Fifth Joint Meeting of the Plant Pathology Society of Alberta (39th Annual) & Saskatchewan Regional Group of CPS

October 15–17, 2018, Days Inn and Suites, Lloydminster, Alberta

Gold Sponsors

Silver Sponsors

Program and Agenda
Fifth Joint Meeting, CPS-SK and PPSA

Date & Time	Event
Monday, Oct. 15th	
6:30 pm – 8:00 pm	Registration and poster set-up
7:00 pm – 9:00 pm	Reception
Tuesday, Oct. 16th	
7:30 am – 9:00 am	Breakfast (provided)
8:00 am – 9:30 am	Registration and poster set-up
8:30 am – 9:30 am	PPSA business meeting
9:30 am – 9:55 am	Refreshment break Poster viewing (presenters not expected to be at posters)
9:55 am – 10:15 am	Welcome, opening remarks, and greeting
10:15 am – 11:45 am	**Paper session I**: Student oral presentations, (15 min) **Chair: Noryne Rauhala** Nicole Fox - Evaluation of clubroot disease development in canola in response to variable lime products and rates Brittany Hennig - Evaluation of the impact of liming and weed control on clubroot of canola Keiko Nabetani - Detection and evaluation of the residual effect of defeated stripe rust resistance genes (*Yr* genes) in wheat. Keisha Hollman - Evaluation of the impact of hydrated lime on clubroot severity in canola over multiple growing seasons Yixiao Wang - Yield losses of canola caused by blackleg and pyraclostrobin sensitivity in populations of *Leptosphaeria maculans* Zhiyu Yu - Genome-wide-association studies on the resistance of rutabaga accessions to *Plasmodiophora brassicae* isolates from Alberta, Canada
11:45 am – 12:00 pm	Alberta Canola, Gold Sponsor, presentation delivered by Brittany Hennig
12:00 pm – 1:00 pm	Lunch (provided) Posters available for viewing, presenters not expected to be present
1:00 pm – 2:00 pm	**Invited Speaker, Tim Murray** (Washington State University) Climate change and its impact on diseases of winter wheat
2:00 pm – 3:20 pm	**Paper session II:** Foliar and cereal diseases (20 min) **Chair: Merek Wigness** Kelly Turkington - The impact of barley variety rotation, mixtures, and intercropping on leaf disease and silage production

Michelle Hubbard - Managing *Ascochyta rabiei* in diverse environments by intercropping chickpea with flax

Lipu Wang - LC-MS/MS based Mycotoxin/Deoxynivalenol (DON) diagnostic platform for FHB research and breeding programs

Daniel McDougall - Development of a *Pseudomonas syringae* based biocontrol agent for use against Canada thistle

3:20 pm – 3:35 pm Refreshment break
Posters available for viewing, presenters not expected to be present

3:35 pm – 5:00 pm **Poster session** (presenters available at posters)

6:00 pm – 6:30 pm Cocktails

6:30 pm – 8:30 pm Banquet

Wednesday, Oct. 17th

7:30 am – 8:30 am Breakfast (provided)

8:30 am – 9:00 am **Invited Speaker, Yantai Gan** - Adapting agronomic practices to changing climates through 'System Integration'

9:00 am – 10:00 am Paper session III: Environment-phytopathogen interactions (20 min)
Chair: Mary Ruth McDonald

Michael Harding - Disease trends in wheat, canola and peas in Alberta from 2015 to 2018

Syama Chatterton - Seasonal and regional variability of pea root rot and yield in field trials naturally-infested with *Aphanomyces euteiches* in Alberta

Michelle Hubbard - Assessing the potential of managing root rot with nitrogen fertilizer and a commercial arbuscular mycorrhizal fungi product in three Saskatchewan environments

10:00 am – 10:20 am Refreshment break

10:20 am – 12:00 pm Paper session IV: Disease resistance and identification (20 min)
Chair: Yu Chen

Dilantha Fernando - CRISPR/Cas9 mutation of an avirulence gene allows understanding of *Brassica napus* - *Leptosphaeria maculans* interactions

Fuyou Fu - Identification the durable blackleg resistance loci in Chinese and Canadian canola germplasm through genome-wide association analysis

Yan Zhang - Introgression of disease resistance from *Brassica nigra* into canola

Jie Feng - Using RNase H-dependent PCR (rhPCR) in species identification and plant disease diagnoses

Charitha Jayasinghege - The roles of auxin, ethylene and abscisic acid in clubroot development in *Brassica napus*

12:00 pm – 1:00 pm Lunch (provided)

1:00 pm – 1:40 pm Paper session V: Clubroot management (20 min)

Chair: Wen Rui

Mary Ruth McDonald - The efficacy of fumigation and totally impermeable film for the control of clubroot of Brassica crops

Bruce Gossen - Managing small patches of infestation of *Plasmodiophora brassicae* (clubroot) in fields

1:40 pm – 2:10 pm **Invited Speaker, Gary Peng** - Managing blackleg of canola in western Canada - An integrated approach

Adjournment.

