2016 Canola Discovery Forum
Meeting Proceedings
The Fairmont Winnipeg

Tuesday, October 25, 2016

WELCOME REMARKS
Meeting Chair: Brian Chorney, Chair, Crop Production and Innovation Committee, Canola Council of Canada
As producers in the canola industry, there are always adverse conditions that challenge canola production. It is important to look at how a resilient crop like canola can withstand all of these adverse conditions. Technologies such as GPS, RTK/overlay maps which improve drainage or pod shatter research which allows for flexibility of swathing operations are important tools to growers. Are there research gaps and what research will result in bigger yields? The Canola Discovery Forum looks for opportunities for new technologies to increase the resilience of canola and to define a path for the implementation of technology for growers that can be capitalized on.

DISEASE WORKSHOP – IS THERE A DOCTOR IN THE HOUSE?

SCLEROTINIA
Keith Gabert, Agronomy Specialist, Central Alberta South, Canola Council of Canada
Sclerotinia is still one of the most difficult diseases to predict.

Epidemiology of Sclerotinia – the Road to a Warning System
Dr. Luis del Rio Mendoza, Associate Professor, Plant Pathology, North Dakota State University
The disease cycle of sclerotinia is dependent upon weather factors which affect the viability of sclerotia in soil. Sclerotia can survive more than 3 years. Survival of sclerotia in the soil depends upon microbial activity and carpogenic germination (CG) and is influenced by soil texture, pH and moisture. Sclerotia do better in lighter soils. Constant moisture is better, with a soil saturation point of at least 25%. Fluctuating soil moisture can reduce CG while constant moisture can allow for more apothecia production. When the soil dries, the clock is reset and the time needed for apothecia to be produced is doubled. Why does this happen? Sclerotia will only produce stipes when fully hydrated (25% moisture) and research shows that full hydration can be reached in 5 hours. Questions still need to be answered about what happens in the top 4 inches of soil, what happens when soil temperature is taken into account and what is the association of soil temperature and soil moisture.

Ascospores are airborne and "effective transport" is less than 40 meters. The mortality of spores is highest when relative humidity is greater than 35% and temperatures are higher than 25^{o}C. The survival of the spores is affected by leaf wetness and UV light. Forecasting ascospore release: the duration of release depends on weather. Spores are released between 10 am and 1 pm and a full release of spores can occur if conditions present a seven-day period of 89-90% humidity under the crop canopy. A mean of 89% can mean a 50% chance of spore release. Ascospores germinate at 10-35°C while the optimum is 20-25°C. In terms of temperature and disease development, lesions develop at 10-30^{o}C, while the optimum is 20°C. The incubation period is 4 days at 20°C and 7 days at 25°C. Lesion visibility will decrease as temperatures increase. Plants' leaves can be destroyed within 9 days at 20°C and within 15 days at 25°C while no damage is seen at 30°C. The interruption of leaf wetness reduces and delays sclerotinia stem rot but does not stop its development. The effect of fluctuating temperatures, the effect on stem tissues and the effect of crop genetics all need further investigation. There is a level of resistance by plants.

An empirical disease warning system is made up of an extensive network of weather stations throughout North Dakota and relies on the data collection of precipitation, air temperature, relative humidity, and dew point. Extensive disease data is also collected from field surveys. Colour coded maps are produced every 3 days and producers can check their location. A logistic regression model (equation) is used as a sclerotinia risk calculator, taking into account most importantly precipitation and soil temperature and although not perfect, does have an overall accuracy of around 75%. The overall objective is to identify areas where there may be issues and whether lesions will become an epidemic and result in economic damage.

Questions and Answers

Q: Can you describe what 25% soil moisture looks like?
A: It is difficult to describe: field capacity is 50-75% saturation thus 25% soil moisture is less than the half the field capacity soil saturation.

Q: Is there a difference in isolates?
A: Yes. A single isolate was inoculated on canola, sunflower, soybean and dry beans and then sclerotia was collected. Sclerotia were then grown on media and all had the ability to develop into apothecium but among these the sunflower had best/most apothecia development. If sunflower is in rotation after canola, they produce good sclerotia. Sclerotia produced in canola are inferior to the sclerotia produced in sunflower plants. In canola, sclerotia are "lazy" in apothecia production.

Q: In the study which showed increased temperature reduced lesion, is it *in vitro* or *in vivo*?
A: All studies are live flowers that were inoculated and then were used to inoculate live plants then grown in the chamber.

Q: Are there benefits to spraying sulfur instead of fungicide?
A: Sulfur has fungistatic capacity. Formulation is the key: elemental sulfur is toxic to fungus but vaporizes easily. Timing is everything: doing the right thing at the right time. Do not skimp on water. With a contact fungicide, decreased water means less coverage and will compromise exposure to fungus. There needs to be good coverage of the canopy.

Q: In the disease cycle, which is more detrimental? Is it possible for sclerotia to cause direct infection of the stem by the mycelium?
A: Sclerotia can develop into apothecia or mycelium. Mycelium can directly cause disease – this is unimportant in canola but a big issue in sunflower because it germinates at the ground level.

Sclerotinia Risk Assessment for Economical Use of Fungicides; Sclerotinia Resistant Canola

Dr. Lone Buchwaldt, Research Scientist, Agriculture and Agri-Food Canada, Saskatoon

Screening canola for sclerotinia is being done in Saskatoon by a team composed of researchers, extension staff and growers. Sclerotinia is weather driven. Sclerotia germinate when leaves shade the soil surface and the soil is at water holding capacity for 7-14 days. Spores infect only when petals and pollen adhere to plants and there is free water (8° - 25°C).

Two scenarios:
Scenario A
- Low free water and temperature leading up to early flowering, fungicide application is not recommended.
- Wet weather conditions after flowering will not cause infection.
- 15% infected stems is not reached in most fields, so the accuracy of the 'do-not-spray' recommendation is high.

Scenario B
- When rain showers occur regularly leading up to early flowering then estimation of inoculum level becomes important.
- Fungicide application is recommended but based on several risk factors each with a level of uncertainty.
- Weather conditions later in the season also affect the level of disease severity (in either direction).
- Canola growers need to choose the level of risk they are willing to undertake.

Canola growers will benefit economically by separating scenario A from B.

To modernize sclerotinia-risk assessment in canola specific to the Prairie Provinces**,** the following is proposed:
- Develop a sclerotinia-risk App for smart phones that provides location specific, real-time rainfall data.
- Provide sclerotinia-risk points associated with rainfall, crop rotation and other factors.
- Provide calculation of the economic threshold for fungicide application.

This can occur in two phases: Sclerotinia-risk App1 and App1.1. App 1 will have location specific, real-time rainfall data and use the current cut-off for mm rainfall and associated risk points. In App1 the user will point to a map location to obtain the mm's of rain accumulated from 1 to 14 days in a 10 kilometre resolution. AAFC's Agroclimate group in Regina will synthesize the weather data using approximately 700 WIN weather stations and 50 federal or other stations across the Prairies. App1 will use the current risk points for crop rotation and disease in the last crop. App1 will have a built-in calculator showing a 3-D surface of canola yield, seed sales price and cost of fungicide application where growers will select a point that is specific to each canola field. App1 will use a cut-off of 15% sclerotinia infected stems corresponding to 7.5 bushels/acre (European data).

In App1.1 risk points for rainfall can be improved over the next 3-5 years based on correlation between mm rainfall and sclerotia germination in depots. Sclerotia will be sent out to depots in mesh bags (50/bag) and volunteers will report the % germination via smart phones. Information will be accessible to growers on SaskCanola's website but range is limited as each depot will 'cover' a maximum of 10 kms. An in-depth Canola survey is needed to look at: sclerotinia severity at harvest, whether fungicide was applied, a 10 year crop history, the canola variety, whether sclerotinia was seen in the last crop year and the soil type/zone. In App1.1 risk points should be re-examined with data collected in the Prairie Provinces over the next 3-5 years from growers using precision farming technology measuring yield in sprayed versus unsprayed parts of the same canola field.

The expectation is to separate scenario A and B and improve the risk assessment with scenario B. The proposed collaborators developing and maintaining the Sclerotinia-risk App will include AAFC in Saskatoon and AAFC's Agroclimate group. AAFC in Saskatoon will help coordinate people responsible for data collection, oversee App development, develop a calculator for economic threshold, provide sclerotia-depots, analyze data (rainfall, sclerotia germination, canola surveys, yield maps) and evaluate the accuracy of the App. The Agroclimate group will contract for access to WIN weather data and be responsible for the daily synthesis of weather data.

Sclerotinia Resistant Canola

Sclerotinia screening method currently used: the main stem is inoculated by attaching a plug of sclerotinia mycelium with Parafilm. The lesion length is measured 21 days after inoculation. This method is the accepted standard of the Western Canada Canola/Rapeseed Recommending Committee (WCC/RRC) used for the screening of canola lines with a claim of sclerotinia resistance. It is used to identify resistant germplasm in gene banks, map resistance genes and identify genes for cloning and transformation. This method can be used in the field and in the nursery.

Sclerotinia resistant *B. napus* sourced from Pakistan, South Korea, Japan, China and Europe. Seeds of resistant lines that are available from AAFC, Saskatoon include: PAK54, PAK93 (Pakistan), DC21 (South Korea) and K22 (Japan). A survey of sclerotinia isolates on the Prairies using DNA fingerprinting has identified 17 sub-populations. Inoculation with 17 representative isolates showed that PAK54 has the highest level of resistance and isolates SK35 and AB29 are significantly more aggressive than other isolates. The 17 sclerotinia isolates are available from AAFC. Molecular markers linked to sclerotinia resistance were identified in 5 resistant lines. These markers can be used for marker-assisted selection of resistant progeny in canola breeding programs. Molecular markers in PAK54 and PAK93 are available from AAFC, Saskatoon. The transfer of sclerotinia resistance from PAK54 to AAFC's elite canola line, N99-508 was performed and after backcrossing and the production of a population of double haploid (DH) lines, it was found that 17% of DH lines had sclerotinia resistance similar to PAK54, and early flowering similar to N99-508 when tested in the field in 2016. Canola quality open pollinating lines with sclerotinia resistance are available for licensing from AAFC, Saskatoon. Fine mapping of sclerotinia resistance loci was done on 180 *Brassica napus* germplasm lines and 114 significant markers were identified as defense genes. Genes underlying sclerotinia resistance pathway were identified. Transformation of *B. napus* with cloned defense genes showed results ranging from no effect to 40-50% reduction in sclerotinia symptoms relative to an untransformed line. The first generation of Sclerotinia resistant canola varieties were from Pioneer and CPS. The second generation (currently underway) from AAFC show new varieties with resistance from PAK54, PAK93, DC21 and K22 similar to N99-508. Hybrid canola transformed with one or more cloned defense genes (PEN1, lectin, hevein etc.) will encompass third generation material. Future objectives should look at which genes are most effective as well as identifying the best transformation strategy of hybrids, including different genes in the male sterile and female lines and stacking genes in one of the lines.

Questions and Answers

Q: How does one deal with sclerotia depots during the summer and their issues?
A: Sclerotia are subjected to cold temperatures (vernalisation) for one month before they are distributed to the volunteers. This will improve sclerotia germination.

Q: Is the App 1 still a test? When can it be launched?
A: There is hope to launch it in 1-2 years with a disclaimer. Forecast systems will always involve a disclaimer.

BLACKLEG

Justine Cornelsen, Agronomy Specialist, Western Manitoba, Canola Council of Canada

The concerns and issues related to blackleg management go beyond yield, quality and resistance stewardship to international market barriers. The use of management strategies such as variety selection or rotation of resistance genes over time, in combination with good quantitative resistance and best agronomic practices such as crop isolation, and four-year rotations of canola crops to minimize the impact of these new strains, should provide the protection necessary for successful canola production. Stewardship of blackleg resistance and agronomic practices designed to control blackleg are recommended to be used together.

Learn to identify blackleg at different stages, signs, symptoms - get out and scout! Fungicides need to be applied before symptoms develop in the plant, typically in the 2-6 leaf stage. On already resistant varieties, little or no reduction in blackleg severity or improved yield has been found when applying a fungicide. Lengthen rotation; there is the opportunity to grow other crops to help better manage disease and insect pests. Rotation has really been the only thing to make a difference in the long run.

In 2016, 800 fields were surveyed with the % prevalence of blackleg infected fields in all 3 Prairie Provinces ranging from 90% in Alberta, 80% in Manitoba, and 60% in Saskatchewan. In terms of incidence of blackleg infected plants, Alberta topped the list with 34% incidence, Manitoba with 12% and Saskatchewan with 7%. The relationship between blackleg severity and yield components can be explained by linear equations. Assume a 20% yield lost per unit of severity increase. The pod number will also decline as disease severity increases. Mitigation of the disease can improve yield and there is a need to look at which R genes should be used by producers/industry. It was estimated that $38 million was lost to Manitoba due to yield loss related to blackleg.

Update on Trade with China

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

China is the largest client of Canada's canola oil, worth $3 billion a year. In China's fields, only *Leptosphaeria biglobosa* has been found, not *L. maculans* that is found here in Canada. In 2009, China thought that there might be a risk of *L. maculans* entering the country on dockage. This resulted in new trade terms, collaborations and research to manage risks for non-transmission of the disease via seed dockage; what to do if there is transmission; report disease survey data to industry and to mitigate the risk to China by reducing the level of blackleg incidence by 2-3% in Canada. Many strategies are outlined and are currently in place, but this work with industry and scientists must continue.

Why am I seeing more blackleg in my R rated variety?

Lucette Badiou, Student, University of Manitoba, Grower

Lucette is a fifth generation farmer on the mixed dairy – grain operation farm in Manitoba. The farm is on class 1 clay loam and has 124 frost free days. A tight rotation was used with canola and spring wheat, along with alfalfa under-seeded to barley. In spring 2014, the same R rated variety was used and initially the canola crop looked promising; however, by summer post-flowering browning continued and there was early maturity with 95% blackleg from an R rated variety. Yields were 20 bu/acre, not the 60 bu/acre they would expect. The farm modified its crop rotation (alfalfa, canola, spring wheat, soybean, corn) and changed its varieties annually. These measures have reduced disease incidence to 5%.

Paul Saelhof, Grower, Paulisa Saelhof Farms Ltd.

Paul has been farming for 20 years. He is a fourth generation farmer from central Saskatchewan, has 17,000 acres in crop annually and experienced the same story. Three and sometimes a 2 year rotation were used. R rated varieties were badly managed. In 2010 there was early browning of canola, it looked like it had "smashed it down". The assessment was 75% blackleg with an R rated variety. The recommendation was to change varieties. When researching 2016 varietal trials on Google, the first hits were 10 seed companies. How do you get all the information? What does "R" mean and how should this information be used? There should be a narrowing of this designation so that proper decisions can be made and not rely on a 'single letter'. Is there more information that can be released? Disease is a major issue on the farm and the producer must be able to make an informed choice.

Introducing R-gene labelling in canola in Canada: Making durable canola production possible
Dr. Dilantha Fernando, Department of Plant Science, University of Manitoba
The producers were acknowledged for sharing their experience; they have set the stage for the research – demonstrating the importance of genetic improvement along with integrated farm management. The team of researchers, collaborators and funding agencies were also acknowledged.
What is known about blackleg: the infection can occur in any part of the plant.
Lesson 1 – Disease incidence of blackleg increased over time indicating the breakdown of resistance genes. The efficiency of resistance of the commercially successful cultivars has decreased as shown by the breakdown of R-genes in canola. Most Canadian cultivars carry the *Rlm3* gene along with 'unknowns'. The prairie population of blackleg surveyed from 2010 – 2011 showed that the percentage of isolates carrying *AvrLm3* (the supposed partner of *Rlm3*) is very low. To explain the breakdown of *Rlm3*: where *Rlm3* (resistance gene from canola) pairs up with the *AvrLm3* (the avirulent version of the blackleg gene) there is resistance. However, when *Rlm3* pairs with *avrLm3* (the virulent version of the gene from blackleg) it will cause disease and this is called susceptible interaction. Given the high presence of *Rlm3* in Canadian cultivars and the high presence of *avrLm3* (virulent version), this has led to the breakdown of *Rlm3* resistance.
Lesson 2 - The frequency of *AvrLm3* decreased from 2010 to 2015.
Lesson 3 - The higher the *AvrLm3* allele frequency was, the lower the disease incidence, meaning that *AvrLm3* frequency is correlated with disease incidence. No *AvrLm3* resulted in a higher disease incidence.
Lesson 4 - The lowering of *AvrLm3* allele increased the frequency of *AvrLm7*. It was also observed that *AvrLm3, AvrLm7, AvrLm9* dramatically shifted in 5 years. They are part of the *AvrLm-3-4-7-9-LepR1* genetic cluster in *L. maculans.*
Lesson 5 - A game of "hijacking" occurs with perceived credentials. There exists 'aggressive mimicry'. The presence of a functional allele of *AvrLm4-7* 'hides' the *Rlm3* mediated recognition of *AvrLm3*. A survey of isolates show that in some isolates *AvrLm4-7* co-exist with *AvrLm3.*
Lesson 6 - The "hitchhiking" effect: lowering of *AvrLm3* also lowered *AvrLm9* frequency. *AvrLm3* and *AvrLm9* have shifted dramatically in 5 years. They are part of the *AvrLm-3-4-7-9-LepR1* genetic cluster in *L. maculans*. There has been a decrease in both *AvrLm3* and *AvrLm9* frequencies.
Lesson 7 - The "hide and seek" effect: *AvrLm1* and *AvrLm2* are in the same cluster but are rarely found in a single isolate, and thus can be rotated.

