (NAM) of Spring *Brassica napus*, can hopefully demonstrate if seed biology contributes to dormancy potential, genome sequencing is important.

The **take home message** is that secondary dormancy is problematic and is possibly related to seed vigour and longevity related traits. Dormancy and establishment traits are very complex and NAM may be the best platform to investigate and advance an understanding of this to offer practical outcomes.

The Relationship Between Seeding Tools and Stand Establishment
Craig Shaw, Grower, Durango Farms
Are canola seeding tools the key to good stand establishment? Good discovery creates more questions. The use of vacuum planters as a possible alternative to standard air drill technology was investigated. A 12' Monosem vacuum planter was tested in farm trials for three years looking at both seeding rates and row spacing. It highlighted issues with current seeding technology and identified certain issues with using planters in broad acre applications. It was found that precision planting needs to be accompanied by a good growing environment.

Seeding technology in Western Canada is likely more focused on logistics than precision, and ½" depth is a very precise target. The greater the demands of the equipment in terms of variety of rates and sizes of seed, the more difficult it is to get precision. The current shortfalls in most seeding tools relate to the delivery system: the amount of air at the opener, airflow and seed distribution from row to row, consistency in seeding depth across the tool, metering for size and speed, singulation, and changing crop types. The planter systems for Western Canada are not designed for one-pass seeding, are better suited for row crops, are able to seed different size crops, there are more moving parts requiring more maintenance, they generally require modifications to handle canola, plugging of vacuum plates, and ability to maintain moisture at seed depth. Planter benefits include: a more consistent depth, the ability to singulate and better adapted to residue control.

Findings from the study showed that 12" spacing using the planter gave nice uniformity. Other observations from the study were inconsistency of seed size, with variation often over 3g difference between the large and small seeds in a bag; TKW was consistently off; it was normal to find 1lb of fines in a 50lb bag of canola (causing plugged holes of vacuum plates). Lower seeding rates need a good seed environment; higher mortality was seen with higher rates and reduced stubble counts compared to emergence seen at higher seeding rates. Issues included varying soil firmness and timeliness of seeding. A level seedbed and residue management is

needed. There is likely no yield penalty for row spacing up to 20". Wider rows means the plants are closer together at the same seeding rate.

Setting a Drill for Success

Owen Kinch, Field Research Manager, SeedMaster

There is usually only 40-60% seed survival under normal conditions. In a survey of 65 farms conducted over 3 years, the average survival was 66% with the SeedMaster Ultra Pro versus 57% with Bulk Delivery. The average seeding rate was 3.88 lbs/ac, average plant population was 5.57/square foot, and the average seed weight was 4.68 gm/thousand seeds (TKW). Know the plant count; most growers do not know their plant population. Tips to achieve better emergence include: seed at a consistent shallow depth (¾" below packed surface), seed slower (preventing rear openers from throwing soil over front rows), limit seed-placed fertilizer to liquid form only with the seed (granular phosphate requires a higher fan speed which can compromise seed placement), reduce packing to limit crusting in wet conditions, and pack more in dry conditions to conserve moisture (auto-adjust packing pressure is a tool), ensure seeding is done into warm soils, post style openers leaves a black strip for absorbing sun's radiation, and base seeding rate on weight and anticipated seed survival.

Plant Establishment Questions and Answers

Q. It seemed like reseeded acres this year had better success, and most likely were not seeded slow and shallow: Why were the reseeded acres experiencing 80% germination versus 50-60% for the single seeded acres?

> **A:** Neil Harker suggested moisture as a factor in increased germination.
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> **A:** Dan Orchard thought conditions actually got drier and thought temperature or fertilizer with the seed, or a combination of both may have had an effect on seed survival.
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> **A:** Owen Kinch agreed temperature may have a major impact on seed survival: customers in Australia are achieving higher seed survival, and the only difference seems to be that they are coming out of the really hot summer and seeding into the winter. The soil temperature is a lot higher at seeding time.
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> **A:** Dan Orchard commented that because planters are blackening up the soil, it leads to higher survivability because the soil is warmer. Perhaps one of the biggest factors influencing survivability is temperature. If planters are getting 80% plus survivability, they must be warming up the soil or clearing away the straw much better. The biggest advantage to a planter is opening up this blackened area, maybe black soil is the key?
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> **A:** Craig Shaw stated that they got to the stage of saying temperature is critical to canola, so they work the canola ground ahead in the fall and get it black. It does increase the risk factor to flea beetles, but the temperature to keep the plant growing is a huge bonus because if the plant is growing it at least has some resiliency against flea beetles. It is producing bigger leaves and has a chance to get ahead of that critical point. Influencing the environment provides the ability to manage risk better. The more variables that can be controlled, the more seeding rates can be brought down and still maintain optimal yields.

Q: Is it time to ask seed companies to provide "seeds per bag" instead of pounds?

> **A:** Craig Shaw said this one of the things that was looked at with planters. Bigger seed has a better chance to be placed at the right depth. If uniform seed placement in the ideal location can be maintained, then maybe everyone will want to go for the smaller seed. It would be good to see more uniformity with seed size in a bag. A number of varieties were looked at and all of them had a consistent amount of variation in seed size.

Q: As row spacing widened from 16 to 20", was there more of a challenge with weed control in between the rows with the less dense population?

> **A:** Craig Shaw commented that weed control was not a huge issue. There was a noticeable difference in canopy closure in the first year. There was consistently a week's

difference between the widths- so the 12's would get canopy closure, then a week later, the 18's, then a week later, the 24's. It was all relative to when there was weed emergence. There was manipulating of seeding rates because as the rows got wider, the seeds were placed closer.

A: Neil Harker added that with wider rows there is more light so weeds can thrive better, but with wider the rows, there is less disturbance, and disturbance also increases weed germination. So it kind of goes both ways, and depending on the year, one thing will be better than another.

Q: How do you put your fertilizer down and what is your fertility program with a planter?

Q: Also, what is the additional time required to seed with a planter versus a drill, including the time to filter the fines?

A: There are a number of planters in Central Alberta, but people usually use their normal seeding tools to apply their fertilizer; some are putting liquid in their planter. In terms of efficiency, planters and seeders are pretty comparable.

Q: There has been a lot of talk about air velocity at the opener. Does SeedMaster have any experience with air brakes at the opener?

A: Owen Kinch reported that SeedMaster is in the development stage of a new plot drill design. It takes 4 hoses from 4 individual tanks, and one of the challenges with the project is not supplying four times the air to the opener which brings in the air brake component. A lot comes down to convenience and time management. They are finicky and need adjustments and with over 80 air openers, there is merit in it, but it would be tough to convince growers to slow down and make the appropriate changes.

A: With the disc drill, there are actually two types of seed brakes used: Dutch at the opener, and also there is a CPU system at the manifold. The idea was to get back to gravity feed, but it is hard to adjust, and it seems that there is still a need for some air flow. There are plugging issues with larger seed.

Q: Are there any comments regarding the findings of the SaskCanola funded research project that looked at the UltraPro roller versus the conventional roller.
They are available online at www.SaskCanola.com.

A: The study will need to be reviewed.

"FERTILIZER MANAGEMENT" PILLAR PANEL

Overview and Best Management Practices

Warren Ward, Agronomy Specialist, Southeast Saskatchewan, Canola Council of Canada

Fertility management plays a role in reaching the goal of 52 bushels/acre by 2025. The target is to increase yields by 3 bushels/acre through fertility management. In 2015, there was a pretty good balance between nutrients applied and nutrient uptake, both in micro- and macro-nutrients. A survey done shows the need to increase information regarding fertility management. There is a need to take a closer look at which products are necessary, for further testing on products for efficacy, and sustainability, on N\nitrogen-use efficiency, as well as on the economics of increasing fertilizer rates and yield profitability on the farm. There is a need to continue to encourage proper soil sampling.

Developing Fertilizer Recommendations for Canola

Dr. Ross Mackenzie, Ag Consultant, Mackenzie Ag Consulting

Soil testing is the basis for creating fertility recommendations. Based on target yields, one needs to know how much nutrients the soil provides and how much you need to provide. Develop soil recommendations from there. Soil provides nutrients after the cotyledon stage, and canola has high nitrogen, phosphorous, potassium, and sulfur requirements from cotyledon to bolting. Only 10% of growers actually soil test which is concerning. Soil sampling should be done in incremental depths, and take into account variances in topography. The Modified Kelowna method is used for Alberta and Saskatchewan and Olsen (Bicarb) method is used in Manitoba

(Bray-1 is the calculation for the US). Make sure the right method of soil testing is used for your area. It is important to always ask for various opinions regarding how and when to apply the necessary nutrients, and which forms are best. Use soil testing to determine nutrient needs for each field.

For nitrogen, two main things to consider are the mineralization rate and the soil tested nitrogen level. Mineralization rate can be challenging to determine. Losses can occur due to volatilization, denitrification, immobilization and leaching. Source and placement of fertilizer is very important. For example, urea is good in soil, but converts to ammonia and can be lost if broadcasted on the surface.

Economics need to be taken into consideration when calculating the required amount of fertilizer to reach yield targets. Crop target field and local N fertilizer response information can be used to determine N fertilizer rates. Application rates can be determined based upon the economics of yield and inputs.

There are options for nitrogen application: Mid-row or side-band N at seeding using urea or urea/ESN blend; band nitrogen in the fall at soil temperatures above 5 degrees (N must remain in NH4+ form over the winter to minimize losses, ESN can be used to avoid this) (70% uptake); band N in the early spring, broadcast 46-0-0 just before or after seeding (this can be very inefficient and depends on rain to move fertilizer into the soil. Do not broadcast ESN); or in-crop using 28-0-0 (20-30% efficiency). The least efficient choice is foliar N applications with only around 5% uptake via leaves and potentially causing leaf burn (at >20lbs N). ESN (Environmentally Smart Nitrogen) is a polymer coated urea fertilizer that will release over a 10-60 day period. There needs to be ongoing field research to maintain up-to-date N fertilizer response information and farmers need that field research information to fine-tune N fertilizer application time, form, rate and placement.

For phosphorous (P) nutrition, one first needs to determine the soil P available to the plants using the Modified Kelowna test in Alberta and Saskatchewan and the Olson BiCarbonate method in Manitoba. Bray-1 and Mehlich-3 are not recommended. Seed-placed P is important because it allows for good uptake. If more P is needed than what is safe in the seed-row, it needs to be side-banded or placed elsewhere for good uptake. Currently, there are good P recommendations for dark brown soil zones which will eventually have to be updated. Phosphorous soil test has been declining in recent years and as canola yields increase, P requirements will also increase. This will have to be looked at in the future.

There are good levels of potassium in the soil, but it is slowly declining as well. Are current recommendations for potassium going to be enough down the road?

The boron soil test is not reliable, with one-third of tests showing low to marginal B levels, and yet canola does not respond to B application. Soil recommendations for B are inadequate.

Canola responds well to applied N, P, K, and S when soil tests are marginal or deficient. Nitrogen is almost always deficient, and recommendations are needed for placing high N rates. Phosphorous and sulfur frequently are frequently deficient, and potassium is on occasion. Boron deficiency is unknown. There is a need to do more work and updating on recommendations.

Variable Rate Musings from the Canadian Prairies
Terry Aberhart, Grower - Aberhart Farms; Agri-Coach and Owner- Sure Growth Technologies Inc.
A lot of information is available concerning variable rates, but it is overwhelming. Using our farm as an example, there has been a $7/acre input reduction and a $28/acre economic benefit from

increased yield using VR technology for a $35/acre net. There has been a decrease in the variation of yield between zones and a saving of nutrients when using variable rate compared to using a flat rate application. Wheat trials on the farm showed that VR technology resulted in the highest yields using the least amount of nitrogen. Also, increased disease rates were seen with high rates of nitrogen. There is a dramatic difference in net return to the farmer. A canola trial resulted in a gain of an extra 9 bushels/acre using the same overall pounds in a variable rate method as compared to the flat rate method. Some of the fields were left with $30-40/acre of residual nitrogen not utilized and variable rate application over time balanced this out. Why fertilize the high producing areas of the field the same as the low producing areas?

Some growers use the two zone approach to VR technology: splitting the area into high and low zones. Low areas usually are lower producing than high areas. Vegetative index does not necessarily indicate yield. Some growers opt to use sector audit correlations.

There is no one way to approach variable rate programs, but proper zones are needed. Growers that successfully use variable rate are seeing more uniform maturity, less straw, higher yields, and increased efficiency with harvest, inputs, and equipment.

Fertilizer Management Questions and Answers

Q: Can too much ESN be put in the seed row?

> **A:** Ross Mackenzie commented that quite a bit a work has been done with ESN and rates as high as 100 lbs/ac have been applied without experiencing any damage, but are not recommended. One could certainly go to about 60 lbs/ac of seed-placed ESN; however, P and S requirements need to be considered. The nice thing about ESN is that it releases slowly, so a lot more can be put on with the seed.

Q: What tools are used to create zone maps?

> **A:** Terry Aberhart commented that creating zones is a challenge for producers. After personally trying out different programs, electro-conductivity (EC) data was the most successful. It needs to be interpreted properly, and then combined with elevation and yield to define zones. Due to cost, the Power Zone product from Agritrend is used. It is a combination of multiple years of satellite imagery, and is very accurate, and much cheaper. It was found that creating zones with satellite imagery and higher resolution imagery was inconsistent due to working with single year data and being unable to tell if the higher vegetation is affected by weeds or equipment error. It is very important to use as many layers of data as possible, and use what makes sense for your operation.

Q: Because ESN releases more slowly and costs more, a lot of growers are decreasing the amount of N and thinking that it will be the same bang for the buck. Does that make sense?

> **A:** Ross Mackenzie commented that it really depends on how much fertilizer the farmer is using; ESN can improve efficiency, so perhaps N could be cut back overall if there is a potential for loss. It could be looked at the other way: putting on some N as urea during the growing season and some as ESN. Be cautious about cutting back, though. There are different types of slow release N: Type 1 releases in 20 days, Type 2 in 40 days, and Type 3 in 60 days. ESN is between Types 1 and 2, so perhaps in the future there could be a move towards a blend of urea and Types 1, 2, and 3 so that it releases gradually over time. Currently, ESN is probably the best slow release product.

Q: A lot of growers are incorporating soybeans into rotation: how will this impact phosphate deficiency and how should phosphate levels be managed?

> **A:** Ross Mackenzie reported that one of the reasons there is less soil test phosphorous is because there are more peas and canola in rotation, and farmers are not putting on enough phosphorus to match removal. One option might be to go in every 2 to 4 years and band a rate of 75-100 lbs of phosphate in late fall to provide P for the next couple of years.

A: Terry Aberhart added that perhaps one of the issues is that soybeans are not very responsive to phosphorous. One is able to get away with not replacing the phosphorous short-term, but not the long-term. It is a concern.