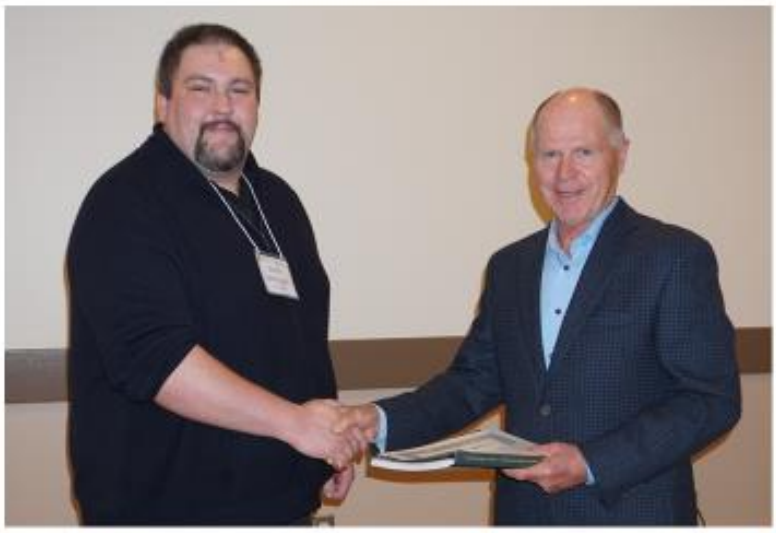
Nicole Fox – 1st place, Student presentation, presented by Dr. R Howard

Keisha Hollman – 2nd place

Yixiao Wang – 3rd place

Posters

#	Presenting Author	Title
	Cereal diseases, Fusarium species and plant-pathogen interactions	
1	Kate Garland	*Rhynchosporium commune* and *Pyrenophora teres*: Screening for resistant barley varieties at the Lacombe Research and Development Centre
2	Kris Kumar	Virulence of *Puccinia striiformis* on wheat and barley in central Alberta during 2015-2017
3	Carol Pugh	Prevalence and distribution of *Fusarium graminearum* chemotypes in Alberta corn fields from 2015 to 2017
4	Greg Daniels	Evaluating temporal variation in fungicide sensitivity assessments of *Fusarium* isolates collected from potato tubers
5	Lipu Wang	New sources of resistance to Fusarium Head Blight in spring wheat
6	Lipu Wang	Plants employ two different types of programmed cell death in response to low temperature stress and pathogen invasion
	Diseases of legumes	
7	Dustin Burke	A survey of pea diseases in Alberta in 2018
8	Syama Chatterton	Chocolate spot disease survey of faba bean on the Canadian prairies in 2018
9	Syama Chatterton	White mould (*Sclerotinia sclerotiorum*) intensity and ascospore release in dry bean fields in southern Alberta in 2018
10	Michelle Hubbard	Isolation and characterization of *Aphanomyces euteiches* antagonistic bacteria from lentil root and rhizosphere
11	Doug Fehr	Performance of Lumisena™ fungicide seed treatment for the control of *Phytophthora sojae* in soybean
	Clubroot and blackleg	
12	Jinghe Wang	Screening of Brassica species for resistance to *Plasmodiophora brassicae* (clubroot) pathotype 5X
13	Rui Wen	Transcriptome analysis of *Brassica napus* lines carrying single and double clubroot resistance genes against the *Plasmodiophora brassicae* pathotype X-LG2 (5X)
14	Mary Ruth McDonald	Production of single-spore isolates of *Plasmodiophora brassicae* using micromanipulation of resting spores
15	Bruce Gossen	Application of molecular quantification of *Plasmodiophora brassicae in soil*
16	Linda McGregor	Developing a droplet-digital PCR-based protocol for rapid screening of quantitative resistance against blackleg of canola
17	Blake Hill	Survey for blackleg on canola in southern Alberta in 2018



Daniel McDougall – 1st place, Technician presentation, presented by Dr. R Howard

Linda McGregor– 2nd place

Blake Hill– 3rd place

Abstracts

A survey of pea diseases in Alberta in 2018. D. A. BURKE, G. C. DANIELS, S. CHATTERTON, C. VUCUREVICH, R. BOWNESS, T. DUBITZ AND M. W. HARDING. *Alberta Agriculture and Forestry, Crop Diversification Centre South, Brooks, AB T1R 1E6, Canada; (S.C., C.V.) Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB T1J 4B1, Canada; (R.B., T.D.) Lacombe Research Centre, Alberta Agriculture and Forestry, Lacombe, AB T4L 1W1, Canada.*

A survey of diseases on field pea (*Pisum sativum* L.) was performed in Alberta in 2018. Disease prevalence, incidence and severity was recorded for root rot, mycosphaerella blight and bacterial blight in 74 fields. Within each field, 100 plants were examined for foliar diseases and 25 to 50 roots were evaluated for root rot symptoms. Diseases were characterized visually based on root discoloration and foliar lesions. Disease severities were estimated using published disease rating scales ranging from 1 to 7 where a rating of '1' represented no visible disease symptoms, through to a rating of '7' which represented extreme disease severity, and often plant death. Root rots were present in 90% of fields with average disease incidence and severity of 55% and 2.0, respectively. Mycosphaerella blight was present in 66% of fields with average incidence and severity of 53% and 2.0, respectively. Bacterial blight was observed at trace levels in two fields. These results represent a slight decline in root rot and mycosphaerella blight and an extreme decline in bacterial blight when compared with survey results reported in 2017.

Seasonal and regional variability of pea root rot and yield in field trials naturally-infested with *Aphanomyces euteiches* in Alberta. S. CHATTERTON, R. BOWNESS[2], AND M. W. HARDING. *Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB T1J 4B1, Canada; (R.B.) [2]Lacombe Research Centre, Alberta Agriculture and Forestry, 6000 C E Trail, Lacombe, AB T4L 1W1, Canada;*

and (M.W.H.) Crop Diversification Centre South, Alberta Agriculture and Forestry, 301 Horticultural Station Road East, Brooks, AB T1R 1E6, Canada.