Blackleg management since the 1980's has used *Rlm3* in breeding for resistance and minor gene stem canker resistance. Where once 4 year crop rotations allowed for canola stubble to disappear and small usage of applied fungicides, there are now tighter rotations and increased no-till management practices. From 2000 to 2016, blackleg disease severity increased in part due to increased canola acres. It is known that *Rlm3* and *Rlm1* are being overcome. There are now trade issues with China due to blackleg.

In Australia, resistance was overcome within 3 years. There was 90% yield loss worth $30 million on the Eyre Peninsula and seed was withdrawn from sale. This situation needs to be prevented in Canada. It has very serious implications for trade with China and results in high yield loss to growers and industry. In Australia, the strategy of rotating resistance 'groups' has resulted in successful crops with little to no disease. The question is can rotating R genes be done in Canada as was done in Australia? A proposed strategy is to use the R gene makeup of the varieties and place them into 4 groups (A, B, C, E). One variety can be assigned to multiple resistance groups. The key message of a rotation map is to avoid growing varieties from the same resistance group and that crop rotation with R gene rotation can minimize disease incidence. The Australian experience has shown that a certain group can be planted back into the same field after a certain period of time. Rotation of single resistance genes does influence pathogen populations. The impact of stacking resistance genes may have fewer options of groups in a rotation system. What about the future? There is a need for detailed surveys of *Avr* gene distribution and a need to track cultivars and their resistance. The biggest advantage with R-gene rotation would be to decrease blackleg incidence substantially in the next 3 years which would be a perfect bargaining tool with China. R gene rotation can be a way of sustaining our crop.

Questions and Answers

Q: What level of rotation is needed in terms of location, region?
A: Farmers should look into the scale of the canola farm, farm practices, disease management, disease incidence survey and input everything. The level of rotation needed varies. For example, determine the occurrence of the *Avr* isolates present in the area and whether it is the virulent or avirulent strain will affect rotation strategy.

Canola Resistance Groups – do they exist and how useful can they be?

Ralph Lange, Team Lead, Crop Pathology and Molecular Biology, Alberta Innovates Technology Futures

Cultivar rotation is a simple concept. Take the example of Group A, grown where most *L. maculans* isolates cannot infect but a few can and they produce yields. Then plant Group B where most *L. maculans* isolates cannot infect but a few can and they produce yields. Plant Group C and the result is the same. These groups are components of many cultivars. Which cultivar is in which group? First, what needs to be known if cultivars can even be grouped? What if all cultivars have the same resistance gene? What if each cultivar has unique resistance genes? Cultivar groups exist if they react differently to *L. maculans* populations with different *Avr* genes.

If cultivars are grouped based on differences in major (seedling) resistance genes then there is 'bliss'. However, other things can explain differential reactions. This is not necessarily due to resistance factors: weather, initial inoculum load (crop rotation), fungicide use, all need to be considered. For instance, some stubble produces many pycnidia, other may produce few pycnidia. "Tub testing," where residues are suspended above test plants, works best with ascospores. This method does not work well in Canada, where ascospores are rare as most pseudothecia 'crusts' turn out to be mostly pycnidia. Better inoculation method will remove ambiguity. For instance, if pooled populations of spores representative of genetic diversity generated from many individual stems are used, then uniform, high disease pressure can be obtained.

Theoretically, cultivars in the same group should react in the same way but what about mixed *L. maculans* populations? What about the effect of different *L. maculans* populations on quantitative resistance? The variability of *L. maculans* over space (field, local, regional) and time (what is the rate of change in response to cultivar rotation?) needs to be consistently described. There are techniques for phenotyping, genotyping isolates.

Quantitative or "Adult Plant" resistance will confound groups and that is a good thing. Sometimes called Adult Plant Resistance, it manifests after the cotyledon stage with many genes of small individual effect, showing a significant cumulative effect. This is more durable and is difficult for the pathogen to adapt. It could be that MR cultivars may not be a bad way to go. It could be moderate in withstanding disease pressure but stable. Quantitative resistance actually be doing most of the 'heavy lifting'.

If major genes were the only source of resistance, then cultivar groups would be straightforward and one could simply group by genes. If R-genes present in cultivars were known, then there would be no need for resistance group testing. If *L. maculans* populations could be easily, cheaply and accurately characterized on a single field basis (and commercially available to producers), then a particular R-gene or resistance group could be used until the *L. maculans* population starts to shift. Once the population shifts, would selection pressure make non-adapted *Avr* genes disappear or would they linger? This could eventually result in "super" *L. maculans* populations that would be able to infect all major resistance genes. New resistance genes and pyramiding would need to be constantly developed but with CRISPR technology on the horizon, perhaps this would not be a problem. Quantitative or adult resistance makes pathogenic adaptation happen much slower and this is probably the reason why we have not seen major pathogenic adaptation across the landscape. The only disadvantage is that it makes resistance groups hard to define and therefore cultivar rotation is difficult. Even if though it is confusing, both effective "seedling" and "adult" resistance is present in all cultivars.

Visioning exercise: How can we have it all? The simplest solution would be to group cultivars according to resistance genes. Producers could then make cultivar choices based on a resistance "package" (this information would need to be published). It would be best to base this on a limited number of genes. To implement this, there would need to be detailed data on *Avr* gene frequency. This would require agreed-on standard, robust molecular markers, sampling, and protocols for characterizing L. maculans populations, as well as a big data approach to regular standardized surveys with cultivar, spatial and environmental information, conducted annually in Western Canada within a publicly available and searchable format.

Questions and Answers

Q: China has a fair amount of *Rlm9*. If *Rlm9* was avoided could there be trade to China?
A: There were 156 lines studied from China and they have *Rlm3* and *Rlm4* and the *Avr* frequency is high. For 3 years, Canadian and Chinese scientists have been working together and have found that *Avr1, 2, 3, 4* are all present in China.

Blackleg of canola: Challenges and opportunities from crop and cultivar rotation to R gene stacking and labelling

Sakaria Liban, Research Associate, DL Seeds

Resistance genes are composed of major genes, which are qualitative and race specific (no disease present) and adult plant resistance (APR) genes which are quantitative and broad (showing some disease). Minor gene resistance or APR does not trigger a hypersensitive response to stop infection unlike major gene resistance. While it does allow some infection, it can reduce the severity and the progression of disease long enough for the plant to generate some yield.

The Canadian canola industry has not experienced large crop losses due to blackleg as in Europe and Australia, partially due to a shorter growing season and the predominance of asexual pycnidia. However, with larger acreages and tighter rotations, there is an increase in disease pressure both in incidence and severity. This has led to the emergence of new races in Western Canada. The Canadian industry needs to adapt to this changing pathogen population. Even though all commercial cultivars are rated resistant or moderately resistant, many fields are showing a high incidence and disease severity. This is due to the occurrence of new races. Since 2013 most varieties seeking registration are no longer receiving a resistant rating. This is due to the high frequency of *Rlm3* in Canadian canola germplasm as well as the pathogen population from site to site is showing that *AvrLm3* has less than 40% frequency. R-gene identification shows that *B. napus* carries *Rlm 1-4, 7, 9*; *B. nigra* with *Rlm10*; *B. juncea* with *Rlm5-6*; *B. rapa* with *Rlm8*; *B. rapa* subsp. *sylvestris* with *LepR1-4* and *RlmS*. Adult plant resistance identification shows that most of the 88% of the resistant accessions (that comprise 39.4% from the total accessions) have both APR and R resistance. The major reasons for increasing disease levels are: increasing acreage of canola, decreasing rotations, pathogen adaptation to resistance in commercial lines, and low diversity of blackleg resistance sources (mostly *Rlm3*). Disease levels are still lower than Australia and Europe due to cold winters and shorter growing seasons. Blackleg has evolved into a necessary trait for the market to continue to sell profitable hybrids and maintain a high quality product for export. The industry needs to continue to produce blackleg resistant lines.

The Australian approach to deal with the disease issue was to circulate a blackleg management guide to growers. This entailed regional monitoring, something which is not done in Canada. Australian groupings showed that the same site could produce yield from a cultivar of i.e. Group D but severe disease & weak yield from a cultivar of Group E. The Australian blackleg situation is not directly applicable here in Canada. Australian varieties stay at the vegetative stage nearly twice as long as Canada and this increases the opportunity and length for infection. Adult plant resistance (APR) becomes less effective. APR is not captured in the Australian resistance group system and more than half of Canada's varieties carry APR. R genes or groups do not all have equal performance. One R gene can provide greater protection than two and vice versa. Under labelling, stacking R genes means being in multiple groups, with less options to rotate, which favors single gene varieties. Multigenic resistance provides better stability for the broad market target. There is a trade-off between increased resistance over a larger acreage, and decrease of rotation options when virulence occurs. There is also a trade-off to obtain blackleg resistance groups. It is costly to capture other market traits along with several different R genes. Over time, this effort will reduce yield and genetic gain and increase selection pressure in breeding pipelines. When to use R genes? If all varieties carry common R genes there is a risk of overcoming or depleting resistance. High yielding varieties with APR should be used in areas with low disease pressure to limit selection but these varieties will be less marketable. It is very important to monitor sites and, unfortunately, in Canada there is a lack of regional sites with blackleg data as compared to around 35 sites in Australia. Cultivar rotation or labeling is less effective without this data.

The existing R, MR and S rating system should remain prominent as it incorporates both R gene grouping and APR data. In Australia, both the R, MR, MS, S ratings are available along with the resistance groups as additional data. There should be flexibility in regional labeling. Groups will perform better in some regions than others, data needs to be monitored and ultimately it should be farmer-based decisions. R gene labeling and grouping data should be generated as a combination of private and public data. To avoid confusion, clear extension and annual guides with all of the data should be available with a focus on farm site management and R gene use as needed. There should be gradual implementation, with R gene labeling phased in over a few years.

Blackleg summary and next steps

Clinton Jurke, Agronomy Director, Canola Council of Canada

Canada's top 5 importers of canola are USA, China, Japan, Mexico and Pakistan. The blackleg issue is serious, especially considering the 2010 trade barrier with China. The industry has to pay attention and take responsibility in decreasing blackleg disease. The Canola Council is working with industry and has formed a steering committee to determine what to do to stay ahead of blackleg and to communicate this in an understandable format. The blackleg strategic plan identified research priorities. New sources of blackleg resistance resulted in the identification and characterization of quantitative resistance.
The NEW blackleg strategic plan includes these research priorities:

1. What R-genes should producers and industry use?
2. What is the *L. maculans* diversity?
3. What is the speed at which *L. maculans* can change or adapt in Canada?

4. Should the registration requirements be increased for blackleg?
5. How can one increase the effectiveness of R-genes?
6. Are there new sources of resistance to blackleg?
7. What are some mechanisms to preserve quantitative resistance?
8. How can blackleg scouting and diagnostics in the field be improved?

How can the right information be provided at the right time? In terms of blackleg resistance classification, there are 2 proposed systems to ensure resistance durability:

1. R-genes and quantitative resistance in multiple line or regional deployment or use of quantitative resistance
2. The pyramid of R genes or use of single R gene

The immediate steps will be to examine both systems in detail and discuss internally which system is preferred. Blackleg has been treated as a simple disease but it is complicated and it needs a complicated response. More information needs to be provided to producers, for more education. What R classification is best for the industry? The decision will be made at the December WCC/RRC meeting on what system to use. At the February WCC/RRC meeting the new classification system will be launched and procedures adopted around how to determine these classifications.

Questions and Answers

Q: There are over 100 commercial varieties. How will canola growers do the profile and resistance grouping?
A: Try to rotate away from varieties that have been grown and learn from model sites.

Q: How does a grower make that choice? The list is not available and growers need to know what varieties to move to.
A: There is a huge gap in information. Producers need to know what is out in the fields: survey and consistently record observations. An information system is needed for major genes.

Q: How many years of survey data are needed until a system is in place?
A: The time line is potentially close if identification of major genes is used but there needs to be industry cooperation.
A: The genes to incorporate need to be identified. Knowing the R gene content to incorporate will be of help but it is different than Australia as there are 20 million acres in Canada as opposed to 3 million acres in Australia.

Q: Can infected stubble be sent to a central depot for screening of tissue for genotyping?
A: Yes, clipping and sending of stubble is a good system, as well as collaboration with producers.

Comment from the floor: There are molecular tools in place now and now it is more a question of coordination. Industry has to put their varieties to the test. Introduction of groups within the industry is a good start rather than simply listing varieties as “R”. This is also to Canada’s advantage to show the world that we are managing our industry.

CLUBROOT

Clubroot Steering Committee Update

Steven Strelkov, University of Alberta

The Clubroot Steering Committee was established by the Canola Council of Canada in 2013. The committee is made up of researchers, life science representatives, grower group representatives and provincial specialists. Its goals include identification and prioritization of research opportunities, development of consistent messaging and extension and advising industry on standards for resistance.

The most recent meeting was held in Edmonton in August 2016 where several issues were discussed. These were around regulations for the movement of new pathogen strains out of Alberta and current clubroot variety ratings. Following the Canola Discovery Forum, plans are to re-evaluate the steering committee's research priority list, work on a variety resistance rating recommendation and develop extension around new genetics and information on new pathotypes of *P. brassicae.*

The first cases of clubroot were identified in 2003 and annual surveys have been conducted ever since. These are conducted by the University of Alberta and by Alberta Agriculture and Forestry, who place an emphasis on regions on the periphery of the outbreak, some municipalities, and a targeted survey for cases where resistance has been broken or eroded. By 2015, there were 2,154 confirmed clubroot field infestations. More than 260 new cases have been confirmed in 2016. The emergence of new strains of *P. brassicae* capable of overcoming resistance has been an issue since 2013. New strains capable of overcoming resistance have been confirmed in a total of 42 fields (2 in 2013, 16 in 2014, 24 in 2015). There are about 30 suspect fields for testing in 2016.

The Saskatchewan Ministry of Agriculture conducts 2 canola disease surveys: a general disease survey with fields selected at random and a targeted clubroot survey where soil is collected and tested for the presence of *P. brassicae* DNA by qPCR analysis. A total of 2 fields with confirmed infestations were reported in Saskatchewan.

In Manitoba, recent testing has been conducted through PSI, a MCGA-owned DNA detection lab. The benchmark project is to screen one soil sample per township where there is canola production. Samples are tested for *P. brassicae* DNA by qPCR analysis. Soil samples first tested positive in 2011. Clubroot has been reported in 8 fields, 2 fields in 2013 and 6 fields in 2015.

New strains of *P. brassicae* were found in Alberta, beginning in 2013, where patches of severe clubroot in fields planted with clubroot resistant (CR) canola were observed. Greenhouse testing confirmed the increase virulence of the pathogen strains from these fields. The challenge is to accurately detect pathogenic diversity. Pathotypes of *P. brassicae* are identified by testing pathogen collections on a group of *Brassica* hosts known as a "differential set". The ability to identify pathotypes depends on the ability of these hosts or "differentials" to give distinct disease reactions in response to these pathotypes. Unfortunately, several of the commonly used differential sets do not capture the full range of pathotypes. The solution is to develop a set of Canadian clubroot differentials. Studies are aimed at identifying a set of *Brassica* hosts that can be used to accurately and easily distinguish pathotypes from Canada. Host selection is based on existing differentials, information in the literature and empirical data. A putative set of 13 Canadian clubroot differentials (CCD) were evaluated over 2 years with strains of *P. brassicae* collected in 2014 and 2015. The set consists of *B. rapa, B. napus* and *B. oleracea* genotypes. Older differentials were retained in order to compare pathotype designations. A total of 11 distinct pathotypes/virulence phenotypes were identified from the 2014 and 2015 collection using the CCD set. Ideally, there should be a set of differentials consisting of (isogenic) lines with defined resistance but this will take time. The CCD series builds on previous differential systems to better identify pathotypes of *P. brassicae* that are of particular relevance to Canadian production. It is hoped that the system will be finalized very soon.