A: Ross MacKenzie stated that peas and dry beans are also less responsive to phosphate fertilizer. If the soil test is less than 30 lbs using the Modified Kelowna method, there may be a response, but over that there is less of a response because legume crops have a different mechanism for taking up phosphorus compared to canola, but you do want to be putting that phosphorous on.

Q: There is a lot more of fall floating of fertilizer. A lot of the phosphorus is going down in the spring, but there is a lot more phosphorus going down in the fall. Fertilizer prices have not gone down, and equipment cost has gone up, so lots of people are not upgrading. Fall application seems to be the cheaper option. What are some comments on that?

A: Ross Mackenzie responded that broadcasting N as urea in the fall, and with a few warm days, it could be activated. Rather than floating it on, it should be banded and put down a couple inches so there is no run-off.

Q: During a study the depth and proliferation of secondary root hairs in low N treatments was noted: it was 3 or 4 times the depth in biomass. Is there any recommendation for side-banding N during seeding; is there a chance that putting N on during seeding is compromising root development?

A: Ross McKenzie responded not to worry about side-banding N fertilizer, because if it is broadcasted appropriately, there is much more efficiency of uptake. The preference is to see it side-banded. In terms of root development, when the roots are growing out they will proliferate around the band, and also go down looking for moisture. In research trials, soil moisture samples are taken at planting and at time of harvest, and as long as there was moisture, canola roots would always go down to 36 - 40 inches, effectively. In dry years, moisture can be seen to be extracted all the way to 36 or 40 inches. Side-banding N fertilizer is the better of the methods. The next step is looking at water. One of the canola studies where the pivot irrigation broke just before flowering resulted in the best yields. What are the negative effects of high moisture on disease?

"INTEGRATED PEST MANAGEMENT" (IPM) PILLAR PANEL

Overview and Best Management Practices

Keith Gabert, Agronomy Specialist, Central Alberta South, Canola Council of Canada

The strategic plan to get to 52 bushels/acre by 2025 is broken up into agronomic areas. An increase of two extra bushels/acre of canola is the target for the insect and disease management area. Insects and disease were not major issues in 2015. There were some pockets of insect pressure, but for the most part this year was a struggle with stand establishment and moisture conditions. There were some exceptions which were mostly linked to stressed/slow growing plants (early season flea beetle damage). Cabbage seedpod weevil expanded as normal, and lygus pressure was fairly average. **Key message** is that scouting and identifying problems early is the key to success. Some notable pests of concern for canola production are resistant clubroot, verticillium wilt, swede midge, and glyphosate resistant kochia.

A Grower's Perspective on IPM

Renn Breitkreuz, Region 6 Director, Alberta Canola Producers Commission

Rotations continue to gravitate towards wheat-canola for economic and logistic reasons. Both crops are fairly simple, easy to grow and market, and maximize profits. This rotation means that every wheat acre or canola acre is on or close to wheat or canola stubble. Pathogens are building up. Integration of IPM is fundamentally crop rotation, and using all technologies and agronomic practices available to sustainably protect the crop and avoid pest issues. Clubroot is a major issue in Alberta. Clubroot spores are numerous, survive for a long time in the soil, and are genetically diverse, meaning that resistance is quickly overwhelmed. Genetic resistance will

not be long-lived, unlike blackleg. Newer technology is needed for clubroot resistance, like RNA interference or some type of nano technology. In the interim, there is a need to steward the resistance that is currently available, practice equipment sanitation and lengthen crop rotations.

The Economic Threshold Concept with Reference to the Management of Lygus Bugs in Canola

Dr. *Héctor Cárcamo, Research Scientist, Insect Pest Management, Agriculture and Agri-Food Canada, Lethbridge, Alberta*

Coauthor: Jennifer Otani, Pest Management Biologist, Agriculture and Agri-Food Canada, Lethbridge, Alberta

Thresholds and pest management include biological (natural enemies), chemical, behavioural, cultural, genetic issues facilitated by sampling, models, thresholds, taxonomy, biology (life cycles) and ecology. Some of the major challenges include identifying the insect to begin with. Life cycles of the pest, as well as interactions, are very important for management. Thresholds take into account ***injury,*** defined as the physical harm to a commodity caused by the activity of a pest, such as pod damage, flower and seed punctures due to feeding. ***Damage***, on the other hand, refers to the value in dollars lost to the commodity as a result of the injury. Not all pest injury results in damage (i.e. lost revenue as a result of injury). Damage curves are looked at: the relationship between injury and yield. The economic injury level (which is usually equated to the population of the insect) is the smallest number of pests or injury that will cause yield losses equal to the pest management cost. The economic threshold is a related concept (action threshold) is the density of a pest or injury level at which control measures should be taken to prevent the pest from reaching the economic injury level. The relationship between crop injury and yield is not fully linear, as there can be a period of overcompensation. The exception to this is if the crop is already extremely stressed. Thresholds include: Nominal or Subjective and Dynamic Action Thresholds. Dynamic Action Thresholds include natural enemies and temperature development models and are very difficult to establish as there are many variables. These have been established for soybean aphids in the US and Ontario.

The lygus bug is a native species and encompasses many different species. They are a major pest. Their population peaks at the end of flower/pod stage. Damage and insecticide control should occur at early-mid pod stage. They have 5 instars; the first two are not taken into account in economic threshold calculations because they do not appear to have the ability to puncture the seed. Symptoms can be confused with abiotic factors such as heat blasting. The current thresholds of 1 lygus/sweep at the end of flowering-early pod and 2 lygus/sweep at the mid-pod stage were developed in Manitoba for conventional older cultivars. There is a need to update thresholds for new hybrid herbicide tolerant cultivars.

A study is being conducted to determine the impact of lygus on canola yield of current hybrid cultivars and to update economic thresholds for 3 regions of Alberta. Preliminary results from this work suggest that newer cultivars may be more resistant to injury. Economic injury levels are complex, fluctuating depending on the region, the crop stage, environmental conditions, and commodity prices.

Verticillium Update

Dr. Mario Tenuta, Soil Science and Soil Ecology, University of Manitoba

In 2014 there was evidence of shredding of canola stalks during harvest on a farm south of Winnipeg. Verticillium was isolated and cultures sent to CFIA confirmed *V. longisporum.* The farm was quarantined. CFIA sampled commercial fields in Manitoba in 2015, as well as planned sampling in Alberta, Saskatchewan and Ontario. CFIA lifted the quarantine on the Manitoba farm mid-August 2015.

Verticillium resting spores survive in soil for many years and can withstand radiation, heat, etc. Canola has very little defense mechanisms against this disease. The canola plant basically is choked to death. There may be a compound released that stunts the growth of the plant. Infection will cause shredding of the stalk surface and a cross-section of the stalk will have pepper-like bodies (microsclerotia).These microsclerotia are released as the residue decomposes. When roots of susceptible hosts are nearby, the microsclerotia germinate, leading to infection through the root into the vasculature system of the plant.

It is found in Europe, Russia and Japan. V*. longisporum* infects brassica plants, with known infection of cauliflower in California and horseradish in Illinois, as well as non-brassicas such as eggplant, tomato, and watermelon. Infection in canola will cause stunting, reduced oil content and seed size, and yield loss of up to 80% per infected plant. It has not proven to greatly reduce canola yield on a field or regional basis. Infection typically occurs mid-season, but if it occurs earlier it may decrease yield more. Resistance/tolerance seems to be present in canola genetics. This is a diploid hybrid species. Hybridization has occurred at least three separate times. *V. dahliae,* which infects potatoes, is the common parent of the three lineages, but the others are unknown. Right now, there is intensive soil sampling being done and attempts at determining the parental lineage of Manitoba isolates. Transfer of protocols and training is being conducted at the “Pest Surveillance Lab” in Manitoba to prepare for monitoring the pathogen.

Stewardship of a Precious Resource: Is Durable Resistance to Canola Diseases Still Possible?

Ralph Lange, Program Leader, Feedstock Development and Microbial Products, Alberta Innovates Technology Futures

The host-pathogen arms race:

- Phase 1: pathogen is introduced or evolves to attack a new host
  - blackleg in SK in 1975, clubroot adapts to canola, Verticillium wilt in MB
- Phase 2: try to limit spread
  - blackleg and clubroot containment strategies; encourage longer rotations
- Phase 3: breeders introduce superior technology
  - blackleg and clubroot resistance genes
- Phase 4: pathogen adapts
  - resistance breakdown of blackleg, clubroot development of new pathotypes
- Phase 5: new resistance genes, followed by adaptation
  - success depends on availability of new resistances and ability of pathogen to adapt

Why does the arms race develop?

Reproduction: how quickly does the host reproduce versus the pathogen? Pathogens usually have hosts beat: millions/billions of propagules versus hundreds or thousands of seeds. Because of this imbalance, pathologists thought long-term resistance impossible, but sanitation measures (crop rotation, maybe fungicides) have been shown to reduce the population downwards.

Selection Pressure: to survive, the pathogen must be able to attack the host and the host must survive the attack. This is true for obligate pathogens which cannot live one debris and needs to eat to survive, creating a huge selection pressure for that organism to adapt. Contrast that with blackleg that can survive on some residues. Clubroot (*Plasmodiophora brassicae*) is an obligate pathogen; therefore, there is a high selection pressure to adapt and have survival strategies such as resting spores. There is always pressure to change and to change quickly. On the host side, selection pressure is exerted through major gene resistance; multigenic resistance facilitates tolerance (the ability of the host to survive despite infection).

Genetic exchange and selection: can the pathogen freely exchange and recombine genes (through sexual recombination or something similar)? Clubroot can exchange genetic material.

Blackleg has a sexual stage. Verticillium and Fusarium Wilt have no sexual stage, so there is little recombination.
Can breeders access resistance genetics quickly enough to counter pathogenic adaptation? Blackleg has many resistance genes, both major and minor. Clubroot has a limited supply. Resistance is weak and rare in Verticillium wilt. Fusarium wilt has no other resistance known if the current major resistance fails.
Dispersal: can the pathogen move around freely to new areas? If dispersal can be prevented, disease can be eradicated. If adapted pathotypes cannot spread, the race change is limited to mutation rate.

The example was given of the Alberta blackleg control strategy where there was slow spread through the 1980's until resistance became available in the 1990's. It looks now like it is overcoming resistance. What is going to work as a defense?

Feasibility of resistance group labelling in Canada: Producers need not repeatedly use the same resistance genes, but how do they choose? AITF (Alberta Innovates Technology Futures) is testing the Australian approach for labelling blackleg resistance groups (exposing varieties to different crop residues, then grouping the varieties). This system helps growers select the right resistance group for their region and to rotate resistance genes.

Can Canadian cultivars be placed into resistance groups based on reaction to crop residue-borne inoculum? Ascospores only form profusely on residues that have undergone two winters. If this testing works, growers will have blackleg resistance rating and resistance group information available to them to make variety selections, allowing for the management of genes (ability to put resistance genes into fields where they will be effective and avoid repeated exposure of effective genes to the pathogen).To manage genes to maximize effectiveness and longevity, we need to rotate cultivars, not just crops, and have knowledge of resistance genes in our canola cultivars.

IPM Questions and Answers
Q: Is there any work being done on thresholds for multiple insects, for instance: Diamondback Moth and Bertha Armyworm?
> **A:** Héctor Cárcamo was only aware of the work being done in Lethbridge on Seed Pod Weevils and Lygus. Developing thresholds for even a single species is a challenge.

Q: What have been the benefits or observed improvements of a lengthened canola rotation?
> **A:** Renn Breitkreuz commented that if clubroot is discovered in his particular municipality, you get a notice from the county preventing you from growing canola for three years, locking you into a four year crop rotation. It is one in four years in that particular field until it is not seen. The effectiveness of lengthening the rotation still needs to be looked at. Having clubroot makes seed selection relatively easy because there are only a few varieties to choose from. It also forces the grower to look at other crop considerations.

Q: When stubble was sampled from different fields from different hybrid combinations, was there ever the chance to sample three strips of different hybrids in the same field and see whether there was differentiation there?
> **A:** Ralph Lange stated that a few examples came to mind. One was where there were strip trials with presumably the same field history, and different varieties reacted differently, which was expected. But there were examples where those same varieties were planted somewhere else, and reacted differently. In other words, the local populations are different from one to another. This is bad news in that a blackleg rating or race adaptation may not necessarily apply to all of Western Canada.

Comment: There is a need to start looking seriously at the early bud stage for lygus damage (not just the pod stage). Damage has been observed from anywhere from 2-6 adults/square

meter at the bud stage. Lygus bugs cannot be picked up in the sweep net sometimes as they are buried in the bud where they stay unless they are knocked out. When 10-20 pods are missing on the main stem, there is significant yield loss. To achieve increased yields, there is a need to look at the damage to the pods, but also to the damage done to the buds. Less buds per plant is less yield. There is no entomologist in the wide area around Edmonton, this should be looked at. Comparing cage studies to actual field situations was also questioned. There needs to be a re-think about the whole cage idea not just at the pod stage, but at the early bud stage too, because this is costing yield.

Response: Héctor Cárcamo agreed that the data collected from cage trials, needs to be validated at the farm level. Data is needed from all ecoregions and the data needs to be updated for that region in Alberta. Other data from other parts of the world show no effect of insects on the pod-blast. In the cages where there are no insects, there is the same amount of abortion of reproductive structures as there is when lygus are present, and invited some collaboration.

Q: In an area where there was no rainfall for close to 10-12 weeks, flea beetle damage was observed from the cotyledon right down to the root. It was thought that 40-60% of canola was sprayed at least once with a foliar insecticide because of a lack of control from the seed treatment. Is there dialogue with industry representatives in terms of a plan for next year to consider some of this extreme dryness, and the three week threshold level?

A: Keith Gabert stated that 2015 was a really unusual year. While it was discussed with industry, the expectation for those seed treatments was probably met. The surprise for most of the growers was the support they got for some of those near failures, and the emphasis will be to make sure fields are being scouted. Seed treatments are good only for a certain amount of time, so it should not be characterized as a failure; the conditions in 2015 tended to promote more feeding, less growth of the canola plant, and resulted in more stem feeding. Other seed treatments are coming out. It was felt that seed treatments met their expectations, but a better crop was needed to help this out.

Q: The last two years has shown an increase in flea beetles feeding on the stem. Conditions were experienced where flea beetles were going underneath for protection. Field assessment is based totally on cotyledon damage, but the thought is that stem damage is far more destructive than cotyledon, because when the stem has been chewed, you have nothing. The economic thresholds do not seem to account for that.

A: Keith Gabert added that the whole plant should be evaluated. With adequate moisture, a bit of stem feeding is still recoverable, but with hot weather and dry conditions causing poor ability of those roots to push moisture up into the cotyledon, stem feeding is pretty severe. Being a little aggressive in spraying for flea beetles this year would have been the right call. That is going to be a guess, being unaware of any data for stem feeding of flea beetles.