Aphanomyces root rot, caused by *Aphanomyces euteiches* Drechs., was first detected in pea (*Pisum sativum* L.) fields in Saskatchewan and Alberta in 2012 and 2013, respectively, and has caused significant crop loss in both provinces. Currently, extending the cropping interval between susceptible crops and avoiding infested fields are the only root rot management recommendations. Field trials were conducted in four locations in Alberta from 2015 – 2018 to determine the effects of various seed treatments. Trial sites were located in producers' fields that last had peas in 2014 and were identified to have high levels of natural inoculum of *A. euteiches* and *Fusarium* spp, based on root rot ratings during the 2014 growing season. Trials were conducted in the same fields but research plots were placed at unique sites within the naturally-infested fields every year, with some exceptions due to producer practices. Some seed treatment products provided early season suppression of root rots at some locations, but did not result in significant yield differences. Average yields across all treatments varied from 0 to >4,000 kg/ha at different locations, regardless of disease pressure, emphasizing the seasonal and regional variability of root rot severity, and difficulties assessing impacts of root rots on pea yields. At some locations yields improved slightly as the length of time out of peas increased, but root rot severity did not, except at one location. Results highlight the long-term impact of *A. euteiches* on yield loss, and the lack of effective management options for this destructive pathogen.

Prevalence and distribution of *Fusarium graminearum* chemotypes in Alberta corn fields from 2015 to 2017. G. C. DANIELS, C. A. PUGH, M. KUNDU, C. L. MCCONNELL, K. ZUZAK, J. FENG AND M. W. HARDING. *Alberta Agriculture and Forestry, Crop Diversification Centre South, Brooks, AB T1R 1E6; (K.Z., J.F.) Alberta Plant Health Laboratory, Alberta Agriculture and Forestry, Edmonton, AB T5Y 6H3, Canada.*

Fusarium graminearum Schwabe causes stalk and ear rot of corn (*Zea mays* L.). From 2015 through 2017, samples consisting of 100 lower-stem nodes were collected from approximately 1% of Alberta corn fields. Over the three years, 37, 43 and 135 samples were collected, respectively. Nodes were surface sterilized, dissected and cultured on acidified potato dextrose agar. The fungal colonies obtained were sub-cultured to fresh plates and single-spore isolates were generated, identified to species by multiplex PCR, and tested to determine their chemotypes. The prevalence of *F. graminearum* within the province was 70.3%, 73.8% and 46.6% over the three seasons. The 15-ADON chemotype was present in 92.3%, 87.1% and 92.7% of the fields where *F. graminearum* was identified, while the 3-ADON chemotype was present in 26.9%, 35.5% and 18.2% of these fields, respectively. Overall, the disease prevalence for the province dropped in 2017 due to large increases in corn acreage reported in the 2016 agricultural census. Many areas with increased corn production do not yet display a high prevalence of the pathogen. *F. graminearum* prevalence remains highest in southern Alberta, but this report, and others, demonstrate that it is becoming more prevalent in other areas of the province. This report also highlights that while the incidence of head blight in wheat may fluctuate dramatically from year-to-year due to weather, *F. graminearum* stalk rot on corn does not.

Using RNase H-dependent PCR (rhPCR) in species identification and plant disease diagnoses. J. FENG. *Alberta Plant Health Lab, Alberta Agriculture and Forestry, Edmonton, AB T5Y 6H3, Canada.*

The RNase H-dependent PCR (rhPCR) technique can differentiate between two individuals that carry a single nucleotide polymorphism (SNP) within a DNA region through selective amplification of one but not the other. In addition, formation of primer dimers is inhibited in the rhPCR reaction. When applied to the detection of SNPs, rhPCR is more sensitive than standard allele-specific PCR. The Alberta Plant Health Lab has developed and routinely used rhPCR protocols for differentiation of clubroot (*Plasmodiophora brassicae*) pathotypes and identification of *Phragmites australis* subspecies. For clubroot pathotype differentiation, the rhPCR protocol can detect the SNPs between the new virulent pathotypes and the old avirulent pathotypes. Moreover, the protocol represents a simple method to evaluate genetic diversity of *P. brassicae* in a single clubroot gall produced from a

field population, or from a single-spore isolate. For *P. australis* subspecies identification, the rhPCR protocol is as accurate as the widely used restriction fragment length polymorphism (RFLP) method but less time consuming. New rhPCR protocols under development include species identification of phytoplasmas (*Candidus Liberibacter solanacearum* and *Candidus Phytoplasma asteris*) and watermilfoils (*Myriophyllum spicatum*, *M. sibiricum* and *M. spicatum* x *M. sibiricum*).

CRISPR/Cas9 mutation of an avirulence gene allows understanding of *Brassica napus* - *Leptosphaeria maculans* interactions. W. D. G. FERNANDO, R. PADMATHILAKE, Z. ZOU, J. TUCKER, A. CARTER, H. SONAH, R. BELANGER, S. JIA, P. HU AND M. BALESDENT. *Department of Plant Science, University of Manitoba, Winnipeg MB R3T2N2, Canada; (A.C.) Agriculture and Agri-Food Canada, R.R. 8th Street & Grand Valley Road, Brandon, MB, R7A 5Y3, Canada; (R.B.) Laval University, Québec, G1V0A6 Canada, (S. J.) Department of Biochemistry and Medical Genetics, Max Rady College of Medicine, University of Manitoba, Winnipeg MB R3T2N2, Canada; and (M.B.) UMR Bioger, INRA, Thiverval-Grignon, France.*