CANOLA PERFORMANCE TRIALS (CPT) WORKSHOP – OLYMPIC GOLD

The future of variety evaluation

A brief history and explanation of the CPT program and its governance structure
Dr. Curtis Rempel, Vice President, Crop Production and Innovation, Canola Council of Canada

The current variety evaluation for canola growers:

- Provides relevant and unbiased data to growers and industry that reflect actual production practices.
- Leading and newly introduced variety data from small plot and field scale trials in short, mid- and long-season zones.
- Distribute information via the CPT booklet and CCC website as well as provincial seed guides.

With recent changes to the CPT program, the CPT Governance Committee is re-evaluating the ideal role and utility of the CPT Program in order to be an effective tool for the industry. The objective is to increase canola production from the current average yield of 34 bu/acre to 52 bu/acre by 2025. One key component to yield increase is genetic improvements. What changes need to be made to the program in order to maximize the value to all those involved (the growers, the seed companies and the provincial specialists).

The CPT program began in 2001-2002 when canola variety testing was coordinated by provincial governments with results going into individual seed guides. With budget cutbacks from government, growers wanted third party/unbiased data containing top varieties and industry was asked to fill the gap. The first year of Prairie Canola Variety Trials (PCVTs) was 2003 which had many companies participating. The check used was 46A65 and data (only) was used for provincial seed guides. From 2004 to 2010 checks were added and dropped and several companies discontinued involvement. The grower groups wanted full participation by the seed companies with tests representing what was commercially available. There were other concerns such as: managing trials with a higher level of consistency, data published too late, companies only keeping favorable results, and debates on the usefulness of small plot versus field scale trials. After extensive consultation, grower groups and seed companies agreed on a science-based canola variety testing program for 2011. This would be administered by CCC and funded by grower groups and seed company entry fees. It included small plot research and field scale trials conducted by the seed companies and audited to ensure no bias, and the economics of the systems. The CPT program was started with a contracted coordinator managing the research trials and a technical committee (TC). Their responsibilities include protocol development, location selection, inspection guidelines and variety entry review. The CPT has a governance committee which directs the management of the trials, including approval of varieties, protocol design, financial management and overseeing data collection, analysis and reporting. It is comprised of 3 grower group representatives, 3 provincial oilseed specialists, 3 CSTA (commercial) representatives and 1 (non-voting) CCC representative – providing financial and administrative services at no charge. The CPT has continued since 2011, with the current 2016 program still in progress. The TC is currently reviewing the data. Production of an online booklet is in progress as well as an update to the CPT website.

Highlights from February 2016 CPT program survey

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

The CPT Online Survey was conducted to determine the value of the program to growers. The specific goals included assessing the usefulness of the information, which sources are trusted and what information is valued, and the value of small plot data information. Farmers, retailers and industry were surveyed with around 400 respondents, the majority being growers. Ninety percent of the respondents see the value of third-party variety performance data, with 92% wanting variety data from sources other than the seed companies. Most say that they consider data from both their area and other areas. Field scale and small plot data are both highly valued for evaluating canola varieties. Ninety-two percent want to see stats on variety data. Most reliable data comes from a calibrated weight wagon and there is far less confidence in grain carts and yield monitors. Respondents felt that more value could be added with fertilizer application information and trial site information. It was felt that CCC or other third party/provincial oilseed specialists should be conducting the small plot trials, with the field scale trials conducted by CCC and /or farmers. With 76% of the respondents indicating that they have used the CPT data in choosing canola varieties, the take away message is that farmers want the program. The most common comments were that there should be more varieties/companies represented in the trials, and that there should be more complete information and data.

Perspectives on the CPT program

A grower perspective

Bernie McClean, Director, SaskCanola

Bernie joined SaskCanola in 2015 and promotes the continuation of CPT and asks that all companies participate. The CPT is essential to the provincial seed guides. The value of coordinated sites provides valuable information and there is a need to ensure that CPT is working, for example, providing blackleg rating scales. Goals should be set with companies; it is an opportunity for data collection. Growers are looking for unbiased third party data. Although retailers run local trials, this may not be the case for everyone. When a producer sits down to make a decision, they want to be sure that CPT continues and that the participation with it continues. The CPT sets the bar for variety trials and ultimately there should be cooperation from all parties.

Comments from the floor: Growers look to their neighbors and local retailers. Third party information helps a lot in making decisions. Information from seed companies report on different locations. Information should be 'policed' so that the grower knows that it is 'correct'. Distribute the Ultimate Canola Challenge (UCC) information more widely.

A provincial oilseed specialist perspective

Anastasia Kubinec, Acting Manager, Crops Branch - Industry Development, Manitoba Agriculture

The aim is to always try to provide information that enables best management decisions. There are definite improvements that can be made and there are constant vetting protocols. There are multiple comparisons to be made between varieties from unbiased information from breeders, plant pathologists, agronomists, and others. Small scale plots are a good test when done over multiple locations and years. Keeping the seed guide through the years helps. The desire for more localized data is natural. Canola varieties cycle quite quickly (2-3 years) and it is good to compare older varieties with new ones. There needs to be a forum for continuing the conversation so producers have that connection with industry and so that feedback can go back to the CPT.

A Canadian Seed Trade Association representative perspective

Janice Duguid, Senior Canola Breeder, DL Seeds

There are 3 CSTA representatives on CPT's governance and technical committees: Janice Duguid (DL Seeds), Michael Bateman (Cargill) and Al Eadie (Bayer). They provide expertise and assist with protocol development and review data analysis. The value of the CPT program is as an unbiased, third party post registration trial that compares commercially significant varieties and newly registered products using a herbicide system approach. Trial design and statistical analysis allows for valid comparisons between large numbers of varieties and generates audited small plot and field strip trial data. There are links to provincial seed guides and the CPT website is a heavily invested tool for communication.

There are issues and shortcomings to CPT including small plot trial locations and the number of trials, the success rates of the trials, timeliness of the data posting and reporting, evaluation of new traits, and the non-participation of all seed developers (which impacts the varieties that can be included in the trials). The use of weigh wagons has limited the participation in field scale trials and the cost of CPT is expensive. There are issues around the evaluation of new traits such as pod-shattering.

Questions and Answers

Q: What would be the cost to fix the shortcomings of the CPT program?
A: This should be evaluated and visited each year to be able to quantify the next trial. Are growers willing to pay for extra sites?

Q: What number of trials is ideal?
A: Between 24 and 32 small plot sites gives an average success rate of 75-80%.

Q: How can the CPT program proceed if seed companies do not participate?
A: The program needs to move forward as it is doing, to provide third party information and have producers participate with their own research.

Q: How do producers make varietal decisions if there is a wait for information?
A: Some sites can be delayed with some sites coming in earlier. Hard data is needed to complete the publishing of seed guides and sometimes it is a case of quality versus speed. Use the web as a staggered information point as the data come in.

Options to consider for the CPT program going forward

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

There are 3 options to the CPT program moving forward:

1) Value Chain Collaboration – the historic model for PCVT/CPT but not all companies participate
2) Producer Only Participation – is the model used for 2016 trials
3) No Independent Evaluation (no CPT)

Hybrids of models 1 and 2 are possible. Assumptions include that weed control will continue to be by a herbicide system and current notes will still be collected regarding lodging, maturity and other observations.

Option 1 has management and funding jointly provided by producers and seed companies where both parties jointly develop protocols and model operating procedures. The number of representative within each group on the CPT committee (provincial grower groups, provincial oilseed specialists, and CSTA representatives) could be altered. As indicated in the survey, full value for farmers is only there if all seed companies participate. Industry submits the varieties used for evaluations with the entry fee for each variety covering the cost of the trials. Options for sites/location include industry providing sites and being responsible for trials (WCC/RRC co-op style) or utilize independent third party sites at a cost or a combination of both to ensure a high number of sites and site quality. Have pod-shatter traits managed by swathing and straight cutting, as growers have options to manage either way. Continue to include seed company field-scale trials with specific requirements like weigh-wagon for yield measurement and drone photographs twice per season and/or establish a retail network to work with farmers who will put in field scale trials.

Option 2 has producer only participation (if not all seed companies are participating). Producers, provinces, a program coordinator and the CCC would develop protocols and model operating procedures. CPT committee would include: provincial grower groups and provincial oilseed specialists, program co-ordinator and CCC would have non-voting participation. Producers would purchase varieties to include for testing and pay for third party sites such as Agri-Arm/Applied research sites, universities, AAFC and other government organizations. Establish a retail network to work with farmers to put in field-scale trials. Retail would provide weigh wagon and the grower would possibly obtain free seed.

Option 3 is to discontinue the CPT program. Growers would utilize data generated by retail and seed companies to determine variety performance. Provincial seed guides could be discontinued and move to using variety registration data (WCC/RRC). WCC/RRC data could pose a significant challenge including data availability and agronomic relevance due to common herbicide treatment and unbiased information.

Comments/Open Forum

Option 1 should continue because of the independent third party information. If this is untenable, then move to Option 2. Option 2 is considered a possibility with all sites using the same protocols, contacting the retailer agronomist for large plot trials and use WCC then regional data that is site specific. It was recommended to do own trials with larger plots. "Larger" data needed by regional level. If you lose the independent retailer, then what happens? Growers still want the value of the information. Data should be out 4 months after harvest. Regional data is good if it is the same next year (i.e. if weather is the same), averages work best. Either Option 1 or 2, the question will be about the quality of the data. Is there a way of focusing on higher quality data (not necessarily of geographic location) that can be correlated with environmental data?
It was suggested that it would be helpful if WCC/RRC data was available with data that is put into seed guide to complete the information. WCC/RRC varieties are not sprayed with their specific herbicides, only evaluated on canola quality and not yield. Independent retailers value local clients but data is not readily available to the public, it would be good if data was available for western Canada. It would be nice to have information saying here is the annotation and protocols on the website. The guide should be published from data a year earlier, not 3 months after decisions are made. (August 1, 2016 should be from 2015 data.)

Curtis Rempel – Summary

Hearing from producers in the room, Option 3 is not being considered. The full value chain mode (Option 1) is preferred. What can be done to make this happen? Option 2 may have to be considered. Issues around seed cost and trial costs were raised. Prior to 2016, it was a shared cost. Producers/company trials put together a plan and then contracted to independent group/research companies. There was a per variety entry fee which paid for all testing and website development. In the past year (2016) companies withdrew and there was no entry fee. Costs were covered by leftover funds. There were only small plots trials at 18 sites. While CCC appreciates independent retailers' efforts, it also needs to look at other sites to pick varieties. Maybe it will evolve to field scale trials but it is not there yet. In 2017 there will be small plots, replicated at good sites like 2016? Seed costs are still greater than 20% of the input cost. Option 1 seems to be the preferred option.

Could 200 growers from across Canada use their own tools and equipment to carry out large field scale protocol? That is a good theory so that it is in-field, but there is an issue of practicality: what varieties to use; would it be balanced and would the companies provide the seed? It is not that simple to have growers run field trials as there are steps to be considered. There would have to be signed agreements with companies.

All changes were made to involve companies in the trials, then why not go back to WCC/RRC data for publishing? Companies still need to give authorization to release data – data is coded. There is still one more year of small plot data in order to transition. Could you 'pin out' a trial in a current field to obtain a data set? Can we connect to a producer and work side-by-side, to do this? Modeling needs good statistics for good algorithm modeling depends on good robust data. If we tie back with small plot to on-farm participation but we are unable to use 1 year data. There is a need for high quality data from trials.

Growers need small plots but with links to environmental data. To attain the 2 bushels per acre difference, regardless if small plot, mid or big-scale with 3 replications, 60 trials are needed to achieve that, 18-22 trials are not enough. That is the expectation for variety yield trial and there was some disagreement that 60 is the number that is needed.

The next step is to turn to the CPT Technical and Governance Committees to establish dates to make decisions.

Proposed improvements to the CPT program

Increasing value for program participants

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

How can the CPT program add more value to the data? This can be done by providing more information such as: fertilizer application information; trial site information (weather, soil, seeding information); overlay seeding rate, flowering timing; all products that are applied; perform soil tests at every site and list field history.

Canola Performance Trials – 2016 update and a little more

Rale Gjuric, CPT Contractor, President Haplotech Inc.

The CPT participants included: Bayer, Brett Young, Canterra Seeds, Cargill, CPS, DL seeds, Monsanto, Syngenta, and DuPont Pioneer. This covers the market with top products in each province. In 2016, there were 19 of 24 sites successful, 79% to date and slightly dropping. In 2015 there were 34/42 successful sites (81%).

There are challenges for CPT including technical difficulties with spraying with different herbicides. Grouping allows for better comparison within herbicide tolerant (HT) group than among entries from different HT groups. Voluntary participation results in unbalanced data set over years, this is even worse in field scale. Not all products on the market are represented and it is difficult to compare products tested in different years. A late "go/no-go decision" may mean just leaving a corner of the field for a trial. And there are challenges with value added traits like pod shatter and clubroot resistance. Prediction models show how relevant the information is used in predicting the performance of the farm and includes accuracy, etc. A question was raised: can data from past years be used to predict the performance of products in future years? Does small plot data give a good prediction of performance on field scale? How relevant is data collected in different geographies to my location? Correlations are high and should allow good predictions of performance. There is indication of that the type and magnitude of GxE allows good correlations among environments, years and type of trials. A robust and good quality data set (regardless the type of trial) would allow modeling the performance prediction with high accuracy. A common check or "proxy" checks could be used to link data from different sources
The take away message is more and more accurate data! Good data is good, the more the better regardless of the type of trial.

Questions and Answers

Q: How does crop insurance data fit into the model?

A: It is a factor and although not easily done, it can be used. There have been shortcomings when using crop insurance data. To see if it is feasible, there needs to be careful filtering to weed out idiosyncrasies. The remainder would be useful but would still have limitations.

Field Scale Trials

Taryn Dickson, Resource Manager, Crop Production and Innovation, Canola Council of Canada

Field scale trials provide the opportunity to see how varieties perform on farmers' fields. Growers tend to value these trials because they are large scale and are carried out with regular size equipment. These trials encompass a wide range of conditions, can have more locations than small plots, and are managed by growers. Although fewer varieties are compared at each site, the comparison is of high quality. Usually there is a 2 variety comparison (not necessarily replicated), including a common check. Sites are carried out following CPT protocols and are audited by a qualified professional. This ensures that guidelines are followed, allowing for a fair comparison among varieties tested and giving confidence to the grower that the site was conducted in a scientifically sound manner. Comparisons are based on harvested strips of 0.5-1.5 acres each. Recorded parameters include: yield, maturity, lodging resistance, height and disease information. Once all the data from the trial is collected, it is submitted to the CPT TC to be reviewed. After it is approved, the data is then posted on the website and in the booklet (which may be after the small plot data has been made available).

Additions to CPT field-scale trials for 2016:

- Only varieties entered in the small plot trials could be entered into the field-scale trials.
- Calibrated weigh wagons were used to collect yield data.
- Trials were to be declared prior to herbicide application.
- All field-scale trials were to be inspected or audited by an independent qualified agronomist.
- The auditor and farm cooperator needed to agree if the trial data was valid and suitable for use and whether a trial needed to be withdrawn.

This year the CCC agronomists helped with a large number of site audits. It was a great opportunity for them to be involved, but it is not sustainable when site numbers are so high. Companies were also able to arrange for independent agronomists to audit sites.

How to increase the value of trial for all those involved?

- Importance of field scale trials vs small plot trials.
- Timing of data submitted/approved/posted.
- Data quality and quality assurance – how much monitoring is required by inspectors?
- Use of harvest management protocols e.g. pod shatter tolerance.
- Additional data analysis such as measures of robustness (across regions, certain conditions, over several years) for seed companies.

If the best way to increase the value of trials for all involved can be determined then there would be a strong program in which the CPT data provides value to the companies involved, driving them to be engaged and make more improvements, which would continue to increase the quality of CPT data, which would in turn provide an incentive to growers to use the data, and their use of the data would continue to strengthen the value that companies derive from it.