"HARVEST MANAGEMENT" PILLAR PANEL

Overview and Best Management Practices

Angela Brackenreed, Agronomy Specialist, Manitoba, Canola Council of Canada

It is felt that two bushels of canola per acre can be captured over the next ten years through improvements in harvest management. **Key messaging** is to swath at the appropriate time, measure and mitigate losses behind the combine, and where feasible, incorporate straight cutting as a way to manage harvest in order to move towards this goal. In 2015, swath timing was a challenge as thinner stands led to more branching and less yield was contributed by the main stem. Seed colour change had to be assessed on the whole plant to capture full yield potential.

Keeping Ahead of the Harvest Curve, When the Curve is Straight Up
Kevin Serfas, Grower, Serfas Farms Ltd.
Harvest management basically starts at seeding time with a good seeding plan. For seeding, it is important to keep it simple. It is not efficient to be cleaning out drills and tender trucks every 1000 acres, so do not try to grow everything. Plan seeding according to the geography; the less moving the better. Harvest timing should correlate fairly close to seed timing (start harvest where you started seeding), and harvest geography to seed geographies. Focus on priorities that are 2-3 weeks ahead. Get the early harvest sold as soon as possible so that it is not spending so long in the bin. Having the right number of people to handle the work load is probably one of the cheapest input costs on the farm.

Swathing versus straight cutting? Swathers allow harvest to start 10 days earlier than straight cutting, so they are a good harvest tool. Swathing eliminates most green spot problems, allows the crop to sit in the field maturing, and allows for 1 combine per 3500 acres, as opposed to 1 combine per 2500 acres for straight cutting. The decision to straight cut depends on geography and weather. Cut the canola in the direction of the prevailing wind and measure harvest loss. Do what you know best.

Straight Cutting Canola, the New Normal
James Humphris, Manager Oilseed Crops - Herbicides and Trait Agreement, Bayer CropScience Canada
In 2013 harvesting techniques in Canada show about 3% of farmers are straight cutting 100% of their canola acres and around 8% are doing a combination of straight cutting and swathing. About 6% of total canola acres are straight cut, the rest is swathed. In 2013, a lot of growers were harvesting before 50% seed colour change, which is concerning because it gives up yield. The main reason for swathing is to reduce pod shatter losses during the harvest operation. The main reasons for straight cutting are fewer operations, fewer machinery costs, and higher yields. In 2013, 48% of growers straight cutting their canola did not use a harvest aid, 47% used glyphosate, 6% used Reglone or another desiccant. Those percentages have not changed significantly, yet.

Pod shatter or dehiscence/rupture is a natural process for the plant to reproduce. Shatter resistant varieties do still shatter otherwise they would go straight through the combine. The attempt is to reduce this shatter effect. This is the trait that is focused on in pod shatter resistance and through scientific innovation and perseverance InVigor L140P hybrid was produced. This was a big opportunity and a big risk. It is a non GM trait.

All hybrids can be straight cut, but sometimes there are significant losses. Leaving canola standing while maturing is better, but it may also be riskier. In replicated trials, it was found that with the same genetics, there was a 4% increase in yield by letting canola stand and fully mature for straight cutting versus swathing· In general, there was increased seed density (but not oil content), and fewer volunteers the next year. Incorporating a shatter resistance trait and straight cutting can allow more flexibility for harvest management. Both straight cutting and swathing are important for proper harvest management

A Comparative Study on Harvest Equipment for Direct Cutting Canola
Nathan Gregg, Project Manager- Applied Agricultural Services, Prairie Agricultural Machinery Institute
It is important for growers to test their combines, not to just rely on industry graphs. It is common to see 2-5 bu/acre loss out the back of the combine. Worst cases have 5-15 bu/acre. Contributing factors for machinery losses are: more power (horsepower has more than doubled since 1990); maximum throughput is greater than the capacity of the processing and cleaning

systems; and combine leakage through seals. Modern spreaders and choppers hide the loss because they distribute and mask the residue.

Misconceptions about combines: miles per hour is equal to capacity, therefore more power is equal to more capacity, keeping the machine full will make for less losses, same settings for a crop will be fine for the entire day/season, and the loss monitor shows the loss level. The operator needs to adjust harvest speed to match conditions. Higher yielding genetics, cut height and the width of the header impacts the amount of material being put through the combine and speed needs to be adjusted accordingly. **Recommendations** for growers: look for loss, quantify those losses (with spreaders and choppers disengaged), invest time in optimizing settings and calibrating loss monitor, do not use all of available power all of the time, slow down and do more combine hours instead, do comparisons side by side in the same conditions, correlate loss with the loss monitor and watch for changes, do not use the same settings all day and all year, try doing a kill stall, and monitor cut height.

A three year Randomized Complete Block split-plot design comparative study of direct cutting headers was initiated in 2014.The varieties used were InVigor L130 (standard) and InVigor L140P (shatter resistant), with Dekalb 74-44BL and 75-65RR added in 2015. The focus was to determine combine header performance at fixed ground speed and loss level for four harvest treatments: swath/belt pick up (control, targeting 60% SCC), 36' draper header with rotary divider, 35' rigid auger header with vertical side knife divider, 35' "Varifeed" header (cutterbar extended 23") with vertical knife divider. The data collected included: harvested yield, header loss, environmental shatter loss, seed size and quality (moisture, green count, oil content and dockage). Targeted harvest at 50% seed colour change.

Swift Current had dry conditions in 2014. The grain was dry, but green stems and undergrowth caused problems going through the machine resulting in low productivity and plugging. Shatter losses were low. Indian Head in 2014 was less dry than Swift Current, but there was a wind occurrence so shatter-tolerance proved beneficial. All header treatments were close in harvested yield, but this is only one year of information. So far, it appears that the extendable cutter bar does show slight advantage, but it may not be statistically significant. Environmental shatter was low except for Indian Head. When looking at where the loss occurred along the header, it was greatest at the perimeter and the middle of the header. The draper's rotary dividers had the greatest overall loss, and the fixed divider had very asymmetrical loss (high on the knife drive side). The standard variety had greater losses along the header than the shatter resistant variety. More sampling resolution is needed for header loss location. Oil content and seed size was very similar between treatments and the green count was low.

Preliminary results and observations in 2015: topography and crop conditions play a significant role when considering straight cutting canola. For instance in Humboldt, the crop was overripe in spots and green in others. In Indian Head the losses were greatest at the ends and the middle of the header. L130 had more loss than L140P across the header. The draper header's rotary dividers had a greater overall loss than the vertical knife. The fixed divider had an asymmetrical loss. There was high variability in Swift Current. Early dry conditions and late rains resulted in multiple stages of maturity, so it was a good candidate for desiccating or swathing. The down and lodged canola was difficult to harvest. Auto header height control was very nice in these conditions, whereas the rigid headers bulldozed dirt when cutting close to the ground. The sideways auger conveyance system is more positive than the draper; the draper is more sensitive to reel position than the auger header. The full fingered auger helped to grab and compress bushy crops, and the cutterbar extendibility allowed for optimization of feeding based on the height of the crop. Overall, the "Varifeed" was the most comfortable and forgiving header for straight cutting canola. There is no reason not to try straight cutting as all headers did the job.

What is next? The list includes: effect on combine performance, desiccation, fuel use, productivity, settings, losses and on farm storage of straight cut canola. Stored grain may have higher dockage now because of greener material. This is what can be looked at in the future.

Harvest Management Questions and Answers

Q: Are there any comments about pushing canola?

A: There is not a lot of experience with it and it is not a prevalent practice. There may be more interest in it in Australia.

Q: Are there any comments on the shatter and non-shatter traits and how it goes through the combine? Was there any difference?

A: Nathan Gregg commented that the varieties were pretty well matched. There was nothing notable, but it was not being looked at either. The fundamental limitation with the research was that combine loss and ground speed were fixed for all treatments, so maybe at a higher speed; there would be more of a difference.

A: James Humphris added that based on the feedback from growers on harvestability, no significant difference is seen. It was felt that where there would be differences is when there are genetic differences in maturity. If there is a difference in maturity, one variety may be a little drier, so there might be a few differences in the machine as a result.

Q: Question about swathing in the heat versus quality.

A: Kevin Serfas stated that his farm does not shut down for heat and runs for 24 hours at that point. Issues are not seen when it comes to the quality of the grain.

Q: Is there a way to measure losses underneath the swath treatment? (To measure potential losses from the swathing operation itself, losses as it cures, and losses as it is picked up)? Usually when picking up a swath, it is shaking a ways further up the windrow.

A: Nathan Gregg said this has been done a lot over the years. There are some documented loss numbers involving belt pick up, but not in these specific fields.

Closing Remarks: "Things I've Learned"

Curtis Rempel, Vice President Crop Production and Innovation, Canola Council of Canada

- When it comes to seeding and good establishment, shallow up and slow-down is still relevant, although the "slow down" piece of it may be more debatable than we thought. Shallow up seems to still be very important.
- Secondary dormancy does have an impact on germination, and it is a very genetically complex trait.
- A lot of growers do not know what they have for plant stands.
- Nitrogen response curves have utility for the grower to make fertilizer rate application adjustments based on cropping economics.
- If nitrogen rates need to be increased, it will have to be done more effectively and efficiently.
- There is documented net return from growers on variable rate technology.
- Clear work needs to be done on action thresholds and damage at different crop stages.
- Verticillium wilt is a potential threat to canola yield.
- Genetic resistance will require a combination of control measures.
- Swathing and straight cutting is dependent on environmental conditions and time management.
- There is a need to communicate time of swathing. Often it is a judgement call.

2015 Canola Discovery Forum
Meeting Proceedings
Coast Canmore Hotel & Conference Centre Canmore, Alberta
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CANOLA DISCOVERY FORUM: GROWING MOMENTUM

Scanning the Global Crop Research Landscape

Curtis Rempel, Vice President Crop Production and Innovation, Canola Council of Canada

What are the variables in reaching the goal of an average canola yield of 52 bushels/acre across Western Canada? The enablers include:

- Nutrient and water use efficiency; soil/water health; or sustainability: utilizing and conserving canola production and natural resources for present and future generations.
- The "OMICS' platforms (genomics, metabolomics, and phenomics) allow for very high throughput.
- Gene and Genome Manipulation (GRON, CRISPR, Talen, Zinc finger, RNA interference, etc.)
- The Big Data/ Information Revolution: the information revolution has made possible climate/weather modeling, pest predictive modeling, greater precision of spatial and temporal management decisions via sensing, mapping and variable-rate application technology and intelligent algorithms and data interpretation that are reducing input costs and product losses via increased production efficiency.

Improvements to canola in the coming decades:

Genetic Improvement

Gene Editing - CRISPRCas9 and other CRIPSRs; RNA interference; targeted gene changes equates to non-GMO; drought tolerance; disease and insect resistance; tissue targeted gene expression (high erucic acid and glucosinolates in vegetative tissue for protection against insects and disease and if this can be achieved in the leaf and stem, but not the seed or floral tissue it may help defend against flea beetles and other pests); reduced anti-nutrients in seed (i.e. phytic acid) and increased minor use constituents in the seed.

Field Phenomics/Phenotyping= Big Data & G x E x M= Precision Ag

The genotype, environment, management, and their interaction influence quantitative traits in a complex and dynamic manner. Lab studies are limited to a few, sometimes extreme, environmental treatments or treatment-level combinations. Plant phenotypic responses are generally characterized by response curves or norms of reactions to the environment, which for complex traits are inherently continuous and mostly non-linear. New pollination control systems that are stable and allow for higher levels of heterosis (hybrid vigour) Yang et al. 2014 looked at stand uniformity: the effects of canola stand uniformity on seed yield across various environmental conditions: the relationship among fertile pods, seed set, plant survival to the hot summer, and seed yield in canola. Uniform stands play a significant role in yield potential. Seed size is positive for early biomass, seed weight, seed oil and shortened flower duration, but has a higher dormancy potential.

Big Data and Precision Ag:
Establish Management Zones can be done using vegetative maps and yield, soil tests (grids vs zones, how large a grid?), topographical maps, or soil conductivity maps. Select one approach and start and see how it works. Choose a method where there are good resources available.

Biologicals and rhizosphere microbiomes:
This is a new frontier in agriculture. Agricultural productivity rests on a foundation of soil microbial activity. The soil has long been understood to harbor enormous microbial diversity. Within a given soil type, plants exert selective forces on this enormous pool of biodiversity, shaping and restructuring microbial communities in the rhizosphere. The rhizosphere is the microbial habitat around the root, where the soil's physical, chemical and biological composition is influenced by the plant and vice versa. The rhizosphere is made up of microbes, metabolites, organic matter constituents, plant growth regulators, concentrated root exudate fractions, amino acids, sugars, and on and on.

Composition of root exudates varies by plant species, and even cultivars within a species (Kowalchuk et al. 2002; Högberg et al. 2006; Micallef et al. 2009). As a result, the soil microbial community also varies.(Grayston et al. 1998; Kuklinsky-Sobral et al. 2004;Salles et al. 2004). This suggests the potential for manipulation of root exudation in agricultural cultivars in order to create specific selective effects on the rhizosphere microbiome. This concept comes from intestinal microflora. There are over 100 trillion microorganisms in our intestines. The rhizosphere microbiome is the taxonomy, populations & totality of genomes of microbiota (fungi, bacteria, archaea). It is often used to describe the entity of microbial traits encoded by a microbiota. The rhizosphere metabolome is all of the external and internal metabolic activity (exudates, nutrient transport, defense proteins) in the rhizosphere.

CANOLA IN THE MARKETPLACE

The 26 Million Metric Tons of Canola and How We're Going to Get Differentiated Value

Lisa Campbell, Oil Nutrition Research Manager, Canola Council of Canada

It is important to highlight canola oil's differentiated value to the market: continue to develop the health benefits of canola oil and canola meal as well as meeting new customer requirements while maintaining a competitive price. Cardiovascular disease and diabetes are two of the largest lifestyle diseases and canola oil has a role in maintaining healthy blood glucose as well as heart health. The canola meal is very good for livestock feed. There is also the potential for canola as a plant protein for human consumption.

New Opportunities in Canola Oil and Meal Markets, and Lessons Learned from the Oat Sector

Peter Entz, Assistant Vice President, Seeds & Traits, Richardson International Ltd.

Why canola? It is a very important and vital crop in Western Canada for farmers and the industry: producers are good at growing it, there is an established market, and it is profitable. The consumer demands healthy vegetable oil that is readily available, and they are willing to pay the premium.

Palm oil and soybean oil drive the market, followed by canola, sunflower and others. Canola has a healthier fat profile than both of these. Looking at the global vegetable oil markets, the demand is already there for canola. Canada is the leading producer of canola in the world. The US is Canada's major export market for oil and meal. The Trans-Pacific Partnership was signed over 3 weeks ago, helping to reduce or eliminate tariffs. It creates discipline over non-tariff trade barriers and opens markets to support greater access of Canadian canola oil and meal. Asia, Mexico and the US are important markets to the seed industry. In summary, the vegetable oil

market is large and is growing. Canola oil is healthy and has a niche opportunity and there is a lot of up-side.