Leptosphaeria maculans (Desmaz.) Ces. & De Not. causes blackleg disease and remains a significant threat to canola (*Brassica napus* L.) cultivation in Canada. A less understood aspect of this disease is the biotrophic and necrotrophic phases and how that shift affects the intrinsic gene expressions within the plant and the pathogen. The pathogen population in Canadian prairies have a very high proportion of the *AvrLm7*, making *Rlm7* one of the most desired R-genes to be used. Canola industry has introduced the R-gene rotation as a new disease management tool, and the seed industry is beginning to label its varieties with the R-genes. A mutant isolate umavr7 was generated by using CRISPR/Cas9 with a point mutation of the *L. maculans* isolate UMAvr7 which carries only a single avirulence gene, *AvrLm7*. Pathogenicity tests validated that the mutated umavr7 caused large/grey leaf lesions on cultivar 01-23-2-1 which carries a single *R*-gene, *Rlm7*. Isolate UMAvr7 causes a hypersensitive reaction 01-23-2-1. RNASeq was employed to interpret the reactions of *AvrLm7-Rlm7* and *avrlm7-Rlm7* interactions. Cultivar Westar was used as the susceptible check. Cotyledons of these two cultivars inoculated with the two isolates, UMAvr7 and umavr7, were collected at different time-points and used for RNA extraction. RNA samples were sequenced to identify the differentially expressed genes in these host-pathogen interactions. Comparative analysis of the changes in host and pathogen transcriptomes under incompatible over compatible interactions, expression differences of receptor genes and genes associated with signal transduction during biotrophic and necrotrophic stages of the pathogen infection will be presented.

Evaluation of clubroot disease development in canola in response to variable lime products and rates. N. M. FOX, S. F HWANG, V. P. MANOLII, G. TURNBULL AND S. E. STRELKOV. *Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, T6G 2P5, Canada; and (S.F.H.) Crop Diversification Centre North, Alberta Agriculture and Forestry, Edmonton, AB, T5Y 6H3, Canada.*

Clubroot (caused by *Plasmodiophora brassicae* Wor.,) is a soil-borne disease that has become a constraint to canola (*Brassica napus* L.) production in Alberta, Canada. The disease is managed primarily by the planting of clubroot resistant cultivars, but new *P. brassicae* pathotypes have emerged that can overcome this resistance. Therefore, the need for other effective clubroot management strategies is imperative. The application of lime creates a less favorable environment for clubroot development by increasing soil pH and calcium levels. A greenhouse experiment was conducted to evaluate the effects of hydrated lime, limestone and different rates of each product on *P. brassicae* infection and clubroot severity (index of disease) in susceptible and moderately resistant canola cultivars grown in soils with varying inoculum levels. At 8 weeks following inoculation, indices of disease of 92-100% and 9-13%, respectively, were observed in the susceptible and resistant controls (no lime) treatments. The index of disease decreased to 0% in both the susceptible and resistant cultivars following treatment with any of the four rates of hydrated lime In contrast, the application of limestone only caused a modest decrease in clubroot severity and only at the two lowest inoculum levels evaluated. Quantitative PCR analysis is underway to measure the impact of the treatments on *P. brassicae* inoculum levels in the soil and proliferation in the host tissues. The results highlight the need for careful selection of lime products and rates for clubroot management in canola.

Identification the durable blackleg resistance loci in Chinese and Canadian canola germplasm through genome-wide association analysis. F. FU, X. ZHANG, F. LU, G. PENG, F YU AND W. D. G. FERNANDO. *Department of Plant Science, University of Manitoba, Winnipeg, MB R3T 2N2, Canada*; *(G.P., F.Y.) Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, Saskatchewan, S7N 0X2, Canada*.

The fungal pathogen *Leptosphaeria maculans* (Desmaz.) Ces. & De Not. causes blackleg disease on canola in many parts of the world. It is important to use resistant cultivars to manage the disease and minimize yield losses. In this study, a total of 13 *L. maculans* isolates from western Canada were used to identify and map resistance genes in a collection of 243 canola/rapeseed germplasm from Canada and China. These isolates showed different compliments of avirulence genes, and the investigation was based on a genome-wide association study (GWAS) and genotype-by-sequencing (GBS). A total of 5,583,338 variants were identified using the CROP-SNP pipeline, including 5,102,201 SNPs and 481,137 InDels. GWAS was performed using the TASSEL 5.0 with GLM + Q model. Thirty-two and 13 SNPs tightly associated with blackleg resistance were identified respectively from the Canadian and Chinese germplasm with a P value $< 1\times10^{-4}$. These SNP loci were distributed on chromosomes A03, A05, A08, A09, C01, C04, C05 and C07, with the majority of them on A08 followed by A09 and A03. Those significant SNPs identified on A08 were all located in a 2,010-kb region and associated with the resistance to 12 of the *L. maculans* isolates. This study provides insights into potentially new regions for discovery of additional blackleg resistance genes. Resistance loci identified in this study may provide new resistant resources for blackleg resistance breeding in canola.

Adapting agronomic practices to changing climates through 'System Integration'. Y. GAN AND H. CUTFORTH. *Swift Current Research and Development Centre, Agriculture and Agri-Food Canada, Swift Current, SK S7H 3X2 Canada.*

Agriculture in western Canada faces significant challenges with changing climates, variable weather patterns, increased production costs, and threats of various biotic stresses. For example, in southwestern Saskatchewan, the maximum air temperature has increased from 9.0°C in 1950 to 10.2°C in 2017 and the minimum temperature increased from -3.2°C to -0.7°C. Accumulated January–April precipitation decreased by 26 mm while May–August precipitation increased by 54 mm. These changes may have direct or indirect impacts on cropping systems with various consequences. Effective strategies/practices are needed to alleviate these challenges. Here, we discuss one of the promising approaches – adapting 'system integration' to increase crop productivity and improve resource use efficiency but without extra cost to the environment. Decades of research at Agriculture and Agri-Food Canada Swift Current Research and Development Centre reveal that the following practices are key to achieve significant, positive outcomes: i) managing microclimates under field conditions through stubble height and straw management to improve WUE and water productivity; ii) comparing rooting systems (root length, volume, diameter, etc.) of different crops to define crop rotation sequences; iii) promoting uniform seedling establishment to improve resource use efficiencies (land area, soil water and nutrients); iv) diversifying crop rotations to buffer biotic risks; v) including N_2-fixers in rotation to convert atmospheric N_2 to plant available N and thus reducing synthetic fertilizer input; and vi) exploring intercropping, relay-cropping and 'gene-mixing' cropping opportunities to enhance system resilience.