2016 Canola Discovery Forum
Meeting Proceedings
The Fairmont Winnipeg

Wednesday, October 26, 2016

GROWER DIRECTED RESEARCH SESSION - PAY IT FORWARD
Updates and research priorities from Alberta Canola Producers Commission (ACPC), Manitoba Canola Council Growers (MCGA), and SaskCanola

Daryl Tuck, Region 4 Director, Vegreville, AB, Alberta Canola Producers Commission (ACPC)
ACPC has 3 goals that speak not only of profitability of the canola growers, but also deals with the sustainability and growth of the canola industry. There is no single practice that can be applied to every situation because growing canola is different from farm to farm, and from farmer to farmer. Multiple approaches are needed. With this in mind, the Agronomic Research Committee works on production related goals while the Marketing Development and Promotion Committee researches new uses and products from canola seeds, oil, and meal.

Three research categories include:

1. Finding the best ways to grow canola. Strategies include intercropping systems, input efficiency, production practices, environmental sustainability, germplasm development, and economic and production risks. Examples of research areas include rotations, seed quality/vigor and latent dormancy, fertility requirement, and others.
2. Finding solutions to pest and control. Strategies comprise research on pest biology and control methods, pest monitoring systems, and germplasm development. Among the research areas are existing and new or emerging pests, beneficial insects, efficient monitoring systems, computer modeling of weather-pest interactions, and others.
3. Finding ways to increase demand for canola. Research strategies are on human/animal health and nutrition, and bio-industrial uses.

ACPC participates and collaborates with multiple agencies geared towards canola research and industry. These include Alberta Ag Funding Consortium, funding agencies that have common proposals as that of ACPC, and CARP for canola agronomy projects in conjunction with SaskCanola, MCGA, and the CCC. Having more research partners means greater leverage of grower dollars. Through this, ACPC can accomplish its mission of profitable Alberta canola farmers. Approval of research proposals goes through a process. A committee of experts is tasked to review, independently rank, and approve the proposals based on the growers' needs and annual budget. Grower-directed research should be quickly adaptable to new problems and should easily respond to regional needs. Examples of this research would be on clubroot (value based on different proposals), storage management (protect the produce especially now that straight-cutting is more common), and environmental push from the general public.

Charles Fossay, President, Manitoba Canola Growers Association (MCGA)
Research priorities include diseases *(Sclerotinia*, blackleg, clubroot, *Fusarium graminearum*, and *Verticillium* stripe), traits (e.g. shatter-resistant varieties) and agronomic practices (straight-cutting that

helps producers cut cost or increase productivity), pest control (focusing on flea beetles and leafhoppers), shorter rotations with disease implications and yield loss. Based on these priorities, the following are among the research highlights:

1. The Pest Surveillance Initiative (PSI) Lab was launched in January 29, 2015 and is a joint project between MCGA, Manitoba Agri-Health Research Network and Manitoba Agriculture with funding from Growing Forward 2. Its first focus was on technologies for the detection of low concentrations of clubroot in Manitoba. In keeping with the theme, "what is in the local environment", the PSI has been culturing isolates from clubroot samples collected over the years. This is particularly timely as seed companies are marketing varieties that are resistant to pathotype YY when growers and extension workers do not know what pathotypes are in Manitoba's environment. All isolates will be sequenced so that the lab can eventually move from plant based assays to DNA-based as part of the goal of a multi-assay test offering for growers.
2. The lab has just started to collect blackleg samples to build isolate collections and screen these isolates once the differential host set is received.
3. In conjunction with Ag Canada and a major seed company, the lab has been working on the production of a Manitoba environment *Fusarium graminearum* mixture for use across disease nurseries in the Red River Valley. The lab will use the Manitoba isolates to develop DNA screening tools for characterizing isolates from Manitoba.
4. In co-operation with AAFC in Saskatoon, the lab is working on field proofing LAMP assays for in-field yes/no of several pathogens. Initially, it will focus on soil-based (clubroot and blackleg of canola) and insect-vectored (Dutch-elm disease, aster yellows in canola).
5. Partnering with MCGA, Richardson International, the University of Manitoba, and Western Grains Research Foundation, the PSI lab is working on understanding *Verticillium* wilt of canola, and establishing surveillance capacity.
6. One of the lab's pilot projects from last fall, a glyphosate tolerant (GT) kochia DNA assay, indicates there is GT resistance in pockets around southern Manitoba. It is expanding the pilot areas and is working with Dr. Gulden from the University of Manitoba and Dr. Gaultier from Manitoba Agriculture to evaluate additional DNA-based assays, both for herbicide and weed species.
7. Clubroot testing will continue to be offered to growers. Last year PSI lab analyzed more than 800 soil samples for clubroot.
8. A couple of years ago there was a resolution made to work on the development of open-pollinated canola varieties due to the high cost of seed. A project was funded with Haplotech Inc. contracted to do trials to determine how open-pollinated varieties perform in comparison to hybrid varieties. The study consists of evaluating 10 entries composed of 2 checks and 8 new varieties (5440, 45H29, AC Excel, A05-6NI, 72P01 CL, UA AlfaGold, PSL 11, PSL 385, PSL 427, PSL 120) collected from 7 locations in Manitoba. Data includes vigor, days to flowering, days to maturity, lodging, height, yield, oil content, protein, glucosinolates, and total saturated fats. Three sites were lost due to weather but 4 sites are showing that open-pollinated varieties yields are below hybrid canola checks. Information will be shared as it comes in.

Wayne Truman, Director, SaskCanola
Research is vital for the canola industry/family. SaskCanola represents 20,000 Saskatchewan canola growers and collects a refundable 0.75 cents/tonne levy. There are 141 funded projects and research is directed to canola seeds, meal, and oil. Thirty-five percent (35%) of funding goes into research on diseases (blackleg and sclerotinia). More farmers use the weather app on phone to help in making decisions on when and when not to spray. The canola disease tools in the Prairies funded work to

identify blackleg races in the field. In 2015-2016, the group participated in 17 new projects on risks in the canola industry:

1. Cleaver – an increasing problem for growers
2. Improving N and P management
3. Determining honeybee population, back on track
4. Carbon tax due to N2O emission from canola
5. Response to foliar application of phosphorus

For every $1 invested into research, a $4 return is expected. The ultimate goal is to decrease risk to the canola producer while at the same time promoting sustainability and increasing profitability.

Questions and Answers

Q: What are the top 3 insects in the different provinces?

A: Alberta (flea beetle, cutworms, diamondback moth and occasional army worms)
Manitoba (flea beetle, grasshopper and leafhopper)
Saskatoon (flea beetle, grasshopper and Swede midge)

CANADA'S CANOLA MARKETS – GROW UP AND GO

You play a key role in helping canola and the industry grow and making Canada the leading country for canola production, but where does it go?

Bruce Jowett, Vice President, Market Development, Canola Council of Canada

What are markets? Where are they? What studies are being done on canola oil, meal, and markets? Canada's canola markets were examined in the context of a "Canola Discovery Jeopardy" game. The categories included canola oil, canola meal and canola markets. The following are highlights:

- Canadian growers planted almost 20M acres of canola in 2015. There are over 43,000 canola growers in Canada. There were an estimated 17.3 million tonnes of canola harvested in 2015, making it the second largest canola harvest to date.
- Canola contributes over $19.3 billion to the Canadian economy annually, providing at least 249,000 jobs from canola research, farming, processing, transportation and shipping, final canola products, to loading at the port on its way to export. This is a sustainable industry that all Canadians can be proud of – one that is good for the environment, economy, human health, and a good source of high-value animal feed.

Canola oil

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

- Cardiovascular disease is the number one cause of death, with over 80% of cardiovascular disease (CVD) death occurring in low and middle income countries. Most CVD can be prevented by addressing risk factors, including high levels of blood cholesterol. Both canola oil and high oleic canola oil are effective in reducing blood cholesterol levels. Canola oil has a qualified health claim in the US.
- Canola oil has a high smoke point (242oC) in relation to other common oils. This makes it ideal for high heat cooking such as stir-frying and deep-frying. It one of canola's major selling features in some overseas market. An example of this is Japan, where canola oil is the preferred oil for cooking at high heat in small spaces.
- In 2014, 387 million people had diabetes; by 2035 this will have risen to 592 million. The number of people with Type 2 diabetes is steadily increasing, especially in low and middle income countries. Diabetes is the fourth or fifth leading cause of death in developed countries, and is becoming an epidemic in developing countries. In individuals with Type 2 diabetes, research showed canola oil improved glycemic control and heart health parameters and led to weight

loss. There is strong interest in the health benefits of canola oil with over 160 million media impressions. Pick-up of this research was strong in Canada, the US, and also Mexico.

- Canola oil and high oleic canola oil reduce abdominal fat in comparison with a control oil blend. Further substantiation, as well as understanding the mechanism, is currently being researched.
- EPA/DHA are two traditionally marine-based fatty acids which may soon be found in canola. They are known to lower triglycerides, increase HDL cholesterol and are good for brain and eye development.
- According to one market study, the global plant protein market is $22.2 billion and is expected to grow to $43.3 billion by 2024. Soy currently occupies over 50% of the market share for plant proteins. Food companies are actively seeking alternatives, giving a chance to canola protein for future opportunities. Research opportunities include the economic analysis of human food and high value animal feed, and the genomic improvement of canola meal. A detailed assessment of current processing limitations and potential solutions will be carried out. With worldwide demand for protein use, alternative canola protein has future opportunities.

Canola meal

Brittany Dyck, Canola Meal Manager, Canola Council of Canada

- Recent studies (Martin et al., 2013; Huhtanen et al., 2011) demonstrate that canola fed cows outperform soy fed cows by 0.7kg/day or all other protein ingredients by 1.0 - 1.4 kg/day. Further, a canola meal comparison with early lactating cows showed that canola meal fed cows outperformed soybean meal fed cows by 4.45 kg/day (Moore and Kalscheur. 2016). A year-long joint Sino-Canadian study also demonstrated that when used in lactating cow ration, meal from Canadian canola can increase dairy milk production by 0.6 kg/cow. This study was presented to China's decision-makers in June 2013.
- The US is Canada's biggest meal customer and imported just under 3.6 million tonnes of Canadian canola meal valued at $1.3 billion. (This was 89% of Canada's canola meal exports in 2015-16.) Other canola meal costumers include Thailand, Vietnam, and Mexico.
- The average level of glucosinolates in Canadian canola meal (processed) is 4.4 µmol/g. Poultry glucosinolate tolerance (GT) is varied. Using 1.5 µmol/g as a conservative level in complete feed, canola meal could constitute between 15 to 20% of laying hen diet (Khajali and Slominski, 2012). For swine, 2.0 µmol/g is the accepted GT in complete feed. A study by Landero et al. (2011) fed canola meal containing 3.38 µmol/g at 20% for weaned pigs. There is room to increase recommendation of canola meal in poultry and swine ration.
- Canola meal contains sinapine (sinapic acid and choline). Brown shelled layers with a genetic deficiency cannot convert odorous trimethylamine (TMA) to non-odorous TMA N-oxide. TMA will pass into the yolk and cause a fishy flavor. This genetic deficiency has been bred out.
- Dow's newly developed advanced canola meal ProPound, has just 4% less crude protein than soy meal. It has less fiber, more energy and more phosphorus than standard canola meal.

Canola Markets

Bruce Jowett, Vice President, Market Development, Canola Council of Canada

- The national retail volume market share reveals that canola oil has the highest market share at 40% (2013), and 43% in 2014 and 2015.
- Over 90% of the canola grown in Canada is exported as oil, seed, and meal to markets across the world.
- The major canola markets in 2015 were US, China, Japan, and Mexico. Breakdown of shares for the Canadian canola export for crop year 2015-16: US (35%), China (28%), Japan (12%), Mexico (8%), Pakistan (6%), UAE and EU (3% each), and others (5%), for a total amount of $9,772,946,173.00.

- The US has the highest share (62%) of Canada's canola oil export volume (2,538,211 MT) in 2015.The US is Canada's biggest oil costumer and imported 1.6 million tonnes of Canadian canola oil valued at $1.7 billion. The US population is 320 million, the target is to shift the consumption from vegetable oil (currently the highest in US retail) to canola oil (ranked second) in the future by promoting the health benefits from Canadian canola oil.
- The 2015/16 crop year seed export volume (9,171,769 tonnes) share breakdowns into: China (39%), Japan (21%), Mexico (13%), Pakistan (11%), UAE (6%), EU and US (4% each), and others (2%). China imported over 4.1 million tonnes of Canadian canola seed valued at $2.2 billion. Canola represents nearly 60% of all agricultural exports to China. With the population of China at 1.35 billion, and a rapidly growing middle class, it is estimated that 230 million Chinese adults (1 in 5) have cardiovascular disease (CVD) accounting for 20% mortality per annum, and about 114 million (11.6%) of all Chinese adults have diabetes. Like the US, it is a targeted population for Canadian canola products due to major health issues such as hypertension, cerebrovascular disease, heart disease, and diabetes. Health awareness in China is increasing, but price sensitivities are still relevant. Increased health consciousness, growing disposable incomes, and consumer preference for safe and quality products are driving the growth of China's health and awareness market. Reducing fat intake is the most common dietary approach. Therefore, making lifestyle choices like a heart-healthy diet with an everyday cooking oil low in saturated fat is important for Chinese consumers. Also, important is the neutral taste of canola oil, keeping food flavor is essential for Chinese cuisine.
- Japan is Canada's longest standing costumer for canola seed, importing approximately 2 million tonnes annually. Japan imported $1.1 billion of Canadian canola seed, oil, and meal in 2014-15 alone. Canola oil is Japan's most consumed edible oil. Japan's population is 126 million, and they love the high smoke point of Canada's canola oil.
- Mexico is a seed importer. They imported 1.4 million tonnes of Canadian canola seed valued at $753 million from 2011 to 2016.The population of Mexico is 116 million and the cuisine and cooking techniques use substantial amounts of oil. They are important costumers. Work is being done to promote an awareness of canola oil.
- Cardiovascular disease and diabetes have increased dramatically in India. India source out their oil from palms and animals. By 2025, it is expected that India's middle class population will be 583 million people and we are targeting at least 250 million people. More people are discerning in dietary habits and moving away from conventional edible oils to oils that contain omega-3 fatty acid as influenced by western lifestyle and consumption habits. This drives the increasing awareness of health and demand for nutritious foods.
- The best gift for Korea's Lunar New Year is a set of canola oils. South Korea is among the top ranking countries that import Canadian canola oil at 120 thousand tonnes in 2014-2015.

Canada's canola industry has a good reputation and a regulatory system that provides a clean and healthy quality product.

Questions and Answers

Q: With regards to CVD and diabetes, how do you market the health benefits of canola products to India and China?

A: Through government and influencers such as health professionals and chefs.

Q: Is there an initiative for information dissemination on this aspect?

A: One good source would be the "University of Google". The challenge is the reputation of the source. Website users are followed and information is sourced. Health education is a continuing process. The chart for saturated fat is actually a very good information source.

Q: What is the effect of GMOs on customers?

A: It is one of the reasons there is no investment in Europe due to regulatory battle. Japan is very strict, but they understand the benefits and importance of canola when it comes to health.

FERTILITY PILLAR PANEL – THE NITROGEN ARSENAL
PART 1: Economics and N rates: the N response curves for current canola hybrids. Should more N be used and should it be applied more efficiently? Corn model: How did N keep pace with yield potential of hybrids?

New and Old Technology for Nitrogen Decisions
Dr. Brian Arnall, Associate Professor Nutrients for Life Foundation, Precision Nutrient Management, Oklahoma State University
What is the future of N management? There is no universal approach for canola N management. The goal or end game is: "I will make you think". The Stanford equation for N fertility is: N fertility = (N crop – N soil)/N efficiency fertility. The basis of equation is N uptake = (N uptake – N input from fertilizer)/N input fertilizer because N soil is driven by the weather and previous crops. Therefore, one cannot predict the efficiency of N that is applied because efficiency is affected by many factors. N requirements are dependent on the yield goal, soil class, yield map, biomass map (remote sensing for estimate), and by growth/uptake model approach. Depending on the yield goal, N removal rate is aligned with the yield goal. This means that the higher the yield goal, the higher the removal rates. For canola, it takes 1.88 lb/bu N. A study on the economics of canola fertilization reveals that canola yield increases when N cost is constant. However, canola yield decreased when N costs went up. This is the risk approach.