Farmers could adapt to whichever of the four types of canola oil the market dictates, based on economic drivers, driven by the consumer. HOLL (high oleic, low lin) canola is valued in South East Asia where cooking environments are confined. It is also a great choice for the US deep frying market, as well as other application including spray oils, crackers, and so on. Canola biodiesel is unique in that the oil profile produces better cold flow properties. There are specialty oils such as the non-GMO oil from the Clearfield "Identity Preserved" program (Clearfield canola is a non-GMO canola trait), and commodity oil. Much like HOLL canola, the industry could easily react to higher demand.

Around 90% of Canadian canola produced is exported. Market vulnerabilities include such things as: tariffs, biotech approvals, sustainability, MRL's and phytosanitary issues. Canada's canola advantage is that it is based on science-based decisions, R&D horsepower, innovative and adaptive farmers, and a strong sustainable message.

For continued success, there needs to be continued investment by public, private, and commodity groups. Solutions will need to be developed, demonstrated and implemented.

Why oats? The agronomy is lagging behind other crops, and it is not as profitable. Breakfast cereal has a number of benefits (vitamins, grains, minerals, etc.).The trend now in the market is protein. In the developed market, there is a need to find new ways of enticing "defectors." The canola and oat markets are very different, both have health claims, but oats are dependent on a small domestic market place, not global and canola is still profitable for the farmer and industry.

Canola in the Marketplace Questions and Answers

Q: How will oats go into countries where it is typically only considered animal feed?

> **A:** Peter Entz replied that there are those kinds of challenges. Canadians eat oats as a cultural norm, but if that is not your culture, it would be a change. There is an opportunity to gain some appeal in those countries that want to become more westernized. The domestic market probably has to be viable before too much development in these new markets really makes sense.

Q: Regarding canola meal exports to the US, canola meal's largest market with over 90-95% going to the US; it seems that any trade disruption would have ripples throughout the whole canola industry in Canada. What is being done to help manage that risk?

> **A:** In terms of the international nature of the canola meal, there is a heavy reliance on the Canola Council to keep that path open. Right now, it is going mainly into the dairy market, there is probably some work to be done to make sure that other sectors are considered as well. The crushing business in Western Canada is really quite large, and there is a need to make sure that homes can be found for canola on the meal side.

Q: Does the Mountain View Cold Press unrefined canola oil sells for double the refined?

> **A:** Yes and it is really interesting because it is less refined. It has a marketing advantage because it is not overly processed.

Comment: Growers, and the media, and those not exposed to the market sector as much, need to appreciate that there is a value differentiated component in this. As growers, there is the tendency to stay at home and they can get caught up in the "grow more for less" attitude, but there is the opportunity to grow market share in a growing market and this message is appreciated. Growers respond to economic signals: when there are premium prices, acres will go back up to 22 million, and when oats come back to over $3/ bushel, farmers will grow oats again.

BIG DATA: EVERY ACRE IS A POTENTIAL RESEARCH ACRE

How to Collect Accurate Farm Data and How to Use that to Leverage "Big Data," UCC Results

Nicole Philp, Agronomy Specialist, Southwest Saskatchewan, Canola Council of Canada

The purpose of the Ultimate Canola Challenge (UCC) is to measure the value of available treatments purported to improve canola yield and quality. It is a way to test new/additive products on the farm and to demonstrate the idea that every acre can be a research acre. Multiple products/treatments have been tested like seeding rate, nitrogen application and various micronutrients. In small plot trials, varying the nitrogen rate was the only treatment to have a statistically significant result. In 2015, on-farm testing protocol was developed. Boron was tested in comparison to established best management practices. The protocol addresses the on-farm use of proper check strips, field selection, treatment maps, minimum variability, note collection, managing harvest, and replication. Replication was also talked about. In the data collected thus far, there statistically is no difference between boron and the untreated check.

The Collection and Use of Machine-Logged Farm Data from Multiple Farms

Tom Staples, Director, Echelon with Crop Production Services

Agriculture is being seen as a new frontier for technical investment, with new investments being made in digital technology and big data (For example, Monsanto's take-over of Climate Corporation). Data can be used to get answers to new questions. Data doubles about every 1.2 years, processing data has gotten faster and data storage cost is approaching zero. There is now machine-logged data and no longer a need to put a flag out in the field for trials. Seeding rates can be measured, as well as results at harvest. There is now on-farm research of yield data collection and analysis. In a poll of 179 large companies, those that adopted "data driven decision making" achieved 6-7% higher productivity than could be explained by other factors. There is lots of power here for the grower, but if it was asked how many are using that data to make decisions, most are not. A typical yield map of a quarter section has approximately 1 million discrete data points, temporally and spatially recorded. The opportunity is tremendous. Traditional agronomic research involves a few locations over a few years with 4-6 replications, but big data allows the grower to approach n=all. This increased data set minimizes error. Data can be mined and drilled and the example of tweets and aphids was given.

The Digital Farming Landscape

Warren Bills, Business Development, Digital Farm, Bayer CropScience Canada

Agronomic research includes: people, plants, soil, database tables, replications, and also maps, GIS, yield monitors, tractors and sensors which can be global/space-based, field/local-based and mobile/equipment-based. There is a need to start trusting sensors to relay what cannot be seen. In just one yield point, there are about 17 attributes such as yield, moisture, elevation, speed and so on, and there are approximately 183 yield points per acre. In a quarter section that means there are 497,760 yield points. Averaging yields from strips in fields provides some data, but it is probably not the most reliable considering the amount of variability. Anecdotal evidence is no stronger than evidence from data that has not been handled properly. Technology can fail, but one of the pros with big data sets is that replication can happen within strips. Low yielding areas tend to be in groups. There is a "trust-gap" with using big data for field research with concerns over sensor calibration, running multiple combines, technology is from outside vendors, and it is the computer doing the learning versus people. The ability is there to use big data to move agronomic farm research into economic farm research. Is this more sustainable? Digital farming is collaboration and partnerships with other partners.

Big Data: Every Acre is a Potential Research Acre Questions and Answers

Q: Some labs already use big data, and it is relatively easy to get big data, and when you get sequence data back, it is really easy to process because anyone can do a GenBank search and search BLAST. However, contrast that, with being in the field and doing disease surveys, where is the BLAST, where is the GenBank for landscape scale and variety information? It is very difficult to go out and get a field history. Where is the broad search for crop variety data?

A: Tom Staples commented that some of it is really about making things easier to collect the metadata, and there is a lot of effort in the industry to try. If you think about trying to eliminate the human out of the data collection process, it gets easier. Look at things like RFID and being able to follow a bag of canola all the way out to the drill and the drill seeded something at 5 lbs/acre, then it makes using that technology to collect the data easier. Standardization of one database is another thing so that allows better collection of data. There are numerous data sets in things like sales transactions.

Q: Point of sales databases are proprietary. GenBank's data is publicly accessible. How does one get into the point of sale database?

A: One has to get creative.

Q: Is data becoming a bit of a commodity or a profitable product for the generator of the data, which is the farmer? What are the privacy and ownership regulations on that data, particularly if there is value?

A: Warren Bills responded that he thought that data will probably have some sort of value in the future, but it is a give and take relationship. For instance, with apps, there may be a willingness to share data as long one is getting something back.

A. Tom Staples agreed saying to make sure you are getting value back for sharing your information. Also, trust that person not to use that data against you – not to change pricing, taxes, etc. Be thoughtful about where the data is going: there is no such thing as a "free" app. Follow the money and ask if you are okay with that.

Q: Will the need for traditional research be eliminated or are we just going to get smarter with farming analysis? An example of evaluating a crop variety all over Western Canada was provided, but there still is a need for the traditional research to approve a new variety before it can be analyzed on the farm. Is this all going to be additional information, or will some traditional research be eliminated?

A: Using some of the technology that exists and layering it in as extra layers of the plant breeding process works. Work with understanding: find out why a winning variety did not win all trials, and look for niches for the varieties that did not win.

2015 UN INTERNATIONAL YEAR OF SOIL: SOIL LANDSCAPE AND VARIABLE RATE TECHNOLOGY

Ian Epp, Agronomy Specialist, Northwest Saskatchewan, Canola Council of Canada

The panel of speakers was introduced and background information was provided.

Current Research on Canola Microbiome in Western Canada:

Dr. Mario Tenuta, Soil Science and Soil Ecology, University of Manitoba

Some causes of nitrogen (N) response variation are due to landscape variation, the effects of the previous crop, moisture and three of the "four-R's" (placement, timing and source). A study by Tiessen et al, in 2008 showed losses from fall-banded urea on well drained soils are much less than on poorly drained soils, especially if N is applied early in fall. In high landscape positions, it did not really matter when the fertilizer went on in the fall; low depressions resulted in lower uptake of N and lower yield. As heat units accumulated, there was a greater benefit to the prevention of the N transformation or denitrification.

Effects of landscape position on toxicity of ammonium sulphate for canola. High pH on hilltop induced ammonia toxicity (Grenkow, MSc Thesis).

Effect of N supply and landscape position on wheat yield at Birtle (MB): In wet year, crests out-yielded the depressions and mid-slopes for Spring Wheat. In the dry year, the exact opposite happened. Moisture was the main factor. We need to be able to predict the weather.

Previous Crop Effect used information from crop insurance data in Manitoba and the yield response of major Manitoba crops sown on large fields with various previous crops in rotation. Example: legumes can provide the following crops with N benefits and non-N benefits (ex. disease reduction). Previous crops with a positive increase in yield for canola were spring wheat, barley, and flax. Soybean had a negative effect on canola with a 14 % reduction.

The effects of N source is less with surface placement in reduced till than conventional till systems. NH_3 spring band was highest in reduced till. Immobilization ties up a large portion of fertilizer N and is reduced by in-soil banding. Reducing contact between straw and fertilizer reduces immobilization and increases crop N uptake. Straw removed N band was the best for crop uptake (53% in the plant, 34% soil). Straw incorporated & N broadcasted was the worst for uptake (22% plant, 72% soil). Banding reduces ammonia losses to extremely low levels - if bands were sealed, losses were no higher than from the control (500g per ha=1lb/ac). Some small losses occurred under reduced till when the band did not seal correctly. There needs to be good closure/packing of bands to keep N in the ground. There are a lot of products out there including urease inhibitors and nitrification inhibitors. Under well-drained conditions, there was no yield advantage to use of ESN if urea was banded in soil at seeding (on canola, wheat, barley), but under wet conditions, there was a benefit to ESN (at two of the sites); however, some crops failed due to excess water. There was no benefit to ESN on corn in a dry year, but there was a benefit in the wet year. There is a need to be able to predict the weather. Side-banded N without urease inhibitor (NBPT n-butyl thiophosphoric triamide) reduced canola stand if only 1" below and beside seed. It can overcome the problem of toxicity. Agrotain urease inhibitor (NBPT) reduces volatilization losses and increases yield, especially with zero-till. In summary, banded N is 20% better than broadcasted N, and spring band application is 20% better than fall. Can things like Nserv level the gap.

There are limitations to the nitrate test, as it only measures immediately available NO3-, it doesn't measure NH4+ or mineralizable organic N, which can vary with soil type, native vegetation, erosion, time of cultivation, etc. Nitrate may not be stable; it may denitrify or leach before being used by the crop. There is spatial and temporal variability; therefore it needs very field specific recommendations. Nitrogen response will vary with disease pressure, for example there is better Nitrogen response if a fungicide is applied to control fusarium in wheat. Things that need to be addressed going forward is to resolve why soil testing is not more common, resolve why growers do not tailor additions to individual fields, and to get a better understanding of the amount of losses. Unfortunately researchers are handcuffed to older equipment.

Current Research on Canola Microbiome

Dr. Chantal Hamel, Research Scientist, Agriculture and Agri-Food Canada

The earth will have 9.6 billion people by 2050. This presents opportunities and challenges for agriculture. Plants require soil microbes for food. Microorganisms live outside and inside roots as well; root associated microbes influence nutrient uptake, root health and plant performance. An emerging solution is with high throughput sequencing to manage the plant's root microbiome to enhance mineral uptake efficiency, reduce yield losses caused by pathogens, and promote crop yield. The objectives of this work are to identify the root microbiome components that promote nutrient mobilization (N fixers, etc.), exclude soil-borne pathogens, increase tolerance to abiotic stress, and to improve productivity and nutrient efficiency in canola based cropping systems. Sequencing is used to draw the taxonomic profile of the canola microbiome. The results show that the canola bacterial and fungal profile is unaffected by fertilization and seeding rate, but was different from wheat and peas. The root and rhizosphere bacteria profiles were

distinct. There is no effect of root location on the bacteria profile. The management of fungi is more difficult than bacteria. There are a lot of chytrids (type of fungus) in the roots of canola. Roots are selecting for the chytrids. Opidium (lots of chytrids) can cause disease in canola, but those plants showed no symptoms. Roots select for bacteria, so maybe a type of canola can be selected to improve soil health? Bacterial communities were not different across sampling locations - if root bacteria are more stable than other groups, perhaps plant breeders should focus on bacteria inside canola root endospheres for breeding. Expect an increase in intensity of sustainable production and increased crop productivity.

Managing Soil Variability is Key to Profitability

Colin Cameron, Precision Agronomist, Point Forward Solutions

Why variable rate technology (VRT)? Soil characteristics vary across a field and affect yield. Topography, soil texture, pH, and salinity need to be understood in order to manage them. There is a strong correlation between yields and the topographical features of a field. Hilltops tend to be warmer and drier, low areas suffer from excess water; mid-slopes are the most stable when it comes to yield potential over multiple years of production. Texture dictates moisture and nutrient holding capacity; clay tends to hold more than sandy soils. The pH balance is changing; starting to acidify the top 6" of soil through use of the same fertilizers over the decades. Maximum yield is hit between a pH of 6 and 6.5. In this range, all macros and micros are fully available. In the quest for higher yields, more fertilizers may exacerbate the acidity problem. Salinity is also becoming more of a problem in particular regions, and can quickly affect yield.

Some of the keys to VRT are equipment, measuring variability, use of a yield monitor, and proper analysis. The equipment that can be used to capture information is the receiver, monitor, controller, air cart, etc. Most new equipment is VRT capable. The cost is dependent on how intensive a grower wants to implement VRT. To measure variability, zone maps need to be created: imagery, grid sampling, yield maps and EC data. Use zones to determine where to soil sample and to build recommendations. Yield data and analysis is important. Yield by zone can be graphed as a percent of field average. It is recommended to use check strips in the field to compare yield data to VR. To be successful, one needs to have accurate yield data, constantly measure and tweak zone maps, and start with the best zone map available.