***Rhynchosporium commune* and *Pyrenophora teres*: Screening for resistant barley varieties at the Lacombe Research and Development Centre.** K. C. GARLAND, N. E. RAUHALA, J. L. BUSAAN AND T. K. TURKINGTON. *Lacombe Research and Development Centre, Agriculture and Agri-Food Canada, 6000 C and E Trail, Lacombe, AB, T4L 1W1.*

Leaf diseases in barley can affect the overall yield of the crop by 20–40% in a single field. This decrease in yield is due to reduced photosynthetic area on the leaves. Scald and net blotch are particularly prominent leaf diseases

on the Canadian prairies, caused by the fungi *Rhynchosporium commune* and *Pyrenophora teres* respectively. Resistant varieties are an economic and environmentally friendly solution to combat leaf disease. To test new varieties for resistance, three disease nurseries were set up at the Lacombe Research and Development Centre (LRDC), each independently testing for scald, net-form net blotch, and spot-form net blotch reactions. There were 6,000–8,000 hill plots in the scald nursery, and 1,000–1,500 hill plots in each net blotch nursery. Hill plots were hand seeded in the spring and inoculated twice in early and mid-June. Diseased straw was spread over the nursery sites to provide a source of infection. Additionally, the scald nursery was sprayed with a suspended *R. commune* isolate solution, while the net blotch nurseries were inoculated with autoclaved winter wheat grain infested with either *P. teres* f. *teres*, or *P. teres* f. *maculata*. In July, each hill plot was rated using a 0-9 scale: where 0 = no disease symptoms and 9 = 50+% infection level of lower, middle, and upper canopy. Results and recommendations from these ratings were sent back to breeders for use in assessing levels of resistance and for consideration when determining which lines to advance.

Application of molecular quantification of *Plasmodiophora brassicae* in soil. B. D. GOSSEN, F. AL-DAOUD, F. AND M. R. MCDONALD. *Agriculture and Agri-Food Canada, Saskatoon Research and Development Centre, 107 Science Place, Saskatoon, SK, S7N 0X2, Canada.(F.A and M.R.M.) Department of Plant Agriculture, University of Guelph, 50 Stone Road East, Guelph, ON N1G 2W1, Canada.*

Plasmodiophora brassicae Wor. causes clubroot in canola (*Brassica napus* L.) and other brassica crops. Its long-lived resting spores, ability to erode genetic resistance, and strong impact on yield make it difficult to manage, especially in an extensive field crop like canola. The resting spores are tiny and non-descript, so counts of spores extracted from soil are highly variable and inaccurate. Spore numbers are often so high in heavily contaminated soil (10^6 to 10^9 spores g^{-1}) that assessment of the efficacy of IPM strategies using bioassays is impossible. Estimates of spore concentration based on molecular assessments have recently been enhanced using a competitive internal positive control (qPCR CIPC) and assessment of spore viability using pretreatment with propidium monoazide (qPCR PMA). These techniques have demonstrated that spore numbers decline rapidly in the first 2 years after a susceptible crop, and that high levels of viable spores can be present deep (e.g., 0.5-1 m) in soil. Despite these improvement, issues around collecting and subsampling representative samples are a huge constraint to the adoption of these technologies in risk assessment and disease forecasting.

A recipe for managing small patches of infestation of clubroot in canola. B. D. GOSSEN, A. SEDAGHATKISH, S. F. HWANG AND M. R. MCDONALD. *Agriculture and Agri-Food Canada, Saskatoon Research and Development Centre, 107 Science Place, Saskatoon, SK, S7N 0X2, Canada; (A.S., M.R.M.) Department of Plant Agriculture, University of Guelph, 50 Stone Road East, Guelph, ON N1G 2W1, Canada; and (S.F.H.) Alberta Agriculture and Forestry, Crop Diversification Centre North, 17507 Fort Road, Edmonton, Alberta, T5Y 6H3, Canada.*

Clubroot of canola (*Brassica napus* L.), caused by *Plasmodiophora brassicae* (Wor.), is spreading rapidly on the Canadian prairies. Genetic resistance can be extremely effective against clubroot but breaks down quickly under high disease pressure. A recipe for treating small areas of infestation has been proposed, as follows: mark the area (≥ 2× the area where symptoms occurred), apply lime (hydrated lime for rapid effect + standard lime for longer-term maintenance) to increase the soil pH to ~7.4, then seed a perennial grass crop. pH above 7.2 suppresses clubroot and grass crops such as perennial ryegrass (*Lolium perenne* L.) and smooth bromegrass (*Bromus inermis* Leyss.) further reduced resting spores in soil. A grass cover also minimises the movement of spores from the treated area. Soil samples from the centre of the patch are used to determine when the resting spore levels drop below economic thresholds. Alternatives for reducing resting spore populations are solarisation or fumigation. Solarisation, achieved by covering the patch with totally impermeable film (TIF) for 16 days, increased mean soil temperatures by about 10 °C and reduced clubroot severity to 0% in 2016, but in 2017 only reduced severity from 81% to 35%. Addition of fumigants (chloropicrin or metam sodium) did not further reduce clubroot severity, but each was also effective on its own. However, application of fumigants requires specialized equipment and

licences, and so is not available to most producers on the Canadian prairies. Crop rotation can also be effective, but takes longer.