There is a N rate calculator that uses the Maximum Return to Nitrogen (MRTN) that is currently being used by corn farmers. This is regional and soil specific, uses a large database, and includes economics. Rate guidelines developed from field trials across a wide geography must be recognized as general in nature. The data gathered provides insight into general N needs. It cannot predict site-specific N requirements and is unlikely to provide an accurate estimate of the optimum N rate needed in each specific environment. However, guidelines should provide N rates that reflect economic value and the probability of achieving expected economic returns across a range of locations and period of time. The MRTN approach provides both benefits and allows analysis across a range of N response trials. The goal is to get better but not perfect. There is a risk in doing optimum, but there is also opportunity. Multiple maps of production when combined have a big role in understanding your field. A comparison of yield monitors done over 3 years, shows the difference with the optimization of N application on the different sites of the farm versus a non-optimized field. It can be noted that there is yield stability in the optimized yield. Biomass is a proxy of yield. NDVI and others is a proxy for biomass. Therefore NDVI is a proxy for yield; understanding biomass is a yield essential. Having all this data helps in developing a profitability map, where the increase or decrease in the N rate will have an effect. The thing is it all comes back to utilization.

Soil test results are good for only 2-3 weeks. The N environment changes pre-season and end-season. Soil tests should be done pre-season and in-season. Soil N is affected by mineralization, losses (leaching, volatilization), N addition and N loss due to weather. Understanding the N cycle is essential in accounting for soil N levels after a crop has been planted. Chlorophyll reader (spad meter) is a way plants tell you about soil condition. Another way is a stalk nitrate test. This is a post-mortem evaluation of N in the plants and is done by cutting an 8 inch segment of the stalk and testing for nitrate. This is great if the optimum N rate is consistent yearly. There are also available models available in the market by Encirca, Yield 360, AdaptN, FieldView Pro, etc. For the most part these models look at 2 variables, depending on your priorities, examples are: growth model based heavily on GDD; soil model based heavily on rainfall and temperature and most utilize the NOAA data. NDVI can be combined with a reference strip in determining yield and soil (environment).

The **take home message** is: there is a need to modify the Stanford equation of the source of the total nutrient uptake from N-soil + N-fertilizer into total nutrient uptake from Soil N + Legume N + manure N + (then finally) Fertilizer N for optimized N2 efficiency and economy. So where is your opportunity? N-crop (Is your yield temporally variable? Spatially variable?); N-soil (Do you have at least 0.5% OM and inconsistent weather?); E-Fert (Is your soil texture or landscape spatially variable?); Can you adjust factors based on management? The challenge for maximizing efficiency is the risk adverse mind set. The opportunity is: where can an adjustment be tweaked?

How to apply nitrogen for efficiency and productivity gains
Jamie Denbow, Global Product Manager, Farmers Edge
Four topics will be focused on: (1) Germplasm/genetic increases; 4R's – Right product, Rate, Place, Time (2) Timing of application; (3) Preservation of fertilizer; and (4) Placement of fertilizer.

- Germplasm/genetic increases aspect: any variety can be chosen, but weather cannot be controlled. With proper management the effects of weather can be offset. Decisions on what is the right number to choose for the amount of N to be applied depends on the N required/bushel of desired yield. Decision on choosing hybrid over open-pollinated because hybrids are more efficient; decisions on pest management, overcasting to banding have an impact. The thing is "what is truly driving the change?" Breeding is being done for yield and management traits but not N efficiency so we need to focus on management style. Global climate change predicts that future precipitation increases will primarily occur in the months of May and June thereby affecting management. There is a need to understand the pattern of moisture as it affects management.
- For N management, start with timing of application. Lessons can be learned from corn growers. Look out for the type of soil, weather, and other factors that affect management procedures. Increasing N efficiency means applying when the plants need it. Place the fertilizer product so as to maximize efficiency and ensure that it is present throughout the growing season. For most, improvements in N application from spring broadcasting to spring banding of N were done. For the corn industry, there are models currently being used by corn farmers for their N management. All these products are designed to place the right amount of fertilizer in the right soil at the right time, which is as late as possible. It may be worthwhile to decrease the amount of N at the start of the season and increase end-season amounts.

  Nitrogen efficiency gain trials were done in NE SK with a target yield of 65 bu/acre. There were prescription maps of the fields showing how much to be applied per section. One strip had 20 lbs N reserved for in-season application vs rest of N which was applied fall or spring banded. Note that the field is on an elemental sulphur management plan. At harvest there is the harvest map with prescription and the one strip that had in-season reserved. It can be noted that the one strip with in-season N application showed a consistent green color for the whole strip which means a greater than 114.0 bu/acre harvest.

  Structure the end-season application. Losing fall applied N is a given, the actual question is "how much?" Access all the information data from all points (weather data in the area, from the equipment) and all of this data will help draw a field map. A safer environment is also being generated. It was suggested to stop putting lbs on those spots that do not give good yield. This can result in 30% of N saved to be applied at end-season. The management option is when to apply to try to maximize N efficiency. **Message:** N efficiency increases through placement of N in the right amount in different areas according to productivity.

- Preservation of fertilizer: protect your fertilizer product so as to maximize efficiency and ensure that it is present throughout the growing season. This has major economic and environmental benefits. There are many N enhancement products to preserve applied N2. Examples are: SuperU, AGguardian, Agrotain, ESN, eNtrench, and MicroEssentials slow release. Part of preserving N2 is to understand the N2 cycle. Along with crop intake, there are many other factors within the N2 cycle that will affect the total amount of applied N required to maximize efficient yield productivity. These factors include immobilization, mineralization, volatilization, runoff and erosion, and leaching. The best time to apply N is just before it is needed, so as to minimize losses.

  A Nitrogen Preservation Trial was conducted south of Regina. Initial field maps show when there is vegetation and when there is no vegetation. There is no data yet, but projects like this allow proof of statement of products that the customer chooses and can push yields higher. There is not a lot of work done outside the private community on these products because the land area and equipment needs are high for this type of research. Due to soil and weather interactions, results are not seen every year and many growers lack the capability to accurately measure the results.
- Placement of Fertilizer: place fertilizer according to the land's productive capacity. This takes into account the land's ability to produce yield and fertility so as to maximize efficiency and ensure that it is present throughout the growing season. This means to place the fertilizer according to where it is needed for every section of the field.

  A 2016 canola trial comparing conventional versus management zones was conducted to test if this option saves cost and/or increased yield. The trial is to compare one rate versus according to need. Based on the prescription map, total amount of NH3 as source of N2 was calculated. Fertilizers were applied: approximately 80% of the total amount with the remaining 20% for the end-season tank application. Crop health was monitored for 3 months (June – August) and uniform crop health across the field was observed. Economic analysis shows that conventional management applied fertility rate at 140-30-8-30 with fertility cost of $93.19 ($1.69/bu target yield). While, zone management nutrient plan fertility rate was 134-27-7-28 with a fertility cost of $87.55 ($1.53/bu target yield), there was not much difference in yield between the two management options, but the zone management nutrient option did save cost.

  So what happens when all the recommendations from choosing the right germplasms and application of the 4Rs are implemented? The canola yield winning plot recipe 2015 of 147 acre field averaged 111.3 bu/acre! **Message**: N efficiency gains through placement of N in the right amounts in different areas according to productivity.

Questions and Answers

Q: What is the equipment limitation on the N efficiency?
A: It is a 200 foot transition forward. With the applicator width there are adjustments according to the map. Manufacturers are now making improvements in equipment technologies that may address this problem.

Q: How about Sulphur: Elemental? Liquid?
A: S15 is a separate tank. Elemental sulfur when applicable.

Q: How can you be comfortable doing split application with the existing weather patterns?
A: Due to equipment problem this is hard to say; however, single application is not good either.

Younger generations can do custom applications due to advanced technical knowledge.

Q: Is there one area that can be identified for management exploration?
A: N management needs exploration. In small plot this would be challenging. If there are 6 strips or 7 strips and 3 different tanks, this should be replicated to have good data.
Small plots are not recommended. Determine an on-farm exploration area; manage the field at the farm level and environment level.

Q: What is the biggest farm cost?
A: The top three are: land cost; seed and nitrogen fertilizer

Q: What can you recommend because we are losing opportunities because of so many variables?
A: Focus on rate or efficiency like soil type. Do some fine-tuning of your own fertilizer management.

Q: Is there research that needs to be done on N?
A: Because of funding, who funds fertilizer rate research? The answer is no one.

Q: With regards to N efficiency by plants, what about carbon taxing? Impact on the map?
A: Will this be a producer-driven project or research? There may be a project on this in wheat.

Q: Comment: There is a need for N-related information. For ROI, yield does not necessarily mean profit; fertilization is included in the calculation. Focus on enhancing efficiency products and value of N efficiency in collaboration with your agronomist.

Q: Is there research on "when needed" application for the timing of application?
A: Nano-coding. It depends on the interest of the company.

Q: For fall application, how can we apply for canola?
A: Use enhancing products, stabilizers, inhibitors. Surface N application is a bad practice. Add 20% extra for spring application to anticipate the lost. Fall banded ammonia is still the best practice in MB. AB/SK are different so different practice.

PART 2. A discussion of the organisms in the root microbiome of canola that increase the uptake and efficient use of free-living N and looking into the future of alternative nutrient management.

Opportunities for manipulating the canola microbiome to increase nitrogen acquisition and improve crop performance

Dr. Bobbi Hegalson, Research Scientist, Soil Molecular Microbiologist, Agriculture and Agri-Food Canada, Saskatoon Research and Development Centre

There is enormous potential to enhance plant growth and productivity by exploiting plant-associated microorganisms. Microbial diversity in the bulk soil is high. There are tens of thousands of different species per gram of soil. The development of specific root microbiome communities depends on plant factors as well as microbial and soil factors. However, the functional root microbiome that emerges is capable of contributing enormous genetic and metabolic potential to meta-organism function. The plant has specific mechanisms that it uses to select for microbiome components through signaling molecules, similar to the way that microorganisms can signal one another in response to stimulus. Together, plant and microbial genomes contribute to plant fitness. As that of the human microbiome being critical to our own health, plants are meta-organisms that include their microbiome as part of the living organism. Approaches in enhancing plant growth and yield potential include plant based, microbiome based, and meta-organism based.

One traditional approach in improving plant growth through the manipulation of plant-microbe interactions is through the use of inoculant. An example is a study on canola inoculated with a plant growth promoting rhizobacteria (PGPR) which enhanced early growth and seed yield at 110 days after germination under controlled conditions. This bacterium was isolated from wheat and can survive in the rhizospheres of wheat, canola, lettuce, cabbage and pepper. Although effective under controlled conditions, it was not consistent in the field maybe due to competition in the natural environment. This PGPR affects plant growth through both direct and indirect mechanisms: biological control of fungal pathogens (*Fusarium* and *Rhizoctonia*), and nutrient uptake under limited nutrient conditions. It is not known whether this PGPR inoculant disrupted the root microbiome that indirectly contributed to improved growth.

A second approach is through a more systemic disruption of the microbiome. New genomic technologies can measure the response of microbial communities to external stimulus, without doing lab cultures. Change in microbial community composition upon the introduction of a particular stress, or resource can be easily measured. Relative changes in different organisms help interpret which organisms are important under a range of conditions. Cultural practices (e.g. tillage intensity, crop rotation, fertilizer management) can influence the bulk of soil microbial abundance, community structure and perhaps the root microbiome. A very good example of microbiome disruption via fertilizer application is the unsophisticated system of continuous wheat grown for over 100 years, with and without the use of N and P fertilizers, alone or in combination. Such practice disrupted the "normal" bulk soil communities through the development of strong nutrient deficiencies in the soil. Th objective was to determine if these deficiencies had impacted the soil and root microbiomes. It was hypothesized that over many decades there may have been an adaptation of the bulk soil community in favor of organisms that can assist in plant N and P nutrition. Samples were done 3 times during the growing season, for two consecutive years, then analyzed the relative abundance of different bacteria, archaea and fungi in the bulk soil, rhizosphere (the soil immediate adjacent to the plant root that is impacted by plant metabolites) and roots. Results demonstrate that root-associated communities, both fungi and bacteria were influenced by the presence (or absence) of nitrogen fertilizer application. In an attempt to determine a beneficial organism, deeper study on this context reveal that certain microorganisms responded positively under conditions where N and P were and were not available, and that for bacteria and fungi there were many different taxa that were responding. In particular, there is a bacterium whose abundance increased 4-fold within the roots of wheat where P, but not N fertilizer, was added. Unfortunately, this isolate is hard to culture because attempts to isolate it in the lab have been unsuccessful. This is one example where a strong environmental selection pressure has created an opportunity to study root microbiome responses to N availability and perhaps to identify organisms that confer N uptake.

Both of the above-mentioned approaches involve identifying root microbiome constituents that can be used to stimulate plant growth. However, bulk and rhizophere environments are intensely competitive with high microbial diversity. One challenge in exploiting the root microbiome through manipulation is that the desired inoculum or organism may fail to compete across different environmental conditions. Successful microbial inoculants have symbiotic relationships with their plant hosts that give them a competitive advantage. Good examples include *Rhizobium* that lives in the root nodules, and arbuscular mycorrhizal fungi that partially live within plant roots and derive their carbon from the host. Perhaps the most promising approach to enhancing crops from the metaorganism perspective is by using the plants to create niche space. Through advanced genomics and computational analysis, it is possible to understand plant-microbial interactions in a detailed level. Co-engineering approach can be used to elucidate the specific mechanisms that the plant uses in selecting beneficial microbial partnerships. Central to the most successful plant-microbe symbioses is the fact that the plant provides a niche. It is important to try to understand how different crop genotypes shape root microbiomes so that tools can be developed that can be used in breeding programs to select for traits that enhance plant-microbe associations.

As part of the Plant Phenotyping and Imaging Research Centre initiative, there are experimental studies on how below-ground crop traits are linked to the aboveground crop phenotyping using specialized plant imaging. Tools can be developed that can be used in breeding programs to co-engineer desirable "metaorganisms". In the first year of this research program, with the help of Sally Vail, a canola breeder at AAFC, 16 NAM lines of canola were selected that were known to have differences in glucosinolate content or seed characteristics. Roots and rhizosphere soil were sampled weekly from mid-June to mid-August. Root microbiomes are characterized using amplicon libraries to determine the identity of the bacteria, fungi and archaea that are present both within the roots and in the soil rhizosphere. How these communities change over time as the crop develops needed to be looked at. Root exudates characterization from the soil rhizosphere metagenomic analysis are performed to determine possible differences in the functional potential of microbiomes that relate to plant growth performance as measured by the phenotyping team. Sophisticated tool kits have allowed an understanding of the complexities of the plant-microbe-soil interactions.

Going back to the conceptualization overview of an optimized meta-organism, it is possible to elucidate on how to best use plant-microbe interactions. This can be used to optimize N acquisition through a suite of optimized agronomic practices. Fine-tuning the plant-microbe relationships that can respond to changing soil environmental conditions can also improve N use efficiency. Most N (>90%) in soil is in organic form that must be biologically transformed into ammonia and nitrate, types of N taken up by plants. Urea and AHS needs to be biologically transformed too before becoming plant available, so these processes of N conversion can be directly targeted (and have been – e.g. nitrification inhibitors).

The future of nitrogen fertilizers

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

Nitrogen use is among the drivers of environmental issues. N use has changed the biosphere, losing biodiversity and changing the natural terrestrial system. N use results in losses to the environment via denitrification, volatilization, mineralization, leaching, and nitrification. Nitrous oxide is a concern. It is related to carbon tax where N is increasing annually here in Canada. This concern is due to its effect on greenhouse emission, where agriculture contributes 35% of total emission in MB alone (Environment Canada 2009). Sources of nitrous oxide from agriculture includes emissions from fertilizers and residues (50%), manures to soil, paddocks and pastures, and 27% are indirect from soil. This is showing that agriculture is the biggest source of N2O emissions. The government of MB planned for its reduction: targeted one third drop from 2005 by 2030, half by 2050, and neutral by 2080. Whenever N fertilizer is used, N2O is emitted. Spring melt and high rainfall events following fertilizer application were conducive to high N2O emissions. Monitoring of N2O emissions following crop rotations showed minimal N2O emissions during legume year on plots due to lack of fertilizer additions. During the perennial phase for the annual-perennial treatment, there are negligible N2O emissions. Studies show that the more N added the more N2O emitted. Among the concern is that canola acres and N rates increase N2O emitted in MB (McCombe agroecology project report 2013). Residual nitrate is the problem. The use of N efficiently will greatly reduce N2O emissions.