Soil Landscape and Variable Rate Technology Questions and Answers

Q: Are US soil tests better than nitrate tests?

> **A:** Mario Tenuta commented that work was done in the 70's on what would be referred to as Easily Hydrolyzable Nitrogen. Soil is heated in hot water, and the N is measured. These tests are not new. There are also really complex analyses which tries to predict a whole number of chemical reactions, but the bottom line is that these other tests are trying to get mineralizable N - mainly in the biomass of the bacteria and fungi - so these tests are looking at the N that is in the biomass. The N and P vary depending on when you sample and on residues and mineralization and mobilization turnover, so there is no definitive answer, but cautioned to be very careful in terms of timing of sampling.

Q: Is there any information on how ESN would be affected by a type of soil (eg. sandy), and how much moisture is needed make it dissolve, in say, 2 months?

> **A:** Mario Tenuta said that in terms of soil moisture, the wetter the soil, the more it is going to diffuse, but there is also temperature to consider. The wetter soil is also cooler, so there is not as much diffusion, there is a sweet spot. It is probably something like 80% of available water to maximize it. There are differences seen in the soil, never put on 100% ESN, it should be a mixture of urea and ESN. Soils that heat up faster can use more ESN. Long growing season crops can go 100%.

PRECISION AG- EQUIPMENT UAV's

What are the Practical Applications of Drones? What are the Limitations? Identification of Gaps

Shawn Senko, Agronomy Specialist, Northeast Saskatchewan, Canola Council of Canada

The Crop Production team with the Canola Council tried out some fairly basic drones this past summer to try and understand their uses and limitations in the field. They certainly can be used to assist basic crop scouting, but ground-truthing is also necessary. Other technologies, such as micro-satellites, compete or cooperate with drones.

UAV's for Field Scouting

Dr. Chris Neeser, Research Scientist, Weeds, Pest Surveillance Branch, Alberta Agriculture and Rural Development

There has been a lot of recent development with "drones" or UAV's. They have autopilot, improved battery life, flight control software, the ability to integrate with tablets, on-the-fly image processing, lightweight high resolution cameras, etc. The camera for the project was modified for near infrared (720-1000nm). There are two things drones can do: Field Mapping (set flight parameters, lay out ground control points, launch and capture images, process images into ortho-rectified mosaic and generate NDVI maps) and Field Inspection (examining areas of interest via video and inspection or close up pictures for analysis).

The goal of the project is to evaluate UAV images for disease and weed scouting requirements and protocol, and ultimately assess the value of UAV's for field scouting. The methodology was to look at six crops, at three different times with approximately 120-150 photos to get a whole field image. There were limitations; some things still have to be visually inspected for ground truth. Patterns can show up on the image, but we need to know what they are. For example, one could see winter kill in an alfalfa field, but there is a need to know the context. With weeds, there were some different colours, but an inability to identify species due to blurry images. At 1cm/pixel the image is blurry green, at 6cm/pixel there is nothing, but at 0.01 cm/pixel it was clear. The problem is, better pixels means much larger storage requirements. Grid sampling could lessen the data load. Pattern detection and GPS coordinates can assist with scouting.

These tools generate a large amount of information, so there needs to be the ability to process and store the data. To make good use of the information, there needs to be the ability to apply inputs at variable rates. Regulations must be followed. This is a work in progress: algorithms are needed for automated detection of areas of interest and to quantify the presence of weeds in high resolution images. There is a need to do an economic assessment of the value of this technology.

It is important to note that transport regulations need to be followed when using UAV's.

Farming from Thirty Feet

Camile Baillargeon, Grower, CamCar Enterprises, Baillargeon Farms, North Battleford

Camile Baillargeon performs a lot of on-farm research to test varieties, fertilizer, fungicide, tillage, agronomic practices, etc. The crops investigated are cereals, canola and pulses.

A 2013 study by drone manufacturers says their industry will account for 100,000 jobs and have an economic impact of $82 billion by 2025. There are things to consider before purchasing a drone: whether it should be rotor or a fixed wing, recreational versus business, the need for a Special Flight Operating Certificate (liability, etc.), and data management. It is not about the drone, but about the data. The data has to be timely and accurate. Those that collect the data and utilize it will benefit the most. There is a need for better platforms for producers to manage the data. An airplane (Cessna) may be better because it is faster and longer.

How can drones contribute to “52 by 25?” Plant counts, frost damage assessment, fine tuning fertility programs, insect and disease monitoring, swath timing (allocate time and resources better) and plant establishment (thermal temperatures and moisture sensors could help determine fields to avoid or to start seeding on). NDVI maps could be used for crop insurance claims, making the process much quicker and fairer. It can be used to determine equipment efficacy: there are certain things that can be seen from the air, but not from the ground. For example, the patterns from things like plugged seeder hoses are difficult to see from the ground. There are limitations to this technology: it will not replace scouting. There are regulations that must be followed and time management and the need for two people by law to operate the drone (which poses a problem for time management). They will crash eventually. There is a cost/ownership of data issue. This could just be another tool for the toolbox, and big improvements could come in the future, like pest management sensors. The focus needs to stay on the data and data use, not the drone.

Precision Ag – Equipment UAV’s Questions and Answers

Q: Are the drones strong enough to pull a sweep net for lygus through the field?

A: Chris Neeser stated that the drones are not strong enough.

A: Camile Baillargeon responded that although not able to quantify it, a producer taped a sticky pie plate to the drone and flew it over the top of his canola. Maybe a protocol could be developed.

Q: Is anything being looked at besides NDVI to measure disease and insect problems?

A: Chris Neeser commented that with NDVI a ratio is created to normalize the data between 1 and -1, and this can be modified. The NDVI is often not the best. There are also multi-spectrum cameras, but it is important to know what is you are looking for.

Q: Are multi-spectrum assessment tools $80,000 each?

A: Chris Neeser said they can be expensive, but the price is coming down for many of the multi-spectrum cameras being designed especially for drones.

CANOVISION - INNOVATION AND EXPANDING FRONTIERS

Moderator: Jay Whetter, Communications Manager, Canola Digest Editor, Canola Watch Editor, Canola Council of Canada

Determinants of Summer Weather Extremes over the Canadian Prairies: Implications for Long Lead Grain Forecasting

Ray Garnett, Consultant, Agro Climatic Consulting

The purpose of this research is to improve the climatic early warning system for Canadian Prairie Agri-business. This study looked at 19 different predictors of weather creating a huge matrix. The methodology included use of standard correlation and exploratory regression analysis and simple algorithms of accumulating indices to show sustained forcing of most significant predictors. This novel approach considered correlation coefficients of many parameters and their monthly variation and influence.

Positive phase of the Pacific North America (PNA) index, a derivative of the El Nino/Southern Oscillation phenomenon, conceptual model of Pacific Decadal Oscillation (PDO). Conceptual model of the Madden Julian Oscillation (MJO): the MJO is a 30-50 day oscillation, resulting from large-scale circulation cells oriented in the equatorial plane that move eastward from the Indian Ocean to the Central Pacific. Correlations in February and April suggest that MJO interacts with the annual cycle in late June to favor or disfavor summer rainfall.

Conceptual Model of Four Drivers of Prairie Climate: Most recent findings show that Geomagnetic (AP) Index is a better predictor than sunspots. PNA & PDO indices are better

predictors than El Nino because they persist for years rather than months. North American snow cover ranked low.

Forecast verification – on February 4th, 2014 we wrote: "indications to date are for a July PDSI of -1 to-1.94 in 2015 or mild to extreme drought." Fall predictors are a tip off to moisture next July.

What could Canadian producers do with more accurate predictions? There could be an adaptation strategy when confident of forecast. For instance, for a dry hot summer: spend less on tillage, apply less nitrogen fertilizer, consider drought resistant crops, change Spring planting order or crops. For a wet, cool summer: apply more nitrogen, and change planting order (ex. Consider planting canola first, plant lentils last).

Sunspot activity is in decline, and we are experiencing cooler Mays (when temperatures are below 9.1 degrees there is a 50% chance canola area will be reduced by 10%). The MJO, PDO, solar related AP index are emerging as new and dominant predictors of weather. The direction of 2015 July moisture conditions was foreshadowed in early February. July 2015 temperatures were correctly forecast to the quintile in late February. June- August rainfall in 2015 was correctly forecast to the quintile in late March. The cooling trend over the past 31 years is consistent with solar and geomagnetic activity.

The use of Precision Gene Editing to Develop New Non-transgenic Traits in Canola
Dr. Jim Radtke, Vice President, Product Development, Cibus
Genomics, cell culture and gene editing can lead to a completely new technology path. There are tools available for new trait development. There are the classical ways, through breeding, mutagenesis, tilling, wide crosses, re-synthesized B. *napus,* but all of these are quite random or create "linkage-drag." Transgenics is basically shoot DNA into the cell, but it could land anywhere, and so a lot of time is spent trying to figure out if something is a stable transgenic and regulation concerns. What is rapid trait development system (RTDS)? It is a precision gene editing platform that is highly precise (site-specific) and non-transgenic. Traits are broadly accepted, although work still needs to be done at the regulatory level. It uses Gene Repair OligoNucleotide (GRON) and is applicable across multiple organisms. There is also gene correction. The first product created is sulfonylurea (SU) tolerant canola, which was pre-launched in the US in 2014. The SU tolerant canola has a high level of tolerance to specific SU herbicides. In summary, there are new gene editing tools available for the improvement of canola.

Two BIG things to change by 2025
Murray Hartman, Provincial Oilseeds Specialist, Alberta Agriculture and Rural Development, Lacombe, Alberta
Two big needs for canola to reach its yield goal by 2025: better weather forecasting and identification of things that help canola grow better under high CO2. Other than irrigation, weather cannot be controlled. The next best thing is accurate forecasting to direct agronomic decisions and to make agricultural research more efficient.

There are two approaches to seasonal forecasting: statistical or empirical techniques, which look for relationships that are predictable and dynamic modelling, where physical laws, mathematical equations and supercomputers are used to simulate weather and climate into the future. This approach is mostly used for long-term forecasting, but there is some recent work on seasonal weather predictions. Scaife et al (2014) found that North American winter temperature and wind speed was highly predictable months ahead using new models such as the North Atlantic Oscillation.

Climate research needs to refocus. It has been dominated by long-term projections from elevated greenhouse gases (GHGs), with short-term research being relatively underfunded. Yet the largest stumbling block for agriculture is unpredicted large weather fluctuations from year to year. This will remain important as the climate changes. Developments in satellite imagery and ocean observations will improve estimates of the "initial condition" that affect predictability (e.g. sub-seasonal to seasonal prediction project).

Top weather forecast needs funding that should include programs to improve seasonal weather forecasting. The "Ag" community should compile specific needs, i.e. different forecast skills needed at various times of the year

1. May through July monthly precipitation forecast by April 15 (fertilizer rate decision; crop species)
2. Two to four week forecasts for rain amounts / frequency, humidity during June and July (sclerotinia fungicide; fertilizer top-dress)
3. Number of days above 30 C in June and July by April 15 (crop species; planting date; fertilizer).
4. Last spring frost of -3 C or greater by April 15 and heat units/length of growing season (planting date; crop species)
5. Winter temperature minimum and snowpack depth by September 1 (winter type seeding decision; fall fertilization / N fertilizer type)

Are there ways to increase yield response to increased CO2? There should be a system set-up on the prairies to test new products/genetics to high CO2. The brassica germplasm differs in response to varying levels of CO2. A four year study of 18 soybean genotypes showed genetic variation for yield under high CO2 that was consistent enough to be heritable. There is a need to look at improved N uptake and utilization efficiency under increased CO2 and other production factors in a high CO2 environment. Current methods where brassica oilseeds could fix atmospheric N could improve response to CO2 by moving away from NO3 nutrition. There are a range of methods to measure response of brassica oilseeds to high CO2, such as in the growth chamber, open top growth chamber in field, or free air concentration enrichment in field.

On-farm Trials

Bernie McClean, Grower, Director, SaskCanola

Social license is very important for producers; the license to farm. Generally, the urban population does not understand farming anymore because they are so far removed. Their misunderstanding is influencing government regulations. Farmers need support to help bridge that knowledge gap. @licencetofarm on Twitter.

Big data will hopefully be incorporated into farming, but should not replace research. There are a lot of products claiming to add bushels, but they need to be proven in the field. Input retail can be using information to generate data for growers in their regions. Independent farm trials are great for proving products efficacy for personal use. Big data will probably help overcome the labour and time intensiveness of farm trials. Farmers should be encouraged to do their own trials, with the availability of GPS, CCC protocols, flags, yield measuring tools; it is fairly easy to do.

Integrating Technology, Data Sources and Agronomics to Maximize Crop Production

Ryan Adams, Manager, Agronomic Services, Crop Production Services Canada

Where do our fertility recommendations come from? *Nrecommendation=Ncrop-Nsoil-Nnetmineralization. A* Nitrogen response curve helps to determine recommendations and determine base line for nutrient levels. Take into account N net mineralization and immobilization which is hugely affected by moisture. As a function of moisture you can create curves that dictate how much N to recommend based on wet or dry conditions.

There are a lot of a data sources on the farm: seeding (fertility and seeding rates), spraying (products applied, rate, placement, water volume, time and date of application), harvesting (yield, moisture), etc. Big data can validate or improve yield response curves, provide prescriptions for variable rate programs, and validate that our best management recommendations are correct under various conditions.

Information is Just Information…Unless it Inspires Action
Desmond Ballance, Senior Project Manager, LIFELEARN
Three components of learning are to understand, to remember and to recall. There are three points to consider when providing information to people to truly learn. It is relevant? It is visual? And is it effective? Use these questions to evaluate communication.
Relevance: considers the relationship between what one is learning and what one already knows.
Visual: invites curiosity, communicates faster, promotes retention/retrieval, and encourages forgiveness.

- keep visuals simple so they are easy to quickly take in
- also, it can be made different and "fun"

Effectiveness: Rule of 3. Three because we look for patterns and 3 is the first size at which you can see a pattern. Keep it in bite-sized chunks. This allows people to drop out and tune back in, turning the brain on and off.

Public Research Institutions and the Growth of Canada's Canola Industry
Dr. Wilf Keller, President and CEO, Ag-West Bio Inc., President GCIRC
Over the last 25 years, there has been an emergence of multinational enterprises as predominant players in germplasm development. Public breeding programs changed focus to "germplasm development" and genomic applications. Federal laboratories engaged in canola R&D (research and development) post 2000: AAFC Saskatoon and The National Research Council of Canada (prior to 2012). The universities currently engaged in canola research are: University of Alberta, University of Saskatchewan, University of Manitoba, and the University of Guelph.

The US was ranked #1 in the Top 15 Countries with a total number of influential scientists of 1,616. Canada came in #6 with 89; there were less than 10 Canadians in the general forestry/agriculture/food area and there were no recognized plant/crop scientists.