Disease trends in wheat, canola and pea in Alberta from 2015 to 2018. M. W. HARDING. S. CHATTERTON, R. ABOUKHADDOUR, H. BENNYPAUL, S. E. STRELKOV AND T. GRÄFENHAN. *Alberta Agriculture and Forestry, Crop Diversification Centre South, Brooks, AB T1R 1E6, Canada; (S.C, R.A) Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB T1J 4B1, Canada. (H.B) Centre for Plant Health, Canadian Food Inspection Agency, North Saanich, BC, V8L 1H3, Canada; (S.E.S) University of Alberta, Edmonton, AB T6G 2P5, Canada; (T.G) Canadian Grain Commission, Winnipeg, Manitoba R3C 3G8, Canada.*

Diseases on cultivated crops can fluctuate significantly from one season to another. The amount of disease seen in a given year changes due to variables such as introduction or loss of host resistance, pesticide applications, pesticide resistance, and crop rotation and sequence. In addition, crop disease risks can change dramatically due to weather-related parameters such as temperature, rainfall and relative humidity which exhibit high spacio-temporal variability. These weather parameters varied significantly in Alberta each year between 2015 and 2018. Some crop diseases such as fusarium head blight and white mould benefited from the above-average rainfall and humidity in 2016, whereas clubroot detections were greater in years with higher temperatures. Finally, for diseases such as stripe rust and wheat streak mosaic, overwinter survival was affected by winter weather. This presentation will report disease trends for the 2015-2018 period for eight diseases on four crops; fusarium head blight, wheat streak mosaic and stripe rust on wheat, clubroot, blackleg and sclerotinia on canola, root rot on pea and white mould on dry bean. Disease levels will be correlated with historical weather information that may have played a role in the annual increases or decreases in disease incidence or severity.

Evaluation of the impact of liming and weed control on clubroot of canola. B. C. HENNIG, S. F. HWANG, S. E. STRELKOV, V. MANOLII AND G.D. TURNBULL. *Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, T6G 2P5, Canada; (S.F.H., G.D.T.) Alberta Agriculture and Forestry, Crop Diversification Centre North, 17507 Fort Road, Edmonton, AB, T5Y 6H3, Canada.*

Plasmodiophora brassicae Wor. is a soil-borne parasite that causes clubroot of crucifers. This is a serious disease of canola (*Brassica napus* L.) in western Canada and is managed most commonly by planting clubroot resistant cultivars. New strains of the parasite have emerged recently that can overcome resistance, and additional strategies for clubroot management are needed. Since clubroot development is favored in acidic soils, the application of lime to increase soil pH has been suggested as a potential disease management strategy. Control of cruciferous weeds, which may serve as inoculum reservoirs, also is recommended. Field trials were conducted in the Edmonton, AB, region to determine the impact of soil liming and weed control on soil inoculum levels and on clubroot severity in clubroot resistant and susceptible canola cultivars. Preliminary data indicated that the application of hydrated lime to increase soil pH to 7.2 resulted in decreases in clubroot severity of 13-28%. Overall, clubroot severity was lowest in treatments consisting of a resistant cultivar grown in limed plots with no weed removal, and highest in the susceptible cultivar grown in non-limed plots with full weed control. These experiments will be repeated, and *P. brassicae* resting spore levels will be measured by quantitative PCR analysis.

Survey for blackleg on canola in southern Alberta in 2018. T. B. HILL, C. A. PUGH, C. MCCONNELL, G. C. DANIELS, D. A. BURKE, J. FENG, K. ZUZAK AND M. W. HARDING. *Crop Diversification Centre South, Alberta Agriculture and Forestry (AAF), 301 Horticultural Station Road East, Brooks, AB T1R 1E6, Canada; (J.F., K.Z.) Crop Diversification Centre North, AAF, 17507 Fort Road NW, Edmonton, Alberta, T5Y 6H3, Canada.*

A survey for blackleg disease on canola, caused by *Leptosphaeria maculans* (Desmaz.) Ces. & de Not., was performed in Alberta in 2018. A target of 1% of canola fields in the province, or 385 canola fields in 65 counties,

were to be surveyed. Within each field surveyed, 20 stems were collected from 5 locations for a total of 100 stems per field. Disease was characterized visually based on discoloration within the stem at the crown and/or the presence of basal stem cankers or stem lesions. Disease severity was rated using a 0 to 5 scale where a plant was rated 0 when it had no symptoms through to 5 when the plant was dead due to infection. At the time this abstract was prepared, data from 136 fields were available. Blackleg symptoms were observed in 77.9% of fields at an average incidence of 13.27% and average severity of 0.24. These results were very similar to those reported in 2017 for blackleg prevalence and incidence in Alberta which were 80%, 14.1%, respectively. Interestingly, the average severity of blackleg in 2018 from the 136 fields available was nearly five times greater than the severity reported in the 2017 survey.