A survey on the N use and canola production from 1993 to 2015 shows that canola yields and N rates are increasing, and there is has only been a slight increase in nitrogen fertilizer use efficiency (NUE). A comparative study on NUE shows that hybrids are slightly more N efficient than OP varieties: results of breeding and proper management can contribute to NUE increase. N rate alone cannot get to the target bu/acre for hybrids have improved in NUE, as seen in corn. However, canola is not like corn. Canola grain contains protein therefore improvements in NUE are limited. Breeders may not be able to boost NUE dramatically. The best management is to apply the 4R nutrient stewardship. The 4Rs were already discussed earlier. Being a 4R steward uses the best crop nutrient additions, improved yield thus profitability, limits losses, has co-benefits with the environment, and it applies the agronomic sense of past, present, and future advances. In fact, applied N is not all harvested: 35 bu/acre canola takes up 100-123 lbs N and 61-74 lbs N are removed in grain, 39-49 lbs N returned as residues, and these residues are subjected to mineralization and losses. Crops are not designed to be competitive. This means that they are nitrate dependent. Nitrate in the soil is produced by microbes and nitrate is mobile, making it prone to losses.

Crops take up N only part of the year. A study shows that canola and wheat do the early uptake (mid-May to June) while corn, soy, and sunflower do the late uptake. Add N just before the period of uptake for better NUE. Sources of N are organic sources (manures, legumes, manures), mining (guano, saltpeter), synthetic (dissolving NO in water to produce nitric acid), cyanimide (combination of heated calcium carbide and nitrogen), Haber-bosch (ammonia process from methane and water), and enhanced efficiency fertilizer (e.g. stabilized N, controlled release, slow release, nutrient blends). Some tips for slow release products: urea formaldehyde takes up to a year and is microbial decomposition dependent; methylene urea takes up to 4 months and is used in cooler soils, where ESN and S-coated do not work; isobutylidene diurea takes up to 4 months and is particle size dependent; S-coated urea takes up to 1.5 months via hydrolysis and is coat-thickness dependent.

Enhanced efficiency fertilizers are designed based on the different steps of the N cycle. In using these products one has to understand the different uses and its mechanism of actions to avoid losses, including N2O emission. Nitrification inhibitors are to inhibit the conversion of ammonia (NH3) to hydroxylamine (NH2OH) that is readily converted into N2O. Urease inhibitors inhibit the fast release of ammonium (NH4) from urea, and controlled and slow released urea function as it is labeled – it slowly releases ammonium from urea to a longer extent. Characteristics of future fertilizers includes the use, production and activity based on environmental and efficiency measures; all will be smart or mensa fertilizers; deliver nitrate directly to roots (nano-fertilizers); release N only with crop demand (sensing coated fertilizers release the N according to crop signal); made not from fossil fuels (N from hydrogen has hydrolysis involving algae); may not be easy to handle as today; resident in soil for multiple crops; likely based on nano-technology (nano particles have high surface area and absorption capacity, typical for smart delivery system); and it will not be cheap.

In summary, future of nitrogen fertilizers includes:

- Environmental issues will be driver of N use, sources, and production technologies.
- 4R nutrient management is very important.
- Crop N use characters pose problem for losses of N
- Feeding grain and residue, N in crop residues will be prone to losses.
- Soil biological processes pose problems of N.
- Use of N on farm will be monitored/certified.
- Moving to enhanced efficiency sources – all fertilizers will be SMART or Mensa fertilizers.
- Will move to non-fossil fuel N fertilizers.
- Development of long-lasting, sensor based N fertilizers.

Questions and Answers:

Q: What practices that increase NUE are not being used now?
A: Proper placement of fertilizers, band placement is challenging but more efficient.

Q: Regarding sources of N2O, more restriction during summer fallow when it still green?
A: Recycling. Not really a strategy because there is carbon loss.

Q: How useful in the future is the plant-microbe model?
A: Soil life is fussy, but it will be very useful.

PLANT ESTABLISHMENT PILLAR – STAND AND DELIVER
Plant density: how many seeds should growers put in the ground and why? A look at evolving recommendations.

Economic target plant density
Murray Hartman, Oilseed Specialist, Alberta Agriculture and Forestry
How low can we go? Seeding rate recommendations quoted from Production of Rape in Western Canada (1961) states that "For varieties of the Polish type, such as Arlo, 4 to 6 pounds per acre is enough. For Golden and other varieties of the Argentine type, sow 7 to 10 pounds per acre. Rate of seeding affects the yield very little. In thin stands, the plants branch more than in thick stands and this compensates for the fewer plants." Price of canola at that time was $2/bu. How much is the seed cost? Not mentioned. On page 16, "For the turnip rape varieties which have small seed 4 to 6 pounds per acre is sufficient. The 4-pound rate will deliver about nine seeds per foot of row. For varieties of the Argentine type heavier rates of 5 to 7 pounds per acre used to compensate for the larger seed size. A 6-pound rate will sow about eight seeds per foot of row. The lighter seeding rates should be used where drought is a hazard." Again, price was at $2/bu until 1973 it was $6/bu. In 1978, the price of a new seeder was $5,850 for 8 feet. Rapeseed was around $6/bu.

Canola growers Manual (1st ed. 1984) states that, "As plant populations declined below 60 plants per square metre, yields declined dramatically. Growers should aim at establishing plant populations of 80 to 180 plants per square metre (7-17/sq ft). Table 5 Page 811, recommended seeding rate for *B. napus* was 5-7 lbs/ac in western Canada except for Peace region 5-8 on fallow, 8 lbs/ac on stubble." In 1984, canola was $8/bu but 1980's average was $6.50/bu. By late 1980's canola seed cost was about $1/lb. In 1992, CCC Canola Production Centre reported that seed cost were OP $0.85-2.40/lb, Hyola 401 $3.17/lb and yet the canola price was $6/bu, and by 1990's around $7.20/bu. It was reported that only 10% of producers listened and did the recommended rate of 12 plants per sq. ft. The seeding rates for Argentine producers in southern and central AB tend to seed 5-7 lb/acre. In 2003, the canola growers' manual was revised, stating that "A review of 27 seeding rate studies on the Canadian prairies showed seeding rate was not highly correlated with yield. Of the 65 site-years of data for *B. napus*, 23 showed no effect of seeding rate on yield, 11 had highest yields with rates lower than 6.7 kg/ha (6 lb/ac), 17 had highest yields with normal rates of 6.7 to 9 kg/ha (6 to 8 lb/ac), and 14 had highest yields with rates greater than 9 kg/ha (8 lb/ac). In most cases on the prairies, growers should seed 5.6 to 9 kg/ha (5 to 8 lb/ac). Canola Production Centre reported (2002), OP varieties were $3 - $4/lb, hybrids $5 to $6/lb, and canola was ~$8/bu."

The 2004 re-assessment of optimum target tried to determine if hybrids have a different optimum. There were 17 trials at 61 site years trying to determine if low densities are suited for low yield environments comparing density versus yield on both OP and hybrid. OP results reveal that at 90% critical level planting density is around 37plants/sq.m. and at 95% level it is around 47 plants/sq.m. While for hybrid at 90% planting density it is 30 plants/sq.m. and 95% level is 39 plants/sq.m. Another study by Shirtliffe (2009) found that hybrid data with low plant counts (<2 sq.ft.) was limited. Hybrids achieved 90% yield at 4 plants/sq. ft. whereas OP was more than 8 plants. The Shirtliffe study put in some economics to the study of seeding rates. Adding the 2016 recent trial where low populations and HT hybrids for 65 site years input using the current recommendation of 7-10 plants/sq.ft. Results since 1998 data show that there are high yielding groups that are out of the curves. Are these volunteer crops? Economic seed target analysis (considering all possible factors and all the risks) at 40, 60, 80% emergence. Results show that there is not much difference.

In conclusion:

- Recommendation for target plant density should be lowered largely due to seed cost versus the price of canola
- Under current process, without considering risk and other factors, target 4-6 plants sq. ft. and if risks are included perhaps 5-7 plants/sq.ft.
- There is a need for a calculator for growers to plug in variables to give the best estimate for seed rate
- Research is needed to verify certain practices under low densities.

Canola plant counts: looking at the why
Andre Lacoursiere, Owner, 2nd Opinion Consulting
Canola to date has stood the test of time, increasing in acres over time. Canola by its nature is a very forgiving plant. It gives the flexibility to push its limits and work through things like increasing yield to managing things like disease. Technology and better equipment has provided the opportunity to plant better varieties of canola and to move from swathing to straight cutting. Looking at some major outside pressures like Canola Council of Canada's target of 52 bushel acre average by 2025, for most farms it is still provides good cash flow. Plant counts are considered because it helps to manage risk early and is a part of a good agronomy program. Seeding rates are just as important as soil tests, crop plans, varieties, and the right rate of fertilizer in the right place. Producers are more innovative, business minded, and are willing to hire professionals to help in their operations. They have less fear. They are willing to try new things (varieties, seeding rate, straight cutting). New equipment and improved technologies also are related to plant counts, including costs. Risk management begins early. We work with 3 soil zones, and the mix of dryland and irrigations. Each has its challenges. With this, target counts are 7-9 plants/sq.ft, which provides a range to manage the different risks. We scout between 15,000 and 20,000 acres/yr and do plant counts in every field. The risks today include:

- environment (early seeding)
- pushed rotations (it changes everything from chemical, fertility, disease pressure even in 3-yr rotations)
- fertilizer rotations (deal with different seeding plan, fertility requirements)
- types of equipment (ever-changing requiring new learning and adjustments that are not easy; a very good example is openers)
- early frosts
- weed control (2nd flush of weeds due to influx of moisture throughout the season; consider crop competition for flushing weeds; observed more weeds in 3-4 plants/sq.ft than the 7-8 plants/sq/ft)
- herbicide (chemical rotations, low OM and high pH in our area, group 2s can be an issue)
- fungicide (attention to diseases is becoming important and its economic benefits)
- insects (spring time problem on cutworms, flea beetle, and wireworms; late in the season is SCPW and lygus)
- others include speed kills, VRT seeding and fertility, crop residue, swathing, and the effects of seed size

It is noticed that seed sizes vary from yearly harvest (in part due to varieties and where they were grown). Two main things that are related to seed counts are small seed size, and the survival rate between 55-65%. The high percent difference in seed size can have a huge effect on plant counts. Four (4) grams to 6 grams is a 34 % increase in seeding rates (60% survival at 7plants/sq.ft.). That means going from 4.48 lbs base up to 6.72 lbs. 1,000 acres that's 2,240 lbs or 45 bags x $550.00/bag is $24,750.00 of extra cost. It becomes a balancing act between added costs or lost revenue. Ask yourself, in your operation what is your risk tolerance? The take home messages are:

- Know risks and what can be tolerated.
- Know varieties and seed size (observed that Clearfield varieties are bigger than GT variety).
- When in doubt, do field trials but consider seeding rate in the setup.
- Keep plant counts up if you are seeding early (in our area 1st week of April is early).
- Better crop rotations (7-yr rotation for canola; 3- or 4-yr rotation if economics makes sense).
- The first time trying new equipment, keep plant counts up.
- Fertilizer rotations (be aware of phosphate and sulfur levels)
- Record keeping is the key

Looking ahead, is the discussion to lower plant counts in a push to offset the increase in seed cost, is there more discussion needed around the risks? Is there a potential for lost profits by going to lower seeding rates? Work will continue on determining survival rates with the newer varieties. There seems to be such a variety of opinions, from the agronomist using plant counts, to hearing 5 lbs an acre meets the average plant counts required, to hybrids having survival rates being higher than past varieties. Try to find the right tools that give the flexibility to keep up with advanced producers along with helping those not so advanced in their farming practises that will increase profitability.

Questions and Answers:

Q: Issues in soybean plots where it is too late to spray volunteer crops
A: It is impossible to make the total right decisions. Producers have to go by trial-and-error with movement to straight cutting. Canola at 2-3 years would be 0 seeding rate.

Q: Are there adequate guides to fertilizer and seeding rate?
A: Yes. Improving the seeding rate so that you can lower your seeding rate, making the most of your input.

Q: How many days to maturity are added from going to 7-10 plants from 4-6 plants. Does herbicide have to be applied twice?
A: The maturity difference is observed 1-2 days. There is not enough data to support weed competition. Uniformity should be observed, and producers' tolerance to risk.

INTEGRATED PEST MANAGEMENT PILLAR - LESS IS MORE
Grow more and manage pests! The economic benefits if biodiversity includes pest control costs; better sustainability metrics and improved market access. What can growers do to encourage biodiversity?

Promoting landscape diversity on the Canadian prairies for sustainably increased yield
Gregory Sekulic, Agronomy Specialist, Peace, CCC
Take home message: The area under production in Canada is static. More than 70% of natural wetlands have been drained since settling began. Literature supports the positive relationship between crop yield and natural lands, and natural lands provide habitat for beneficial insects. Diverse landscapes are more resilient due to farm consolidations, new land clearing, obstruction removal, and cultural preconception. About 70 – 90% of wetlands have been lost and this is still happening. Of the 30% habitat remaining, nearly 100% exists on farms.

Enhancing beneficial insects: the latest research and path forward
Dr. Lora Morandin, Owner, Morandin Ecological Consulting
The following concepts are general to all crop agriculture rather than specific to canola or any one crop; but all of it will apply to canola. There have been large changes in agriculture over the last 100 years. Past agricultural landscapes were diverse: small fields, high diversity of crops within a farm, high

amounts of non-cultivated land, few synthetic inputs, and importantly, lower production per unit area. These cropping systems were sustainable, for the most part, but did not produce the high yields. Current agriculture is innovative resulting in high yields but also substitutes many natural ecological services with high cost inputs such as pesticides and fertilizers. Along with higher yields and larger size fields, there are problems with maintaining soil fertility, environmental contamination, detrimental effects to non-target organisms, pest resistance, and greater restriction on pesticides. Future: best of the old and the new through intensification with diversification. The ultimate goal is sustainable production. Ecosystem services use beneficial insects (predators, pollinators) back into the agricultural systems. It is not meant to replace chemical but to complement synthetic inputs. Pollination native bee contributions are undervalued free services. In Canada, there are more than 400 bee species that provide a lot of crop pollination. Bee population is declining due to decreased habitats, chemicals, etc. There are a lot of ways to help these pollinators. There are 5 parts to a diversified farming system :

1. There are many options for diversifying at the farm scale by adding habitat that can fit with any type of farm landscape and production. Options such as hedgerows (woody perennial and grasses or flowering plants), beetle banks, flower strips along edges, pivot corners, marginal land edges or fields under fallow or restored, intercropping, and cover crops.
2. Is there evidence if crops benefit by habitat enhancement? Comprehensive literature reviews of Bio Control 8 years ago concluded that there is substantial evidence that creation of SNH on working farms improves abundance and diversity of natural enemy insects both in restored areas and in adjacent crops. Studies show that wild pollinators are important for crop productivity and stability even when honey bees are abundant. There is evidence that native bees can increase production. There is new research to test crop reliance on bee pollination being conducted at the University of California. It is important to include policies to preserve and restore SNH in agricultural landscapes to enhance levels and reliability of pollination.
3. Economic analysis of hedgerows: in general, installing hedgerows is an additional cost. Studies show greater abundance of native bees and the presence of natural enemies in fields with hedgerows and that there is pest control. Likewise, a recent study (Pywell et al., 2015) showed that wildlife-friendly farming increased crop yield which is evidence for ecological intensification. It was concluded that diverting up to 8% arable land to wildlife habitat increased profitability.
4. There are concerns about increased arthropod pests, increased bird/mammal pests vectors, weedy plants, direct growers benefit, lack of guidelines for establishment and maintenance, and financial support. Many gaps need to be addressed in order to optimize the benefits of diversification.
5. There needs to be financial support: funding from ecosystem service enhancement, premium pricing from bee friendly farming, cost share or payment for service provision, federal/provincial government, and from non-profit organizations. There could be certification and premium for products.

Ten insects canola growers should want in their fields

Dr. John Gavloski, Entomologist, Manitoba Agriculture, Farm Production Extension

"Diversity is expected to give rise to ecosystem stability. Invasions most frequently occur on cultivated land where human influence has produced greatly simplified ecological communities."

Ten insects wanted on a canola farm include:

A. In or on the soil searching for prey
    1. Ground beetle: there are about 40,000 species worldwide and prey on any invertebrate they can overpower (cutworm or pupae of *E. ochrogaster, Delia* eggs, maggots and pupa), and are mostly nocturnal.