There is an underfunding of basic plant biology in Canada. NSERC (Natural Science and Engineering Research Council) is the primary funding body for basic plant science Average grants are in the range of $33-36,000/year with total funding available for all genetic and basic biology (not just plants) in the order of $3-3.3 million. Compare this with CERC (Canada Excellence Research Chairs) with funding at $10M over 7 years per chair (25-30 chairs in Canada). Is there a correct balance between "super stars" and the "farm club?"

Canada's canola industry continues to do well, but public research has been critical in the past. Will it be in the future? Canada has emphasized short term research with tangible deliverables. Agri-food research has been delisted at NSERC and is not a priority with STIC (Science Technology and Innovation Council). Public sector organizations have previously been very valuable, but much public input has come from federal organizations (excessive red tape).
The roles of public and private sectors in crop R&D&C (Research/Discovery & Development & Commercialization): Public (ideas, concept development), Public/private (proof of concept, pilot studies, and early development), Private (late development, commercialization).

There are many opportunities, for instance, in reproduction and seed biology, photosynthetic efficiency, root/rhizosphere biology (water use and nutrient use efficiency, plant health) need to be considered. The Canola Council of Canada can play a proactive role to help impact federal research policies, re-examine their research strategy, and develop a strategic advisory committee.

CANOVISION - DISCOVERY FORCE TASK PANEL Q&A

Q: What is the forecast going to be for 2016?

A: Ray Garnett responded that there is a hint of the weather for next summer, but no forecast as yet because they do not have all of the predictors.

Q: Based on the research, that is a very significant challenge that was outlined. What is it going to take and how can the canola industry support what was proposed?

A: Wilf Keller added that an important place to start would be the federal government. There are plans for the federal/liberal government to reintroduce the chief scientist position. That could be very helpful. This summer Mr. Knox was appointed as the executive director of the Science Technology Innovation Council of Canada, so there is an opportunity to work more aggressively with the federal government. It is about science policy for sure. There has been a tremendous degradation in the number of the people. And, of course, there needs to be a restructuring of the balance between discovery, development, and commercialization.

Q: What do you think producers would have done differently if they knew there would be a drought during the seeding and spraying season, specifically in Alberta?

A: Ray Garnett said lentils were probably the best crop for drought and cutting back on inputs.

A: Murray Hartman commented that if we had known it would be so dry, perhaps the message about seeding depth could have been modified to 1". There was also a very late frost, so seeding early because of good moisture was a poor message. Other crops that could have been seeded deeper, for example, peas did well. There is not a lot of good research on conditions and what to do in light of them, because of not being able to predict what those conditions will be.

Q: What is the proper message about breeding methods and techniques associated with GMOs and non-GMOs for the average customer? If genetics are being changed, they think it is still GMO. What is the best way to communicate a simple message that it is not GMO?

A: Jim Radtke replied that there is no simple message. Clear communication is needed. Keep it simple. When talking to people about RTDS and gene editing, the point we make is that these are traits that would happen in nature given time. It is something that can naturally occur, but we can make it happen faster.

A Bernie McClean added that the simplest answer is: do you believe in science and our regulatory system? Science is key. Communicate to people that science and our regulatory system are trying to do what is best for us.

Q: How can this message be made simple? In a previous answer, the words RTDS, editing, genomics, were used; the general public probably does not understand any of these words. This question is for Desmond: how do we make those messages so that the general public can understand what we it is that we do? What would your advice be?

A: Desmond Ballance responded that it is a matter of understanding the public and they are just like you. If you can think to that level, take out the 4 syllable words and still get that message through. Use pictures and analogies, find things that relate to the public and what is going on, even at the basic 'blue m&m' level. There is a fear around science - stats, graphs – so try to make it not so scary and then stop there. As soon as people are overwhelmed, they shut off.

A: Wilf Keller also added that when it comes to GMO and new technology, there is a need to emphasize the benefits. The other piece is political will. There is a need to go head to head with the activists, because they have a lot of money.

Q: The development of canola started out in the federal sector and universities. Now, it is more in the private sector. How can we entice the federal scientists and government to invest in research if they think canola is a completed success story?

A: Wilf Keller stated that we do have to start working /lobbying with the federal government. Agriculture has to be moved into a much higher visibility file. Many bureaucrats see agriculture as a mature industry, and that is not true. We are a major exporter of food products in the world. Agriculture needs to get into federal priorities; it has not been there since 2007, start with federal research policy.

A: Jim Radtke thought that maybe the discussion has to be changed. Instead of saying here is important data; maybe it needs to be a bit more personal, like “here are some positive things that can come out of investments.”

Q: Are there countries that ‘get it’ when it comes to accepting the potential benefits of your work?

A: Jim Radtke responded affirmatively saying that we tell them what it does, show them results, and ask what they think. Every regulatory body that we have talked to so far has come to the same conclusion as the USDA: yes, this is mutation, and it should be accepted. UK and Germany have agreed that our technology is mutation and should not be regulated. We are still waiting for a final EU decision, but there has been good experience talking to the regulators using that kind of approach.

Q: What is the current yield potential for canola?

A: Bernie McClean said that the 100 bushel challenge is a way to explore those limits. The 80 bushel mark has been thrown around as genetic modification target. It is questionable if you could reach a whole lot more and still keep money in your pocket. It is a great challenge to see where we can go.

A: Ryan Adams commented that the 100 bushel canola mark is achievable in small scenarios. Should we look into those systems more, instead of guessing?

Q: A few months ago, there was the International Rapeseed Congress, and it was recognized that the right research needs to be funded to achieve the 2025 goal. It provided a good snapshot of research in various parts of the world. Where does Canada stack up against other countries in the canola research world?

A: Wilf Keller responded that there is a lot of room to expand canola yield, not in genetics, but in agronomy - phenotyping and the instrumentation that is put in technology. It is the next generation of canola genetics that needs to be addressed. It requires strong foundational work, and what was interesting at the Congress was the very strong presence from China - 150 out of over 800 people. They have hundreds of people working on aspects of canola. They are basically rebuilding the crop for all kinds of traits. So if China is a possible frontier for breakthroughs in canola, a lot of thought needs to be directed towards how to position ourselves and work with these other groups. There may be a need for global network of major centers to work together to take this crop to the next level.

Q: It was mentioned that there is a lack of funding for some basic research. Is this a role for grower groups to pick up, or should they be focused on applied research?

A: Murray Hartman answered that in the past, it was his opinion that it was not the role of the grower group funding to be doing the basic research, but that was considering that there was an existing infrastructure. As that dries up, that will fall to the grower groups, who will need to be very selective, because it is very expensive.

Q: What assumptions are being made about the climate when there is talk about boosting yield? Say the earth gets cool or warm, will CO2 continue to climb? Does it matter whether it gets hot or warm? Is CO2 the big driving factor?

A: Murray Hartman replied that CO2 will increase no matter what, but the impact of CO2 actually helps plants cope with dry conditions, so if yields go down, it will not be by as much if it gets warmer and drier. Murray calls CO2 a meganutrient for crops: it as important as micro- and macro-nutrients for crops.

A: Wilf Keller said CO2 will play a very important role, but CO2 is a plant nutrient. The environmentalist would have us believe it is a toxicant. Plants could carry on with four times the CO2, so Murray is quite right. There is a need to work towards making plants as efficient as possible under those conditions, we need to increase photosynthetic rate. Research needs to be done.

A: Ray Garnett added that CO2 is not a pollutant, it is an inert gas.

Comment: Two key words in agriculture going forward are youth and profitability. It is encouraging to see young people entering the field. As work is being done on science and big data, and to see this industry grow, there is a need for youth and profitability. There needs to be profitability to encourage youth. There were also earlier comments about the importance of agricultural education in the classroom and that time and resources should be made available.
Response: Wilf Keller agreed saying that the youth is picking up at university, so obviously there is uptake and this needs to be sustained.

Q: What are the greatest challenges facing canola growers today?

A: Ryan Adams felt that this was definitely geographically dependent. In Northern Alberta, the biggest challenge is disease management. Disease management, going forward, is a huge challenge working with the varieties that are currently available.

A: Bernie McClean thought that the social license aspect could be a lot more important than production because if growers become too restricted through policy and are not allowed to produce, there will be major problems.

A: Murray Hartman said that too much of a good thing is canola's problem. There are two crops that tend to have high returns, so there are wheat-canola rotations which tend to bring problems like clubroot and new pests. A nice crop rotation is preferred to reduce ups and downs. Economic returns can swing quite a bit with reliance on two crops.

A: Wilf Keller agreed with the social license aspect: producers need to be prepared for whatever comes. It goes back to educating school kids and promoting awareness. This industry can be hurt by things that cannot be perceived at one point. The second consideration is soybeans where there is certainly a drive to promote soybeans at the expense of other crops. Gene editing tools will have large applications with creating high oil soybean, and there is a need to think about this implication. Thirdly, sustainability: there is no more acreage for canola expansion, there needs to be intensive research to sustain yields.

A: It is important to develop technologies to provide choices for growers.

Q: Have you got experience talking to the general public and policy makers to promote an understanding of science and support work on farms?

A: Desmond Ballance responded that this has not been specifically done. It comes down to what is important to you and where you see the value; that is the strategy. Do growers feel like they are getting the information they need, and do speakers have the tools to communicate that information to them? Inconsistent messaging is certainly a challenge and we see it constantly, so are the communication tools in your industry doing their job?

Q: What are the biggest opportunities for canola growers today?

A: Bernie McClean said that with the technology available today, how can we not go forward?

A: Wilf Keller replied that for the short term, it is the package of management tools available. Also, trade is important: the TPP could provide significant trade opportunities. Thirdly, it is food genetics.

A: Ryan Adams added that there is opportunity in increasing efficiencies in all steps of the production system. Big data going forward will be creating more efficiency on the farm and in crop production.

Closing Remarks: "Things I've Learned"
Curtis Rempel, Vice President Crop Production and Innovation, Canola Council of Canada

- Every quarter section a combine travels pulls in a half a million yield data points. The take home message is: how do we put all of this data to work? It is clear that this is a big challenge.
- One variety does not fit all of western Canada. Canola varieties can be adapted to different production zones of the field. This may be important to consider in the next generation varieties: how can they be deployed in different zones in the field?
- We need to trust our sensors in terms of collecting all of this data.
- Does big data eliminate the need for traditional research? The quick answer is no. Research is primarily hypothesis driven and this takes a large research driven community. Big data will allow us to formulate better hypotheses.
- The root microbiome is a new frontier and will have a significant role in production and profitability.
- Images are useful but are incredibly data intensive.
- It is not the drone, but the data. It is the data that is important.
- Better weather forecasting is important. CO2 is a meganutrient and we need to learn how to use this more effectively.
- SaskCanola has a new video on social license to farm. This is a whole new dialogue to have and is very important.
- The canola yield potential is staggering and could be as high as 140 bushels/acre with current genetics.
- Visual cues are important in communicating narratives.
- We are lagging in Canada today in terms of our basic research on canola. We were once a powerhouse and there is an impetus to get us back.to being one of the top groups of the world and to becoming an important collaborator in improving canola yield, profitability, sustainability and reduced crop production risk.
- The Canola Discovery Forum is an idea incubator.

2015 Canola Discovery Forum
CPT WORKSHOP
Coast Canmore Hotel & Conference Centre Canmore, Alberta
Thursday, October 29, 2015

INTRODUCTION AND OBJECTIVES

The CCC Strategic Plan 'Keep it Coming' identifies four agronomic and one genetic pillar which will provide canola growers with the 18bu/ac increase required to bring the (collective) average yield from 34bu/ac up to 52 bu/ac by 2025. As the next generation in variety evaluation for Western Canadian canola growers, the Canola Performance Trials (CPTs) help facilitate that yield boost from the genetics pillar by providing relevant and unbiased data to growers and agronomists through the CPT website, booklet and all three provincial seed guides.

After the number of CPT participants changed this year, the relevance of the program has recently been questioned and discussed more. Since Canola Discovery Forum includes attendees from all sections of the industry, it is a great venue to find out: w**hat role should the CPT program fill and what utility should it provide in order to be the most effective tool it can be to the industry?**

A BRIEF HISTORY OF THE CPT

In 2001 – 2002 the canola variety testing was coordinated by provincial governments and the results went into the provincial seed guides. When the continuation of the program was under question, the grower organizations indicated their strong support for wanting third party/unbiased representative data on top commercial varieties, emphasizing the need for this type of program. So utilizing the cost recovery model from the WCC/RRC public coop trials and with Raymond Gadoua to coordinate, the first year of the Prairie Canola Variety Trials (PCVTs) took place in 2003. This program continued until 2010 when concerns over the program arose. When no data was collected for 2010 the provincial seed guides published WCCRRC data instead.

After extensive consultation, the grower groups and seed companies agreed on an updated version of this science-based canola variety testing program to begin in 2011. It would include both governance and technical committees, be administered by CCC and funded by the grower groups and seed company entry fees. An outside contractor would coordinate both small plot research and field-scale trials that would be conducted by the seed companies and audited to ensure no bias. In addition to the provincial seed guides, the results that would be distributed through a website and a printed booklet and would include the gross revenues/ac values of each variety tested.

The Governance Committee directs the management of the canola variety trials and is made up of four grower group representatives (from Manitoba Canola Growers Association, SaskCanola, Alberta Canola Producers Commission and BC Grain Producer Association), three provincial oilseed specialists (from Manitoba, Saskatchewan and Alberta), three Canadian Seed Trade Association (CSTA) representatives as well as at least one (non-voting) CCC representative. While the smaller Technical Committee made up of three provincial oilseed specialists, three CSTA representatives and at least one CCC representative focus on maintaining data quality.

Since then, the CPT program has produced canola variety test results from 2011 to 2014 and is currently working to complete the 2015 CPT booklet and website update as well a market research study.

CPT PROGRAM HIGHLIGHTS, LESSONS AND INNOVATIVE OPPORTUNITIES

Building toward the innovative opportunities for the Canola Performance Trials (CPTs) Dr. Rale Gjuric, the current CPT contracted coordinator reviewed how the program has continued to evolve with entries being grouped by herbicide tolerance, the trials being inspected and data scrutinized by the technical committee, including both small plot and field scale trials, calculating gross revenues in the booklet and increasing the number of successful sites/growing season from 57% in 2011 to 81% in 2015.

The program has faced several challenges, including: technical difficulties with spraying with different herbicides, unbalanced field scale trials, partly addressed issues of mandatory check varieties and a minimum number of sites and incomplete company participation due to voluntary program participation (not having all products on the market represented).

However, before any changes are made to the program, the main objective of the program should be defined (e.g. to provide growers and industry members with unbiased variety performance comparison within a set geography or the best prediction of variety performance on one farm in the next season). With this objective in mind, the specifics of the program (e.g. trials to include small plot, demo size (mid-sized) plots, and farm scale data only? Incorporate management techniques?) can be clearly evaluated. This also allows for the potential development of performance prediction models and various data analysis methods based on all the kinds of the data available.