Evaluation of the impact of hydrated lime on clubroot severity in canola over multiple growing seasons. K. B. HOLLMAN, S. F. HWANG, V. P. MANOLII, G. TURNBULL AND S. E. STRELKOV. *Department of Agriculture, Food and Nutritional Science, University of Alberta, Edmonton, AB, T6G 2P5, Canada; and (S.F.H., G.T) Crop Diversification Centre North, Alberta Agriculture and Forestry, Edmonton, AB, T5Y 6H3, Canada.*

Clubroot (*Plasmodiophora brassicae* Wor.) is an important disease of canola (*Brassica napus* L.). In recent years, there has been significant interest in identifying effective clubroot management strategies that can be used in addition to genetic host resistance. Preliminary results with hydrated lime have been promising. This amendment increases soil pH and makes it less amenable to clubroot development. However, the impact of lime treatment has not been evaluated over the longer term. Field trials were conducted at two sites in central Alberta to assess whether or not the application of hydrated lime in 2017 influenced clubroot development in the following season (2018). The clubroot susceptible canola cultivar '45H31' was planted in plots that had received low, moderate or high rates of lime the previous year, and was assessed for clubroot severity (index of disease, ID) eight weeks later. The results indicated that the canola grown in the lime-treated plots developed a lower ID (maximum of 8.3%) than canola grown in the non-treated control plots (IDs of 20-25%). These preliminary results suggest that there is some residual benefit of liming the soil, at least in the year following its application. Various soil analyses also are underway to determine the impact of liming on soil parameters such as bulk density and porosity.

Isolation and characterization of bacteria antagonistic to *Aphanomyces euteiches* from lentil root and rhizosphere. Z. HOSSAIN, M. HUBBARD, L. D. BAINARD AND Y. GAN. *Swift Current Research and Development Centre, Agriculture and Agri-Food Canada, 1 Airport Road East, Swift Current, SK, S9H 3X2 Canada.*

Aphanomyces root rot is a serious disease of field pea (*Pisum sativum* L.) worldwide and is becoming a major threat to lentil (*Lens culinaris* Medik.) and pea production in Canada. It is a pathogen belonging to the oomycete class. Resting spores can remain viable in the soil for more than 10 years. This pathogen is not well controlled by any known seed treatment agents and/or conventional control measures. This project was initiated to discover bacteria from the rhizosphere and roots of lentil antagonistic to *Aphanomyces euteiches* Drechs with the aim of developing alternative control strategies. Rhizosphere and root samples of both diseased and healthy lentil plants, just before flowering, were collected from fields at 11 locations across southern Saskatchewan during June and July 2017. After processing, sample suspension was spread onto four different microbial media (Luria-Bertani, potato dextrose, *Pseudomonas*, and Tryptic Soy agar). Approximately 10,000 rhizosphere and endophytic bacteria were isolated. Among those, 510 bacterial colonies were selected based on shape and color, and *in vitro* pathogen inhibition assays were conducted on PDA medium. Out of 510 bacteria, 36 were selected after replicated bioassays for their ability to completely inhibit *A. euteiches* growth. All 36 bacteria were then tested in a replicated greenhouse trial using sterile soils to evaluate their effectiveness for suppressing root rot disease in lentil. Twelve of the 36 bacteria completely suppressed disease; treated plants showed growth similar to controls. Those bacteria were selected for further greenhouse testing to confirm their antagonism toward *A. euteiches*.

Assessing the potential of managing root rot with nitrogen fertilizer and an arbuscular mycorrhizal fungal product in three Saskatchewan environments. M. HUBBARD, Y. GAN, G. PENG, W. MAY and L. D. BAINARD. *Swift Current Research and Development Centre, Agriculture and Agri-Food Canada (AAFC Swift Current, SK, S9H 3X2, Canada,; (G.P.) Saskatoon Research and Development Centre, AAFC, 107 Science Place, Saskatoon, SK, S7N 0X2, Canada; and (W.M.) AAFC, P.O. Box 760, Indian Head, SK, S0G 2K0, Canada.*

Root rot is a major constraint to the production of pea and lentil. The disease is often caused by *Aphanomyces euteiches* Drechsler. It is not effectively controlled by synthetic fungicide seed treatments and genetic resistence is not availabe in pea or lentil. Currently, the only management recommendation is extended rotations away from susceptible crops. Thus, asessment of other approaches for reducing losses from Aphanomyces is urgently needed. Field studies, conducted at three sites in Saskatchewan with differing climates and soil types, were used to evaluate whether the application of nitrogen fertilizer or a commercial arbuscular mycorrhizal fungal (AMF) product could reduce root rot severity in pea. A greenhouse study, using soil from the three field sites, was conducted in parallel to the the field trials. In two of the three field sites, nitrogen fertilization at seeding reduced one of the two disease severity metrics, without impacting nodulation. In the greenhouse, application of nitrogen fertilizer failed to reduce root rot. However, it increased root and shoot biomass in some of the field soils, without decreasing nodulation. The AMF inoculant did not alter any of the parameters measured in the field or greenhouse, relative to untreated controls. These results suggest that the AMF inoculant is not an effective tool for Aphanomyces root rot management. However, under some conditions, nitrogen fertilization may reduce root rot severity and/or ameliorate yield losses. Further study is merited to better understand the conditions in which nitrogen application to pulse crops in Aphanomyces-infested soils might be advantageous.

Managing *Ascochyta rabiei* in diverse environments by intercropping chickpea with flax. M. HUBBARD, W. MAY, Y. GAN AND L. SHAW. *Swift Current Research and Development Centre, Agriculture and Agri-Food Canada (AAFC), 1 Airport Road, Swift Current, SK S9H 3X2, Canada, (W.M.)* AAFC, *P.O. Box 760, Indian Head, SK S0G 2K0, Canada; and (L.S.) South East Research Farm, Redvers, SK S0C 2H0, Canada.*