2. Rove beetles: there are about 63,000 species and most are predators and some are parasitoids of fly pupae. *Aleochara bipustulata* feed on root maggot eggs (1 adult consumes 23 eggs) and larvae (2.6 larvae/day). This beetle is being studied as potential biocontrol of root maggots in canola.
3. Stiletto flies: larvae acts as predators of insect larvae in the soil.

B. Searching plants for prey

4. Green lacewings: feeds on aphids, insect eggs, caterpillars, DBM larvae and cocoons, adult flea beetle, etc. These are reared and sold as control agents.
5. Damsel bugs: generalist predators, catching almost any smaller insects than themselves including DBM, adult flea beetle, and *Lygus*. An average of 131 eggs or 95 adult DBM were killed by a single female adult in 24h at 24°C.
6. Minute pirate bugs: inject digestive enzymes into prey before consumption. Commercially available as biocontrol agents.
7. Hover flies: often mistaken as wasps or bees, and prey on aphids, thrips, and other insects.

C. Insects that lay eggs in other insects, parasitoids

8. *Diadegma insulare*: lays eggs into DBM. It is not known to overwinter in Canada, and is believed to migrate northwards along with DBM. Study shows that *Diadegma* parasitized up to 50-90% of DBM in field trials. Nectar sources increase the longevity of female *Diadegma* from 2-5 days to more than 20 days.
9. *Banchus flavescens*: feeds on armyworm,1^{st} to 3^{rd} instar larvae
10. *Athrycia cinerea*: kills over 20% of bertha armyworm, and female attacks 3^{rd}, 4^{th}, 5^{th} and 6^{th} instar larvae

To conserve these natural enemies, selective insecticides should be applied when economic thresholds have been exceeded. Practice crop rotation, and maintain good habitat for natural enemies.

Questions and Answers

Q: Seed treatment is among the control measures against flea beetle in Canada. Is there a negative effect with natural enemies?
A: There is no evidence.

HARVEST MANAGEMENT PILLAR – THE REAPER

Harvest Technology

Brandon Olstad, Platform Manager – Efficient Agriculture Systems, CLAAS of America
Blake McOllough, Product Specialist, CLAAS of America

CLAAS is a family business founded in 1913 and is one of the world's leading manufacturers of agricultural engineering equipment. In 1990, LEXION was opened by the company for combine harvesters. Then the company developed "Efficient Agriculture Systems" (EASY), the electronics and technology systems and competency of CLAAS equipment, a brand of precision agriculture.
The initial approach to precision agriculture was to minimize the variability by changing the fertility to make the field more uniform. In fact it is the opposite. Precision agriculture, including variable-rate seeding is about making the most of the variability in the field. Variable-rate seeding is not an attempt to minimize variability within your field, but actually it is about maximizing the variability within the field.

The concept of variable rate harvesting is the same as other variable rate technologies, changing operational practices of the equipment to minimize (or control) inputs and maximize outputs. LEXION technologies aid the variable rate via the automation of CEMOS (CLAAS Electronic Machine Optimization System), Cruise Pilot, 4D cleaning system, Auto crop flow, Auto slope, and dynamic cooling. This machine maximizes performance in terms of yield, moisture, crop conditions, crop volume, and topography thereby reducing inputs (labor, fuel, machine size) and increases outputs (grain retention/feed quality, rate of work, throughput). Operation of this machine demonstrates that it reacts to high performing zones of the field differently compared to lower performing zones. CEMOS assist the combine operator in maximizing performance by continuously optimizing combine settings on-the-fly. It is made up of two control systems, auto separation and auto cleaning. Comparison performance of the CEMOS versus manual operation showed that CEMOS reacted to the variability as shown by the fluctuating graphs of fan and rotor speed, and the upper and lower sieves, while manual operation showed almost constant lines. Also, CEMOS operation had very low (or almost pure grain) foreign matter on grain harvest as compared to manual operation (0.11-0.25%). CEMOS operation reveal increase in the engine load (+25%) and throughput (+11%) relative to manual operation. Machine test trials on different crops (soybeans, winter wheat, winter canola, winter rye, winter barley) demonstrate that on every crop, CEMOS outperformed manual operation in terms of throughput (bu/hr), grain quality, foreign matter, and grain loss.

Question and Answers

Q: A concern was raised regarding the computer system.

A: There is an override.

2016 Canola Discovery Forum
Meeting Proceedings
The Fairmont Winnipeg

Thursday, October 27, 2016

GENETIC TECHNOLOGY – THE ODYSSEY

A discussion on the advanced breeding and potential genetic solutions to agronomy issues. How are regulators viewing gene editing?

Application of genomics technologies to canola crop improvement

Dr. Isobel Parkin, Research Scientist, AAFC Saskatoon Research and Development Centre

Canola or *B. napus* has a wealth of diversity but this has been reduced over time. Recent intense breeding has further reduced diversity; *B. napus* has effectively gone through multiple genetic bottlenecks that have reduced the available gene pool. It is now a highly complex genome that is hard to manipulate. To make the genetic improvements that will contribute to increased bushels/acre, yield and yield stability needs to be looked at. Current literature estimates the number of loci controlling such traits to be in the hundreds, seed oil content has been suggested to have controlling factors across 17 of the 19 chromosomes of *B. napus* and that is not even taking into account environmental effects of stress responses that need to be controlled. It is effectively about trying to manipulate the whole genome, which is where genomics comes in. How does one manipulate the entire genome – in a holistic fashion?

The genome of *B. napus* genome was released in 2014. There is now access to the genome sequences of not only *B. napus* but to all of its common crop relatives. What has been gained by sequencing the canola genome? Mapping will identify genes that control traits. Resources can be developed: i.e. DNA markers for marker-assisted selection and enhanced trait development. Regulatory sequences can be accessed as well as plant evolution can be looked at. One element of plant evolution that was an early discovery from the genome sequence turned out to be highly relevant to the adaptation of the canola crop itself. *B. napus* is formed from the fusion of two diploid genomes but these genomes are very closely related and this relationship has been exploited through the exchange of DNA between the two genomes to create novel variation of value to breeders. The exchange of DNA between the two species that hybridized to form *B. napus* led to the variation that brought about the low glucosinolate phenotype.

One of the most widely used tools that was first developed as a result of access to the genome sequence was the first generation *Brassica* SNP array. The SNP array (60,000 markers) is a good snapshot of what a genome looks like. Markers can now be developed very quickly. Where it once took almost three years to develop a map with 400 genetic markers covering the genome, now with the array, DNA can be processed for a few hundred lines, and in just under two weeks a genetic map can be generated with 20,000 points or markers across the genome.

Genome wide association studies (GWAS) can identify breeding targets and simultaneously provide markers to tag those traits and in some instances by looking back to the genome sequence may also be able to identify the causative gene underlying those traits.

How can these tools be used to tackle really complex traits? Prediction breeding, a work still in progress, identifies a subset and then predicts the lines which will have the most value which speeds up the breeding process.

How can variation be brought back? There is a project in *B. napus* to develop a structured population that will uncover loci controlling complex traits and identify favourable alleles. This targeted gene editing is very effective and accurate. The problem is that you still have to know what gene you want to target and so this may not be the magic bullet. Another possibility is to manipulate the natural mechanism for adaptation in *B. napus* and introduce natural pairing. And finally, attempts can be made to capture some of the lost variation by identifying structured populations to capture diversity and uncover loci controlling complex traits and identify favourable alleles, a holistic way to look at 'positive' alleles for a trait, as has been done with maize.

The current limitations include lack of diversity and the complexity of the remaining traits. Potential solutions include targeted gene manipulation, manipulation of recombination and exploiting available variation.

The NAM project

Dr. Sally Vail, Research Scientist, Oilseed Breeding, Agriculture and Agri-Food Canada

The nested association mapping (NAM) project looked to several diversity collections to select 50 Diverse 'Founder' lines (AAFC breeding lines, USDA Genebank, PGRC Genebank, AAFC historical collections). Lines were selected for pedigrees, phenotype and traits, and homozygosity (i.e. AA or aa, not Aa)

What is known about the 50 lines? They were grown at several locations and various parameters were looked at: range of flowering time, oil and protein quality, glucosinolates, and seed quality traits (various groups of quality)

The NAM Consortium Project is based at AAFC and is able to feed lines back into various projects with collaborators in seed chemistry (seed quality traits), plant pathology (new & emerging diseases), physiology (heat & drought tolerance, N uptake), agronomy (pod shatter resistance), entomology (pest & pollinator interactions), soil science (root & rhizosphere studies), public canola breeders (breeding line evaluation) and multidisciplinary collaborators (digital plant phenotyping).

NAM has a huge collaborative potential with captured diversity across the spring *B. napus* gene pool in a fixed germplasm resource with a wealth of genomic information available. There is multi-disciplinary collaboration opportunity as well as seemingly endless opportunities to use the population to study various agronomic traits.

Modification of starch metabolism in transgenic* Arabidopsis thaliana *increases biomass and oilseed production 3-4 fold

Dr. Michael Emes, Professor, Molecular and Cellular Biology, College of Biological Science, University of Guelph

Starch in higher plants is synthesized in plastids, either in leaf chloroplasts or in amyloplasts in tubers or roots. The starch synthesized in green tissues in chloroplasts is called transient starch – it is synthesized during the day and degrades at night to support metabolism. Storage starch (in amyloplasts) acts as a long-term carbon store for plant development, like seed germination and provides nutrients in severe conditions and as a means of asexual reproduction. Most usage is from storage starch.

Why Arabidopsis? It has proven to be a powerful tool to study plant biology. It has the advantage of a small sequenced genome, efficiently transformed, with a large number of mutant lines already available. *A. thaliana* leaf chloroplast starch shares a similar molecular structure and is comprised of similar polymers as storage starch, making Arabidopsis an excellent model system for studying the fundamental mechanism of starch biosynthesis. It has a high degree of homology to canola.

Starch is a polymer of glucose. It is insoluble and involves different groups of enzymes. Branching enzyme (SBE) is one of the key enzymes. It can be subdivided and forms packing of chains of glucose molecules. Arabidopsis has class 2 SBE but no class 1 enzyme. A double mutant with maize (ZmSBEI and ZmSBEIIb) can be made to study: if a plant can make starch, the amount of starch that is produced and even further detail to see granule distribution. This packing of glucose molecules is different in transgenic lines where starch granule morphology is altered in transformants. When observing transformant plants with either *Zm*SBEI or *Zm*SBEIIb, the phenotypes showed increase biomass. It is quite striking at 35 days – the plants are bigger with more pods forming, they are actually 2 to 3 times the wild type biomass. There is an increased number of siliques but they are smaller, showing a change in the morphology of the plants. There is a huge increase in the number of seeds, at least a 3-fold increase. As well, plants expressing *Zm*SBEs show a dramatic increase in triacylglycerol yield and there is no effect on oil quality. Harvest index is not significantly different but is lower than wild type. Another bonus is that carbohydrates (starch) are involved with meristem determinacy and so with extra carbohydrate there is far less abortion of flowers and far more pods form.

So when endogenous SBEs in Arabidopsis is replaced with endosperm-specific maize SBEs we have:

- Restoration of leaf starch biosynthesis (altered starch characteristics)
- Increased biomass
- Increased silique/seed number (11,000 à 50,000)
- Increased oilseed yield (2-3 fold)
- Maintained oil quality

The implications are increasing oilseed yield and biomass. Can this be done in a real crop? Canola seems like a good fit because of its close homology to Arabidopsis. Making a construct using CRISPR – Cas9 where BnSBE2.1 and BnSBE2.2 is targeted and edited out in canola and complement the Bnsbe knockouts with ZmSBEI or ZMSBEIIb constructs may not have identical results but there is potential for positive increase.

Questions and Answers

Q: What is the potential need for fertility?
A: Results were achieved with same input but cannot say what would happen if conditions changed.

Q: There is a vast diversity in other species? What about using them?
A: Using diversity from diploids was thought of but also introducing self-incompatibility. This is a work in progress. The starting point is to understand in *B. napus* first.

Q: On the goal to the 52 bushels by 2025?
A: In terms of hybrid breeding it is the same hope as in corn: traits are underlying yield stability.

Q: Do you think this work will help to overcome regulatory issues?
A: There is the ability to start to bridge between technologies.

ULTIMATE CANOLA CHALLENGE (UCC) AND ON-FARM RESEARCH – THE POWER PLANT

Nicole Philp, Agronomy Specialist, Southwest Saskatchewan, CCC
In the previous UCC program, small plot trials were held for 2 years with multiple products tested and researcher pitted against researcher. The field-scale program was launched in 2015 and was supplemented with small-plot sites. The UCC has now evolved into a vehicle to encourage canola growers to evaluate new products and practices for themselves using their own field scale trials. In 2016 nitrogen trial protocol was introduced to determine how increasing nitrogen rates in canola affect yield and profitability on the farm.

Kristen Phillips, Grower, W.P. Acres Ltd.
In 2013, agronomists' wanted to mimic the UCC 'fight' so various teams were formed who made all the decisions for each trial. As the season progressed, the program gained momentum and 3 tours were conducted. There was no difference in yields at the end of the season. In 2016, there was the opportunity to participate in UCC again. Finding growers to participate was very easy. Producers were targeted who would be interested or were already doing trials on the farm. Unfortunately, Mother Nature interfered with the trials and the first trial was lost to frost. Sites ranged in the amount of N applied, from normal to excessive rates. Replication was encouraged but ended up with random strips. Growers were asked to make observations and plant counts were done. Again weather hit, with 3 out of 4 sites hit with hail. Drones were used to look at fields.
Lessons learned:

- Work with growers who want to learn – these will be the ones to follow up with.
- Even the best plans fail.
- Take good notes, this will teach a great deal.
- Mother Nature will throw curve balls.
- Did we as a unit learn something? Apparently so, everyone wants to do it again.

Conducting these trials created a lasting network with farmers ranging in age from 33 to 63. All growers were interested to see how everyone else did.
Some farmers' comments:

- Learned that it does not matter where you are farming.
- If you do not do a trial on your own, you are losing out on valuable data.
- Scouting is important, missing out if it is not done.
- A trial is only as good as its parts.
- "Could you buy me one of those drones?"

The extra work needed is minimal and the protocol is easy to follow and it opened farmers' eyes to do on-farm trials. Harvest went well but tracking down a weigh wagon is challenging. Growers can use their own equipment to do calculations or there needs to be more wagons and being within a bushel or 2 is acceptable. Challenge producers to conduct trials and form a crop club and to be an advocate!

Nicole Philp:
UCC results will be shared on CCC website.
The short term plan is to continue with N focus and to continue to promote other protocols.
In the future, the wish list includes:

- Online form or application for submission.
- Self-sustaining program with protocol support for farmers but growers will decide what they want to test.

- Develop a database of trial results.

Opportunities are there for UCC: retailers working with farmers, seed companies with variety trials, independent consultants, and a new way to work with farmers for government and universities.

Question and Answers

Q: Did growers compare weigh wagon to their own combine?
A: Everyone was within 1 bushel. Growers did calibrate.
Q: Should we look at N in and N out?
A: Everyone did soil tests. That is currently not part of protocol but it is food for thought.

WEEDS, HERBICIDE RESISTANCE AND STEWARDSHIP – THE WILD BUNCH
Herbicide resistant strategies

Herbicide Resistance in Manitoba
Dr. Jeanette Gaultier, Weed Specialist, Manitoba Agriculture, Agri-Industry Development and Advancement Division, Crop Industry Branch, Farm Production Extension

Why consider weeds in canola? Although it is a very competitive crop there are weeds that tolerate herbicides and create problems in canola, weed management should be maintained. Glyphosate resistance globally is the highest in the US. This resistance has tragically changed how weeds are managed and has impacted all cropping systems. Glyphosate resistance is worse in eastern Canada. On the prairies the issue is kochia. From 2011 through to 2103 of all areas surveyed, 2 cases were found in Saskatchewan and there were more found in Alberta. In Manitoba, the resistance pressure is different. It is found in RR corn and RR soybean crops.

Herbicide use trends collected between 1993 and 2010 show that Group 2, 1 and 4 has the highest usage. Use of glyphosate increased due to the increased use of RR canola. Overall, however, herbicide use trends have not seen a change. The total amount did not increase but more acres received glyphosate. Unfortunately there is little to no information on use patterns.
Strategies for glyphosate-resistance on the prairies include:

- Rotation of herbicide MOA
- Tank-mixing herbicide MOA
- Rotation of HT trait
- IPM

Tank mixing is considered the most effective way to reduce resistance but there are no metrics to measure what farmers are doing. Grower surveys are only collected once a decade. They are useful but not collected often enough. Since 2013 producers have been asked to submit suspect kochia. Green material can be collected without waiting for seeds. Work is being done with PSI (Pest Surveillance Initiative) to use qPCR to analyze for rapid, in-season results. What about increased surveillance? Perhaps the same approach as clubroot should be taken? There is a need to be pro-active and to also look at other weeds of concern such as common ragweed, giant ragweed, water hemp (new find), and smooth pigweed (new find). There are new mechanisms of resistance which means that farmers will see new symptoms in the field. Farmers need to be educated as to what to look for in the field.
In summary:

- Continued education – good impact
- Information on herbicide use (metric, targeted extension)
- Additional qPCR – do we need to look at other tests for other weeds?
- Increase surveillance.