BREAKOUT SESSION: KEY FACTORS FOR EFFECTIVE VARIETY TRIAL RESEARCH

Keeping in mind the question of the day, '**What role should the CPT program fill and what utility should it provide in order to be the most effective tool it can be to the industry?**,' each of the following five topics were considered at each table in each sub-section of this break-out session.

1) **Data quality and quality assurance:** What steps should be taken in order to validate CPT data (small plot and field-scale) in addition to looking at CVs?
2) **Trial design:** Are small plot trials and field-scale trials **both** a necessary part of the CPT program?
3) **Data timelines: what is a reasonable solution?**
4) **CPT data parameters: Should more be added?**
5) **Potential collaborations to investigate?**

CPT market research survey review

In order to address the concerns about the usefulness of the CPT data, the timing of which the data is made available and the direction that the program should take going forward, the CPT Committee agreed to conduct a survey. It will target Canadian canola growers, retails seed company representatives and other industry members and will assess the perceptions and value of variety trial data, with regards to the CPT program and making purchasing decisions.

The workshop participants provided critiques and commentary on the survey questions, which were then compiled and incorporated into the final draft of the CPT survey.

THE FUTURE FOR CPT: ROLE AND UTILITY

The primary focus is for the CPT program to produce high quality data as the program continues to evolve. Currently the data auditing is well vetted and both Rale's statistical work and ability to inspire collaborators is going well. The number of site visits seems to be sufficient to maintain quality control. Compliments were given to Anastasia and other provincial oilseed specialists on using the CPT dataset to get the seed guide data ready for the booklet. The quality of it is very good despites some outliers.

Some the concerns and suggestions that were also mentioned, included:

- The decrease in the number of seed companies involved with the program is an issue. The data set would be more useful for making variety choices if all varieties were represented.
- Maybe some of the local retailers should be approached as there is an extensive agri-retail network? If so, we could share protocols and good information with them (and would have a larger data set).
    - However, there could be strengths and drawbacks to working with the retailers, in terms of the large scale data. It could be valuable if the retailers are able to code the bags and put them in blind so that they're unbiased. But this would limit comparisons in some counties (and potentially where it's most useful).
- The greater the number of sites, the better for stats and the more trustworthy the data and more precise, so maintaining high site numbers is also important. This also affects the sensitivity of the tests that can be run and whether some varieties are significantly different or not.

SUMMARY OF WORKSHOP FINDINGS

With the CPT survey, we will see how many growers and other industry members see value in it too. Dr. Rale Gjuric presented some different ideas of where to go with the program and the data that is produced from it, so we can see which options make the most sense and start incorporating them.

In the breakout sessions it was found that the incorporation of more inspections could be beneficial, but how to accomplish this remains a question. Regarding yield monitors, there were some mixed results, so maybe the industry isn't ready for a shift to a different system just yet. There was also interest in incorporating harvest protocols, along with a few questions around what other traits should be compared, what the experimental design would look like and how would the protocol evolve over time.

In the other breakout sessions it was generally agreed that both small plot and field scale data are necessary, as they both provide valuable information. On the topic of data timeliness, which is one of the areas that will be addressed in the CPT survey, it was generally agreed that we can't compromise the quality of the data, but need to get it out and available faster. The minimum number of sites that should be required before the data can start being posted was also discussed. While some people thought that a number - as low as 4 or 5 - could be used, other thought that a percentage of sites (ex. 50% of all the sites) could be used as a minimum threshold. Consensus agreed that good data is better than fast data that will need to be changed later.

In the last two breakout sessions, it was agreed that, in terms of CPT data parameters, more information is better, but determining the best parameters to incorporate still needs to be decided. The idea of working with new collaborators on the CPTs was considered a pretty good one as long as protocols are followed and site inspections occur to maintain high quality data.

2015 Canola Discovery Forum
CLUBROOT WORKSHOP
Coast Canmore Hotel & Conference Centre Canmore, Alberta
Thursday, October 29, 2015

Where is clubroot and where is it going?
Gayah Sieusahai, Pest Regulator Officer, Alberta Agriculture and Forestry
Alberta,
2003 – Clubroot was first identified in Alberta. There are now over 1800 fields infested in Alberta. Fields have been reported with >10m spores/of soil.
2013 - Six fields of clubroot resistant cultivars were found to have clubroot. Known resistance tested on these strains with typically >90% infection.
2014 – A targeted survey was done of about 250 fields and 27 new fields were found to have clubroot; 16 fields were determined to be a pathogen shift. In addition to 5X, there are 9 distinct pathotype variants. There are new cases of increased virulence up to 600 km away from the typical center.
2015 - 32 new fields in central Alberta had patches of clubroot in clubroot resistant varieties. Testing is underway to determine pathotype(s).
Saskatchewan
2008 - Clubroot was detected in a 30 field random survey.
2009 - Clubroot was declared as a pest.
2011 - Two fields in St Louis and Aberdeen had clubroot galls.
2012 - One field was discovered in Biggar with clubroot galls.
Currently, about 100 fields have been targeted for visual and soil samples.
Manitoba
2005 – Clubroot was found in soil from one field at low levels.
2012 – There were two fields at low soil levels for clubroot spores.
2012 – The presence of clubroot was found in soil from six fields, two fields had enough spores to produce galls when tested.
2013 – Clubroot galls were found in two fields.
There has been limited testing with <5% of fields tested. Of 48 fields with soil detectable levels – two produced clubroot galls.

Questions/Concerns:
Three provinces do not share consistent survey and reporting methodology.
MB map, for example, is based upon soil detected spore load.
Survey training is critical, as staff surveying seems to dictate discovery rate.
Sturgeon County has no regulation in contrast to Leduc which is regulated to 4 years, with checks of every field every year. There is very limited pathotype shift reported in Leduc.

Where and what to look for?
Victor Manolii, Research Associate, University of Alberta
A summary of 10 years of research and surveys:
At a concentration of 10^7 or 10^8 will show wilted canola plants with huge galls and significant yield impact. Soil movement is exceptionally effective in spreading this disease.
Where to look?
A. Find infested patches - characterized by poorer growth, presence of weeds, differences in color, and early death or wilting of canola.
B. Scout near the main field entrance - the entrance that gets used the most use and has the highest traffic.

C. Scout alternate entrances: ditch access, through farmers' yards, highway, via bridge access, alternate entrance near bin yard, alternate entrance near bee yard entrance, oilfield pipeline, and industry access. (downwind from bin yards was mentioned)
D. Scout low areas of the field - moister areas favor clubroot disease.

What to look for? Find the galls!
At 6-8 weeks in some fields there can be some evidence of galls. Check as early as possible to find infected plants before the infection level increases. This allows the farmer to deploy BMP quickly. As soon as a field is infested it is near impossible to eradicate. A western survey from 2007 - 2009 revealed that 90% of clubroot cases were found at the main entrance. It is important to consider where there may have been an old garden or areas where soil was moved onto the farm with some other activity.

Discussion:
Background presence or inoculum spread across the prairies.
There was some discussion that adaptability maps indicated that if clubroot was present earlier than 2003, clubroot was well adapted and would have appeared earlier given the chance. Survey results in the past may not have gone far enough outside the boundaries where clubroot was expected. Resistant varieties are currently encouraged to be used early.

Labelling and Classifying new Clubroot Strains
Stephen Strelkov, Plant Pathology and Associate Chair, University of Alberta
Preliminary Assessment:
Resistant clubroot cultivars represent the most effective clubroot management tool. Multiple strains of clubroot are known to exist; these are referred to as 'physiologic specialization' or the occurrence of multiple races or phenotype. Strains are identified by their virulence on a host differential set. Three differential sets are most commonly used: Williams (1966) 4 hosts; European Clubroot Differential Set – ECD (1975) 15 hosts; and Differential of Some et al (1996) 3 hosts. Williams is the most frequently used.
A pathotype diversity in Canada chart shows Pathotype 3 predominant in AB (90%) is highly virulent on canola. The population in Alberta is characterized typically as Pathotype 3, 5, 2. Clubroot resistance was very effective, and in many cases became the only tool used to combat clubroot ***but,*** *P. brassicae* can adapt to selection pressure from resistant varieties, this adaptation then increases the diversity of the pathogen. In 2013, 6 fields were discovered that had increased virulence on resistant cultivars. Greenhouse testing on one of these fields showed 99% disease severity vs <2% disease severity from pathotype 3. Based on Williams set, this strain was identified as Pathotype 5, but this did not explain its increased virulence on canola so it became referred to as 5X.

A survey in 2014 found 27 fields with higher than expected levels of clubroot in resistant cultivars. Pathogen populations from these fields were retested on the same resistant varieties. Increased virulence were confirmed on 16 of the 27 fields; most causing severity of 90% or more. New cases were not restricted to the immediate area of the one field in 2013. These findings indicated multiple events of selection for resistance breakdown. It was clear that the William Differential set, and others, were not sufficient to distinguish these new strains. Canadian Clubroot Differential Set, ECD Set, Williams, Some, and Medal, Brutor, Westar and Commercial CR cultivars. Virulence of this newer differential indicated 9 distinct virulence phenotypes. Inclusion of additional differentials revealed multiple variants of other pathotypes from earlier differential sets. One variant of pathotype 3 was the most common in 6 of the 16 populations, virulent on 10 of 13 members of the differential set. One variant of pathoype 2 was highly virulent attacking 11 of 13 differentials.

NOVEL STRAINS tested so far are tested as field populations – from a single gall. But likely represents a mixture of pathotypes. Analysis of single spore isolates will also be important.

Next Steps:
In 2015 there were 32 fields identified with increased virulence. This is now being confirmed directly. Data from 2014 populations will be combined with 2015 data to finalize list of host genotypes planned for the Canadian Clubroot Differential set. A nomenclature system also will be proposed.

Emergence of novel clubroot strains cable of overcoming varietal resistance is a serious threat. It is important to develop effective ways to characterize and classify these strains in order to properly focus clubroot breeding activities. A putative Canadian Differential system is being established which should assist in these efforts.

A question was asked on what is known about the history of fields with breakdown? Who is responsible for analyzing? Rotation, spore load and variety would be valuable information for all of these fields.

There was a discussion on the suitability of differential sets: in Europe they use a + to distinguish strains that are virulent on Mendel and Mendelson as well as the differential set. Clubroot incidence in vegetable/market gardens in the clubroot area was discussed. The question was asked if spore load can be used as a guideline for managing this disease. The Manitoba approach to clubroot was discussed and the European use of this concept. PCR test is approximately $100/sample. qPCR reporting based on 10^5 or higher level of spores, below that it is difficult to detect and is results are uncertain. It was felt that soil fertility sampling was not an appropriate way to look for clubroot, particularly when the most valuable clubroot sample is at the field entrance. Bioassay: checking plant roots in the field is the most effective way to look for this disease.

Resistance against 5X Clubroot Strain
Fengqun Yu, Molecular Plant Biologist, Saskatoon Research Centre, Agriculture and Agri-Food Canada
Preliminary work:
Triangle of U of the plant genus Brassicae sources of resistance comes from related relatives. More than 1000 lines of Brassica species were screened. Resistance in canola is very rare: Mendel Variety and one rutabaga. Nothing was found in carinata or juncea in this search. Brassica rapa (mostly vegetables) had a few resistance sources. Brassica oleracea (cauliflower/broccoli/cabbage) had rare sources of resistance. Brassica nigra is a rich source of resistance, but is further removed genetically. It is speculation regarding the narrow source of resistance in our current lines shows as susceptible to 5X. Three isolates tested for P5X, LG-01, 02, 03 and the BN-E-09 napus line was resistant to these three strains. Resistant sources tested 5 – B rapa, 1 B nigra and 1 B. oleracea. Three strains reacted differently across these donors. Four of these show resistance to LG-01 isolate. One additional juncea and B. carinata line had resistance.

Germplasm resistance is available in three napus lines, one juncea and a carinata line. Of these resistance to all the three isolates is available in one napus and the juncea and carinata.

Work plan:
Develop isogenic B. napus line with these three resistance genes (RCr3,5,7)
Identify and map genes
Develop SNP markers for each resistance gene
Tranfer clubroot resistance genes in BN-E-O9 into canola

Characterize resistance specificity in Canadian B. Napus.

Research Project: Identify and Genetic mapping of B. napus for resistance to pathotype 5X of *P. brassicae*
Collected 800 brassica napus lines and identify QTL's through association mapping and major R genes using bi-parental genetic mapping.
Determine if current resistance to 5X associated with earlier genes, if not remap and develop SNP's.
Characterize the new amphidiploid lines
Screen B. oleracea for resistance to P5x.

Summary
B napus, juncea and carinata lines resistant to P5x developed.
SNP markers linked to Rcr1 & 7 developed.
Consortium for clubroot resistance proposed.
There is the need to diversify our germplasm choices.

Discussion:
Single spore isolate testing is critical. What we call 5X is a mixed population currently.
What genome has the resistance sources?
B genome 3 lines, A genome – mixed results, C genome candidates promising.

Clubroot Steering Group and Research Update
Bruce Gossen, Research Scientist, Saskatoon Research Centre, Agriculture and Agri-Food Canada
Research Update: What have you done for me lately?
The Clubroot Steering Group is made up of 17 members consisting of researchers, grower groups, and lifescience companies.
There is the recommendation to no longer use the 5x designation; for now it is suggested that x could be term used. There was discussion about the applicability of this "unknown" system.
A map of Manitoba will soon show 30 of 48 Municipalities identified with clubroot, Saskatchewan will show limited detection as it is still based on field level symptoms. This does not appear to be something easily reconciled.
Where do we recommend resistant canola be grown? If clubroot is present in your "community" you should grow a clubroot resistant cultivar. (Whatever community means to you, and that discussion will help determine your risk.)

Management Strategy Discussion:
Long Rotation and Extensive cleaning are not popular management strategies. Other strategies to date have had inconsistent results. Resistant cultivars were quickly developed and adapted but, by 2008 through 2011 it seemed clear that movement and new infestations were occurring.
There are three principal research teams working together on aspects of clubroot. They looked at virulence patterning, clubroot surveys, role and impact of 1^{o} & 2^{o} zoospores, development of novel molecular approaches, mechanism of clubroot resistance, fungal endophyte research, fumigation, boron sensitivity, spore viability, and partial resistance among other topics.
Spore distribution in the soil is exceptionally variable.