A grower's perspective on weed management

Brian Hildebrand, Grower, Brian G. Hildebrand Farms Ltd.

Resistance is a problem that no one wants to admit that they have. A tell-tale sign is finding kochia in chemically fallow fields. It is not a new problem; previously there was wild mustard which is no longer a problem with the application of 2,4-D. When a niche is vacated, "nature abhors a vacuum" and something else will come in. The problem has been amplified with low cost of glyphosate. When there are known resistant plants in a population, it is a mathematical inevitability.

The Plant Disease Triangle can be used in the same way for weeds. Triangle tools for weed control include: competition (adequate plant populations; healthy strong plants; fertilize the plants, not the weeds); sanitation (herbicides; eliminate soil disturbance when weed seeds are on surface, will not germinate as easily; prevent import of weeds) and diverse rotations (multiple crop types; numerous herbicide groups, do not rely on one group).

The conundrum that the farmer faces: I have done everything right but the farmer up the way has not. What do I do? Do I do the right thing or maximize the tools of technology?

Questions and Answers

Q: Comment: If we want general public to allow us to continue, we have to do the right thing collectively as farmers.
A: People want to do the right thing but how do we do that? Industry has offered their resistance studies. Perhaps there could be the same type of mapping like what is being done for clubroot. The problem is that resistance testing is not cheap.

Q: As a producer buying certified seed from different areas, will weeds be introduced to new farms?
A: Certified seed is a good management tool but all it takes is one to get through. Increased global agriculture will add to problem. Make sure to clean your farm.

Q: Comment: The day that this takes away from land values is when farmers will take notice.
A: Yes, that will have an impact. At this point, land prices are so high; it does not seem to have an impact at present.

Q: Trying to educate as a retailer to the farmer, there is lots of price-sensitive pricing.
A: This has happened previously and we have not learned from the past.

Q: Comment: More time needs to be spent educating farmers. There is a success story in wheat and herbicides must be used in a good, educated way to protect its efficacy.
A: It is a numbers game to reduce risk by having some proportion of producers use products properly; that is a good start.

Q: What is the response to "Yes, but I have to make a living"?
A: There is a short-term versus long-term view.

Q: The Noxious Weed Act in Alberta, – could resistant weeds be included and listed in the Act? Is this drastic or reasonable?
A: Manitoba recently amended its Act – water hemp was added to Tier One weeds and smooth pigweed was added. We do have teeth to go out and get control.

A DISCUSSION ON 15-YEAR FUNDING FOR KEY PROJECTS: WHAT SHOULD THOSE KEY PROJECTS BE? HOW MUCH MONEY WOULD IT TAKE TO DO A GOOD JOB?

Taking Canadian canola to the next level: 2025 and beyond (2050)
Dr. Wilf Keller, President and CEO, Ag-West Bio Inc.
Long-term research investment is required to achieve strategic goals. The cumulative value of Canada's canola industry from 2020 to 2050 equals $1 trillion. At a 1% investment, a fund of $10 billion could be established.

Many anticipated scientific and technological advances could be part of this $10B Challenge, such as: higher protein content (advanced canola meal with protein content comparable to soybean meal but with lower cost, improving animal production); soil organic carbon (canola is 1.5 better than wheat); genetics (using CRSPR to introduce new traits); smart GM plants (sentinel plants that could detect a problem and signal to the main crop of 'smart' plants); rhizosphere opportunities (root to root connection via mycorrhizal hyphae); and hybrids (other methods to produce hybrids i.e. single generation hybrids with no need for inbred lines).

Challenges that present themselves to industry are:

- The consolidations in industry.
- The continuing public concerns over GMO's.
- Canola's low profile vis-à-vis other crops (corn, soybean, cotton, rice, wheat).
- Government policies regarding R&D and climate change.
- Trade issues: retaining existing markets and opening new markets

Despite these challenges there are a number of opportunities such as working with AAFC, connecting with the Global Institute for Food Security, restoring R & D at the National Research Council, influencing universities to pursue strategic research for canola improvement and promoting international collaborations.

To attain these 2050 goals, an inventory of relevant public R & D activities needs to be developed and maintained, ensure appropriate balance across the CCC program spectrum and aggressively lobby for increased crop research and development funding. The CCC has skills connecting with government and should continue to build on the relationships with key players such as ISED (national innovation clusters), Science (NRC) and Finance ("food innovation') ministries, and AAFC (APF clusters and Agriculture Policy Framework) among others.

Alberta Canola Producers Commission research involvement – an eye on the future
Ward Toma, General Manager, Alberta Canola Producers Commission
There have been many changes over the last 15 years. The average yield for canola has steadily increased since 2004. The first canola variety was introduced in 1974 and the first non-government variety was registered in 1985. By 1994-95 there was lots of activity in the world of genetics with the introduction of herbicide tolerant systems and the DH cultivar Quantum. Hybrid canola arrived in 2000 and showed very strongly through drought conditions. How does all this work into long-term arrangements? Over the past 15 years ACPC, trying to solve problems, has conducted over 60 unique agronomy trials, all resulting in published scientific articles. The research became prairie-wide with sites in all provinces. Some of the big impact trials included:

- Riskiness of fall seeded canola.
- Early weed removal.
- Optimal N levels for hybrids.

- Multiple factorial trials – seed rate x weed removal x se seeding date.
- Farm saved seed, the most cited published journal article.
- But the biggest impact overall was getting farmers into research plots and researchers into farmers' fields.

Questions and Answers

Q: What pests would you target?

A: Area of volatiles is a good place to start. It is hard to predict which pest but must make long-term commitments to this area. It is up to the canola industry to decide.

Comment: Thank you to those that have made research work.

Comment: More research money into genetic diversity is needed, more collections are needed.

Comment: Genetic versus agronomy research?

Comment: Are research dollars best spent on 'yield'? The crop still needs to get out of the field.

CANOVISION – ANALYTICAL THOUGHT
Discovery Task Force Panelists

The tools to balance latest evidence with previously accepted standards

Dr. Roger Suss, MD, Assistant Professor, Department of Family Medicine, University of Manitoba

The goal in medicine is to take science and use it to improve the lives of others but who do doctors answer to? Doctors answer to their patients and hospitals, to a certain extent, but definitely to the College of Physicians & Surgeons and to the courts. What is the right thing for the physician to do? There is a conflict between standard of care versus evidence. Navigating this has two potentially conflicting strategies. In terms of the physician's behavior, one wants to be close to the middle of the pack but sometimes it is not what the best evidence shows and then how do doctors implement change?

Who writes the guidelines? They come from different sources and not from the College of Physicians and Surgeons or the courts. They are from professional associations, self-appointed groups, industry sponsored groups and come with a set of recommendations. There are grades for these practice guidelines with 'weak' or 'strong' recommendation based on the level of the evidence's quality. The types of evidence can go through levels of observation, from an uncontrolled observation to a descriptive study to an analytical study. To be at the top level of evidence it should have the investigator assigning exposure. For example, smoking which has a large amount of "medium" level of evidence in research accumulated, so it then becomes a standard of care issue. Another example is butter which had become a standard of care issue with a medium level of evidence but over time the evidence has changed. Finally, there is the issue of external validity when one is fairly confident in one circumstance but not sure of it in another circumstance. Just because it is good for one patient, it may not be good for another. In other words, weighing the harm versus the benefit where the focus is on "does this work" but may want to know by how much.

Unlocking the power of digital agriculture

Todd Eyrick, North American InformationTechnology Lead, Monsanto

"We became a biotech company, we transformed into a seed company, we are now in the process of transforming into a data science company."
- Robb Fraley, Monsanto Chief Technology Officer

What is data science? Extracting insights from data. In 2013 Monsanto launched its first IT product and in 2014 it purchased The Climate Corporation to move further into a data science company.

What is “Digital”? Digital creates value at new frontiers of business through big data, analytics, and collecting simple customer experiences. For example, Amazon knowing what a customer wants. When this is applied to agriculture it becomes: how to get the right seed on the right acre with the right management? Digital Agriculture looks to a deeper understanding of G (genetics) x E (environment) x T (traits) x M (management practices). Monsanto has Big Data, Analytics (over 100 data scientists); and Human Centered Design – for simplicity and ease of use. A key element is bringing farmers into the process of product development.

An example of digital agriculture is Climate FieldView, which Monsanto hopes to be launching in eastern Canada in mid-December 2016, focusing on corn and soybeans. Climate FieldView brings together seamless field data collection, advanced agronomic modeling and local weather monitoring and combines it into simple mobile and web software. Key features include data collection and analysis, field health imagery, yield analysis, geo-located scouting images, historical and field-level weather and personalized notifications.

Monsanto is still laying the foundation and there is still time to get involved. Advancements will always be better if farmers are involved in the innovation. Protect your data is a great asset to have.

Back to the Future: Technology on Our Farm – Past, Present and Future
Ron Krahn, Director, Manitoba Canola Growers Association
Providence Farms is located in Rivers, Manitoba and has 5,500 acres of wheat, canola, peas, soybeans and sunflowers. Equipment has evolved over time and now the farm utilizes many GPS technologies such Light Bar Guidance/Autosteer (introduced 2004-2006), sprayer mapping/section control (2006), yield monitors on combines (2012) and section control on NH3 applicator (2015). The farm has also used variable rate (VR) nitrogen on 900 acres since the mid 2000’s.

Future technology use will look to variable rate crop inputs and disease prediction and modeling as well as new equipment that will help plant establishment, monitor and manage the farm and perhaps more use of drones and robots. This future use hinges on 4 R’s - right place, time, rate, and product. There is huge variability in fields and they cannot be treated all the same.

VR fertilizing has come a long way from 1940’s and manure forked off a stoneboat. Although equipment is not expensive and is straight forward there are difficulties with VR. Agronomy is still the missing link as every zone has a limiting factor. How does one determine different zones and how to treat these differently? There are many different methodologies such as Farmer’s Edge, FarmSite, Decisive Farming but all have the same goals. Three main hurdles to successful VR input applications are: 20-30 years of yield data to predict variability (it is important to have that history); best way to determine soil zones and knowing the limiting factor in each zone i.e. there can be 186 zones on one farm.

VR seeding: overlaying seeding rate is variety and soil type specific. It is there for corn in the US but not quite there with canola. Disease prediction will become more important in the years to come. Ten years from now, will there be a weather station in every field? With the unpredictability of sclerotinia and blackleg and insurance spraying costing between $30-35/acre, this becomes a $60,000–$70,000 decision.

With plant establishment success rates ranging from 50-98%, depth control is important and depth control/singulation planters are gaining popularity in western Canada. An ideal seeder would use tank/metering configurations to plant multi-varieties in the same field and have the ability to plant into zero-till conditions.

Managing and monitoring the farm is changing; for example, now bins do not adequately fit harvest amounts. In 10 years' time it would be great to monitor everything digitally and not have 10 different apps. Monitoring remotely from a tablet or phone could cover weather stations in all fields, machinery and truck operations, grain inventory, accounting & financial information as well as crop records. There are opportunities for perhaps use of robotic tractors, drones used as sprayers and so on. Technology is moving forward.

Questions and Answers

Q: How much is weather related and how much is growers' decisions?
A: Some of these tools can come into play, the ability to use robotics and bringing systems together into one format that will have an effect.

Q: We get battered by the public over our practices and providing better evidence. What do you do in the medical field to combat this?
A: There are different answers for the "you" in the question. Doctors in Manitoba do try to promote. Patients can be referred to good web sites and resources. Some are run by government agencies.

Q: Is there a body in medicine that sets the record straight?
A: Dr. Oz is an example where a governing body decided that was he was doing was entertainment. He is "on the line".
It is a challenge with very little interchange between urban and rural. A lot is not based on fact. The responsibility falls to the farmer in the room to educate the public. The science causes the "middle" faction to move.
Strategy to winning the war is something in common between doctors and farmers.

Q: What are some of the successes to VR technology.
A: It is driven by the 4 R's; we are smarter now than before but still striving.

Q: Is there profitability in more technology?
A: Probably more ROI in the past but there are examples all the time. Small changes increase profits.

Q: What evidence changed your mind or made you re-think something; a use for example such as butter?
A: Experts and a re –examination of previous evidence; something maybe missed or overstated evidence, social forces.

Q: How many times a day are you thinking "Am I making decisions with good evidence?"
A: All the time. Many patients have chronic illnesses and have not been able to make their problems go away trying evidence-based research and end up moving down the evidence ladder to a lower level.
A: Lots of decisions and it depends on what you have to invest in it. Still have to prove it for ourselves.

FINAL RESEARCH PRIORITIES LEADERBOARD OVERVIEW AND SURVEY
Jay Whetter, Communications Manager, *Canola Watch and Canola Digest*, Editor, Canola Council of Canada

Jay Whetter led "priorities" discussions throughout the event and attendees had a chance to add priorities through open discussion or using their phones through the "mentimeter" program at menti.com. Jay then combined all suggested priorities into a list of 30. Each individual who attended CDF had a chance to rank these 30, also through mentimeter. Below is the final tally from 57 CDF attendees who responded. These results show each priority's share out of 100.

Your chance to rank the canola research priorities:
13% - Blackleg: R Gene ID so growers can rotate
9% - Blackleg: L. maculans diversity and how quickly it changes
7% - Sclerotinia stem rot – develop a predication app
5% - Blackleg: Better understanding of major R genes vs. adult/whole plant resistance
5% - Nitrogen: Updated response curves/recommendations for hybrids
4% - Clubroot: Management for infested field including R gene rotation
4% - Genetics: screening nitrogen use efficiency and abiotic stress (e.g. drought, water stress, freezing, cold anoxia/flooding)
4% - Fertilizer efficiency: Practices to reduce loss (including C and NOx), improve ROI
4% - Fertilizer: Does ideal placement vary by soil, geography, conditions?
3% - Genetics: For yield, increase Dr. Eames corn starch gene work
3% - Straight cutting: Economics of straight cutting vs. swathing?
3% - *Verticillium* stripe yield loss quantification
3% - How farming will adapt to greenhouse gas reduction requirements?
3% - Multiple pest interactions. Flea beetles/blackleg; root maggot/root disease, etc., variety
3% - In-row seed spacing. Is it important for canola?
3% - Blackleg: Seed treatment to reduce early infection
3% - Low plant populations: How does weed, disease, and other management change it?
3% - Variety specific response to increasing spring N rates
2% - Technology stewardship for herbicides, fungicides, R genes, etc.
2% - Flea beetles: Predictive information for field or region
2% - Blackleg: Yield loss assessment
2% - Genetics: Disease R gene identification
2% - 3rd party testing: VRT, fungicides, varieties for straight cutting
2% - Residue management for better establishment
2% - Priorities list of best/most profitable practices for producers
1% - Swede midge: What is the threat?
1% - Sclerotinia stem rot: Alternate management, including management of sclerotia using Contans, etc.
1% - Hormones to control pests
1% - Swathing: Timing based plant density, number of branches
1% - Insects: New thresholds for DBM, for example, to consider beneficials

(Final tabulation courtesy of Jay Whetter)

This ranking result is merely a guide to be used as a point of discussion for those making research funding decisions.

Comment: Economics on farms: compare the dollars invested in machinery, $59 billion generated from all crops grown in Canada to $41.4 billion invested in machinery when looking at opportunity.
It would be nice to start to look at rankings per year to see if there are any trends in these priorities.
Pathology groups, we should really push for their work: shooting for heterosis and look to promote pre-breeding work.

Closing Remarks

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

We value ourselves as being an evidence based group, but we still make decisions on incomplete information. This type of forum allows us to identify gaps and move forward when using technology and look to the right people to work on these gaps. This is a great opportunity to facilitate strong networks and to get ready for a GF3 application. This forum has been of enormous benefit.

Thanks to all speakers, all who attended and helped with leaderboard participation to help set priorities and to all team members of CCC. And special thanks to Gail Hoskins and Ellen McNabb for all their work with the logistics of this conference.