Proposed Research Activities
- Resistance to 5x, x
- Identification of pathoypes in Canada
- Pathogen biology and physiology

- Cultural Management
- Epidemiology
- Other sources and types of resistance
- Surveys
- Fumigation
- Biologicals

Proposals for Steering Committee:

- Develop multiple sources of resistance
- Develop reliable screening techniques to assess durability of new forms of resistance.
- Identify and categorize new pathotypes
- Develop a differential set
- Molecular techniques for pathotyping
- Biology and physiology of clubroot
- Cultural control methods
- Surveys and Mapping

2015 Canola Discovery Forum
POLLINATOR AND BENEFICIAL INSECTS WORKSHOP
Coast Canmore Hotel & Conference Centre Canmore, Alberta
Thursday, October 29, 2015

Welcome and Introductions
Gregory Sekulic welcomed the group and outlined the workshop agenda and intended outcomes. In last year's call for new CARP research, some very important applications on pollinator health came in but did not get funded. Today we hope to design a framework for methodologies and protocols for these types of applications.

Presentations: Research objectives amidst an agricultural setting
Dr. Cory Sheffield, Curator of Invertebrate Zoology, Royal Saskatchewan Museum
Cory introduced himself as a bee scientist and taxonomist, primarily focused on wild pollinators. He published a paper last year on wild bee species, in which reported that the highest bee diversity is in the areas of Canada where we grow crops. We are not seeing a bee problem in Canada yet.
Bee diversity is important for the future of crop pollination. For canola we have great pollinators: the honeybee and the leafcutter bee. We currently know of more than 800 species of bees in Canada, and this is probably going to increase. There are up to 200 species of bees in Saskatchewan alone. Wild bees function differently than managed bees for crop pollination, but one thing that all bees need is flowering plants. Bees need food resources, and agricultural systems are abundant food sources for certain periods of time.
Encouraging the landscape to be friendly to native bees is beneficial. Bees are central place foragers and do not penetrate far into the crop systems as they will stay near their nest. Honey and leaf cutter bees are advantageous in that their nests can be placed throughout the crop. The big question is how we integrate aspects of the landscape (crop and non-crop land) to create habitat for wild pollinators. Also, do we need to look at using honey and leafcutter bees more effectively and managing wild pollinators? It would be good to know if yield is already maximized through the field or if there is a need to manage pollinators more efficiently. Natural parasitoids for crop pests in canola likely need some of the same things that bees need, so this is an important conversation.

Syrphidae make important contributions as the adults will visit flowers and use the same resources as bees. When abundant they will have a pollination effect, and will also predate aphids. In terms of monitoring, sweep netting allows for a quick look, but other ways to evaluate each of the insect visitors include bagging plants, pan traps, and malaise traps.

On the prairies the diversity of bees that will use nests we can move around is low. Therefore we need to consider the habitat of ground-nesting bees. Arid or dry habitats are the most diverse. Floral resources are minimal, so overall numbers won't be high but diversity will be. In the prairies there is a long history of modification. If there is sufficient natural habitat left, bees will thrive. It has also been found that well managed grazing land serves as beneficial to bees due to plant turnover and maintenance of soil quality and other insect populations.

Wetlands with bands of vegetation around them may have species for pollinators that are generalists, and also for specific pollinators. On the prairies we have the highest proportion of pollinators that only feed on one crop. The diversity of bees on the prairies is due to the diversity of the landscape. Badlands, wetlands etc. all have valuable plant species.

Dr. K. Neil Harker, Research Scientist, Weed Ecology and Crop Management, Agriculture and Agri-Food Canada, Lacombe, AB
Dr. Harker introduced himself as a weed scientist with a focus on management, cropping systems and minimizing herbicide use to mitigate weed resistance issues. The whole concept of beneficial insects and their importance to sustainability and profitability is just starting to come to mind and is of great interest. For example in Iowa and Ontario, more than 50% of weed seeds are eaten by carabids.

Dr.Lloyd Dosdall's research on beneficials is an important example to pollinator scientists. Lloyd preferred to go into established agronomic research areas rather than laying out plots. Going into agronomically relevant studies ensures that the research is agronomically relevant. Doing research this way allowed them to find out that some of the recommended pest management strategies were incompatible. It was discovered that If we let weeds stay in the canopy for a week or two longer, it will deter the female root maggot from laying eggs and there will be much less damage to canola. His key message: go into an agronomic study that already exists, and start collecting entomology type data.

Neil hopes that some of our economic thresholds for spraying will increase as a result of learning more about beneficials. A diversity of disciplines in studies is as important as natural diversity in finding relevant conclusions.

We currently only have economic thresholds for lygus and diamondback moth, and these were set a long time ago without knowledge of beneficials. For other insect species we only have nominal thresholds, which help to reduce insecticide use, but could be better.

There is a possibility to tap into crop variety trials, but there may be a confounding effect, e.g. bringing in lots of pollinators would increase yield. In the future cross-disciplinary collaboration on a large scale using big data is important. There is always a concern for entomologists that smaller plots are not on a large enough scale to be relevant to mobile insects, and most agronomists are very interested in moving to larger plots.

Dr. Paul Galpern, Landscape Ecologist and Data Scientist, University of Calgary
Paul introduced himself as an ecologist with an interest in big data, conservation and landscape ecology, and their effects on pollinators. The conservation impact of dealing with canola is huge, as it has become a prominent Canadian land cover. There is really an important role for wild pollination in canola crops. Even if it is only a small contribution to yield, the opportunity is huge and has significant benefits to both economic and social license.

Off-field management is an important factor in conserving wild pollinators. Paul's research group has been assessing off-field conditions. They are testing a gradient of landscape conditions and investigating how that has affected bee numbers and diversity. The pulse of bumblebees is totally mistimed with canola blooms, but we need to look at conservation, yield and canola all together. They are still identifying the species caught in the traps. Their first pass was looking at bumblebees, but there is still a lot of bycatch to go through.

It was commented that there would be a lot of people willing to set up these types of traps in their plots. As part of their analysis they take into account exactly how long the trap is deployed, correct for number of bees, collect high level weather information, and measure precipitation so they can discount this time, as bees are not on wing when it rains. They have been using blue vane traps. They would like to add in better comparisons in future seasons. There is very little

work in western Canada on yield and pollinators, and this type of information would be novel to canola.

Jennifer Otani , Pest Management Biologist, Agriculture and Agri-Food Canada, Beaverlodge, AB

Jennifer is a pest management biologist, and her presentation will focus on pest monitoring and what they have observed with lygus and beneficial insects. Their pest monitoring program has given them a better understanding of the types of beneficials that are in the canopy, and an overall better sense of what is in the fields. In the Peace the fields are huge and the canola landscape is massive.

Economic thresholds are very important. The end goal is to protect producers economically, but we also want to protect the beneficials. For example, there are documented levels of parasitism in lygus. Her research group has been working hard to get quantified data on the impact of all beneficials, and also estimating the impact of selected general predators. We need to demonstrate to growers that there is an economic benefit to having beneficials in the canopy. Her research group has done an annual canola survey since 2003. They cover the whole canola production region preferably in early to mid-flowering. They sweep net and keep 20 columns of data, looking at both pests and beneficials. They have created a long-term database that will be housed at AAFC Saskatoon.

An important point for scientists looking to study pollinators is that there is a whole network of people already doing monitoring in canola, and they would have no problem taking another 5 minutes to collect samples for another study. This is an inexpensive way to gain great information.

Wheat midge is a great example of the importance of beneficials. The standard rotation in the peace is wheat/canola. In 2011 wheat midge moved into the Peace followed by wheat midge predators. If canola is planted on wheat stubble, the grower needs to reduce spraying in order to not impact the beneficials for the subsequent wheat crop.

In her view, the three greatest challenges are as follows:

1. Demonstrate the impact and value of beneficials
    - Reduce the prophylactic use of insecticides
    - Improving monitoring and applying thresholds
2. Biodiversity and enhancing through habitat.
    - Field sizes of the future
    - Alternate host plants in margins. We know this is important for high biodiversity, but we don't have the data
3. Urgency
    - Productivity of arable acres
    - Urban sprawl
    - Climate change

Flea beetles are a huge problem economically and a difficult insect to control. There is no doubt that the areas adjacent to the field affect what we see each year for flea beetles. We also need to look at dipterans in a long-term large scale manner as we know interaction is variable on growing season.

Cory Sheffield mentioned that he has been working with molecular tools and has submitted a proposal to address some of these items, in particular the diversity of parasitic wasps. This is a good step to start looking at the benefits of parasites.

Ward Toma, General Manager, Alberta Canola Producers Commission
Ward Toma explained the producer check-off system and outlined their research collaborations. Both growers and beekeepers in Alberta do not feel that there are issues with neonics, but the fact that neonics are increasingly the subject of headlines is of concern. As a result, research in pollinator health is a priority. Farmers do not want to spray, and this is for both economic and safety reasons. Beneficials, cultural practices, economic thresholds, there is an interest in all of these areas.

Last year several proposals on bee health were received but not approved for funding. The CARP reviewers did not understand the bee proposals, and in turn they were not sure that the bee scientists understood agronomy. Therefore, they were not feeling that the proposed studies would yield the results they were looking for. The bottom line is that they fund research that solves a problem.

Farmers have not noticed huge yield increases from pollinators; however, they are interested in pollinator health in terms of neonics and social license. Pollinators, both wild and managed, can be classified as beneficials, a growing area of interest. In order to be successful research applications must answer questions on sustainability, protection of beneficials, and social license (not just today's economic problems, but social problems in future) with solid work and good science.

Scientifically, we do not have a good handle on the yield increase from pollinators. Also, there has not been a lot of work done to characterize what pollinators are present, and each of the species benefits canola. A question was raised on whether we need more work on this for the story to become compelling. Where this question would rank in a roomful of farmers is difficult to say and may depend on where they are from. This should not stop a good proposal from coming forward.

A long-term, large scale pollinator monitoring program would be considered as research. However, there is already a pest monitoring network in place, and it would be good to tie into that rather than having two systems. A question was raised as to whether we could leverage the bertha armyworm forecasting network for beneficials using the CARP cutworm project as an example. The network has only so many resources, but for projects that have value we will find people that will try to help.

It is very difficult to quantify the yield increase from pollinators as canola is plastic and grown across so many regions. Phase 1 of this research could be to nail down yield and proximity to habitat that allow all of these insects to complete their life cycle.

Group Discussion

It would be useful to look at range management/wetland/canola management together and cast canola production as part of a larger biodiversity piece with canola growers as stewards of the canola piece. . Consider canola as a habitat to be managed, and ways in which it has a specific role, separate from any other crop, in terms of pollinator biodiversity.

It is important to ensure both the needs of growers and the surrounding ecosystem are met. Individual growers would not have interest in speciation of bees but rather an interest in wild pollinators and other beneficials and what they bring in terms of yield. From a grower funding perspective this needs to be stated as financial impact of benefits of raft of species on yield. The value must be demonstrated, as in the Winston/Morandin paper which documented more productive plants in close proximity to diverse groundcover. This is big data, and we need to figure out how we even get these numbers.

A start could be with precision ag maps. We could overlay these with stats and work out what are the associations between wetlands, road margins, proximity to other natural systems, and tie this in with yield. We would not know what in the feature is causing the yield increase, but we will know if it is worth trying to figure out a relationship. To do this we would need to recruit farmers to share their precision ag data and correlate it to landscape conditions. We need to pull-out areas of low yield and high yield and see what is around them. We could also pull in beekeepers and get info on their bee yards to get some information on the influence of hives on yield.

Shelley Hoover in Lethbridge is doing this type of work. It is difficult to quantify yield increases, but there is a suggestion that if you get above 1 colony per hectare there are benefits, with a 46% increase at 3 colonies per hectare. Three colonies per hectare are not logistically possible in canola. It is also important to remember that the yield benefits in canola are also cultivar specific, some show no benefit and some show lots of benefit.

If 25% of land in an agricultural system is semi-natural there are benefits to pollinators. The question is if we broke up fields with some of this habitat, would the increase in yield be worth the loss of land and would that be a trade-off that growers would be willing to make. That is the crux of where we are at right now. We would need to have data to show why dealing with "natural habitat" in the middle of a field is important.

We need to characterize the species of beneficials and get an idea of their impact. If we were to lose neonics we would see foliar sprays come back in so we need to have a solid measurement of the value of keeping beneficials in the canopy. The danger in this approach is that we show no impact and farmers have no reason to retain biodiversity.

Having non-crop plants associated with a crop has benefits and builds bee populations for next year. We now have the molecular tools to determine the diversity of insects associated with canola, and then tie in economics. Right now for producers it is always about economics, and we need to frame biodiversity this way.

The current research on flea beetles at the U of M led by Alejandro Costamagna does not include pollinators, but it would be easy to sweep net for them. He would be very willing to try to incorporate other sampling and maximize their time in the field.

Although we could recruit producers to give us their yield data, we must determine how to analyze. It could be using GPS yield points, and determining what is around those spots. It would be best to use existing agronomists to start collecting as this part of their extension. To get buy-in we would need to focus primarily on yield.

There is a parallel situation in Ontario concerning windbreaks. The area saw windbreaks go in after it was shown that there is a demonstrated yield increase from slowing down the wind. But when farms are sold and get larger, those windbreaks start to come out. This shows that even with an economic indicator, we may not change behaviors in all farmer populations. However, we do believe we are making progress on a number of these fronts in canola. For example, the "just throw it in" mentality with insecticide is dwindling.

It we overlay parasitism data with bee data it should be a good indicator of what portions of the landscape need to be conserved. In addition to yield, let's not forget about sustainability and biodiversity, social license is becoming increasingly important.

In short we need to look at:

1. Which species are important
2. Which habitats are important
3. How do we relate both of these to yield

This is an awful lot all in one go. Yield is complicated and variable to many more factors. We would need enough sample sizes and points to overcome this variability and tease this data out.

There are enough growers that have raw data available and would be interested in being part of a “crowdsourcing” campaign. There would need to be a process to have growers to submit a USB stick and have an individual enter the data. This would really be a data management project, with the only costs being servers and people hours.

Ducks Unlimited mentioned a pulse project in which they are a collaborator that would be a good model. They are analyzing grower’s data from Agri-Trend and Farmer’s Edge after they have processed it. In this way they get cleaner data from the beginning.

When we recruit growers for the project, we would need to know what varieties are grown and what applications were made. An easy to complete template may be helpful. Another possibility for this type of information is Manitoba Crop Insurance. If there is an opportunity, it would be interesting to pair monitoring on the fields of participating growers to see what beneficials may be there.

Whichever model we choose, this is a huge undertaking and we need to employ a step-wise approach as we build capacity. As we get more information, we will get more people buying in.

Wrap-up

Gregory Sekulic thanked the group for their participation. We are very excited to move forward with some of the ideas discussed today.

RESEARCH PRIORITIES:

1. Big data, crowdsourced GPS based spatial analysis of yield and proximity to uncultivated land.
    a. Is there an effect?
2. Plot design to measure this effect, in situ, to capture this relationship with statistical significance
    a. What is the effect?
3. Molecular work to identify captured species rapidly
    a. Is that part of our mandate?
    b. Can we support it in other ways (IE: Crowdsourcing overlaps in pest/beneficial insect monitoring)