Chickpea (*Cicer arietinum* L.) is a high-value crop; however, production on the Canadian prairies is currently limited by ascochyta blight, caused by the fungal pathogen *Ascochyta rabiei* (Pass.) Labrousse. The disease can result in complete crop failure under conditions that favor disease. Intercropping of chickpeas with flax is attracting increasing interest from producers. Preliminary research in Redvers and Indian Head, SK, showed that chickpea-flax intercropping can sometimes hasten chickpea maturation and reduce *A. rabiei* incidence and increase chickpea yield under wet conditions and high disease pressure. The objective of this work was to assess if intercropping chickpea with flax can reduce the incidence and/or severity of Ascochyta blight in chickpea grown in three regions of Saskatchewan with differing climatic conditions. In 2018 field trials, disease pressure differed dramatically between the three locations. Redvers had moderate Ascochyta blight symptoms due to higher precipitation than Swift Current and Indian Head. Disease severity was higher in chickpea monocrop than in the chickpea-flax intercropping treatments. In Swift Current, disease severity was very low. The incidence of pod lesions, however, was higher in the mono-cropped chickpea than in the intercropping treatments. There was virtually no disease in Indian Head. The current results suggest that chickpea-flax intercropping has potential as a novel Ascochyta blight management tool. Research is urgently needed in wider range of environmental conditions to evaluate how chickpea-flax intercropping performs, relative to chickpea monoculture, in terms of disease and other agronomic and economic parameters, across environmental conditions. These findings will be especially important as climate change makes growing conditions unpredictable.

The roles of auxin, ethylene and abscisic acid in clubroot development in *Brassica napus.* C. P. JAYASINGHEGE, V. P. MANOLII, J. A. OZGA, S. F. HWANG AND S. E. STRELKOV. *Department of Agricultural, Food and Nutritional Science, University of Alberta, 410 Agriculture/Forestry Centre, Edmonton, AB T6G 2P5, Canada; and (S.F.H.) Crop Diversification Centre North, Alberta Agriculture and Forestry, 17507 Fort Road, Edmonton, AB T5Y 6H3, Canada.*

The manipulation of plant hormones by the obligate parasite *Plasmodiophora brassicae* Wor., causal agent of clubroot of crucifers, is believed to drive the formation of root galls in susceptible plants. The activation of plant defense mechanisms and disease-associated plant stress responses also modulate the hormone profile and hormone action in infected plants. To improve understanding of the roles of auxin, ethylene and abscisic acid (ABA) in clubroot development, the levels of these hormones and associated catabolites and precursors were investigated in susceptible and resistant canola (*Brassica napus* L.) cultivars. No clear association between pathogen infection and the root hormone profiles was observed in either canola cultivar at 4 and 14 days after inoculation (DAI) with *P. brassicae*. By 21 DAI, however, the level of ABA and its catabolites phaseic acid (PA) and dihydrophaseic acid (DPA) was increased in susceptible inoculated plants relative to non-inoculated controls. The level of ethylene precursor 1-aminocyclopropane-1-carboxylic acid also was higher in both the susceptible and resistant cultivars following inoculation, suggesting an increase in root ethylene biosynthesis in response to *P. brassicae* infection. Despite being considered an important player in root gall development, no change was detected in root auxin levels, except for a decline in inoculated susceptible plants by 21 DAI. This suggests that gall formation is not directly triggered by an increase in root auxin.

Chocolate spot disease survey of faba bean on the Canadian prairies in 2018. S. KAUR, R. BOWNESS, S. BANNIZA AND S. CHATTERTON. *Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, 5403-1 Ave. South, P.O. Box 3000 Alberta, T1J 4P4, Canada; (R.B.) Lacombe Research and Development Centre, Agriculture and Agri-Food Canada, 6000 C and E Trail, Lacombe, Alberta T4L 1W1, Canada; and (S.B.) Crop Development Centre, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8, Canada.*

Chocolate spot (CS), caused by *Botrytis fabae* Sard., is one of the most important diseases of faba bean (*Vicia faba* L.) affecting its productivity in Alberta and Saskatchewan. Cool, wet and humid weather conditions favour sporulation and secondary infection. To determine CS severity and presence of other foliar pathogens in the faba bean, commercial field surveys were conducted in 2018. Sixteen fields from Saskatchewan and nine from Alberta were surveyed at mid-pod stage (late July to mid August). Ten sites per field (at least 50 m apart) were sampled in an inverted U-shaped pattern, and the severity of foliar lesions on 10 plants/site was recorded. The ratings were done separately for upper, mid and lower canopy on a scale of 1–5. Leaf samples were photographed and surface sterilized prior to plating on PDA. Hierarchical cluster analysis was conducted to determine the fungal genera closely related to the disease severity cluster. All faba bean fields surveyed in Aberta and Saskatchewan had foliar lesions (i.e. 100% prevalence). Foliar lesions (49–100%) were generally present at all sites within each field. However, disease severity was very low across all fields with small, discrete lesions covering 1-2% of the leaf surface. Disease severity was always highest in the lower canopy (2.1) and lowest in the upper canopy (1.5). A variety of symptoms were observed. *Botrytis* (8%) was isolated from flecked and small, discrete reddish lesion. while *Stemphylium* spp. (21%) were frequently isolated from medium-sized lesions with blight that often started from the edge. Analysis of the isolation data showed *Stemphylium* spp. was most closely associated to disease severity in 2018. Pathogenicity testing of the isolates is underway.

Virulence of *Puccinia striiformis* on wheat and barley in central Alberta during 2015–2017. K. KUMAR, K. XI, T. K. TURKINGTON AND F. CAPETTINI**.** *Field Crop Development Centre, Alberta Agriculture and Forestry, Lacombe, AB, T4L 1W8 Canada; and (T.K.T.) Lacombe Research and Development Centre, Agriculture and Agri-Food Canada, 6000 C and E Trail, Lacombe, AB, T4L 1W1 Canada.*

Stripe rust of wheat and barley, caused by *Puccinia striiformis* f .sp. *tritici* (Pst) and *P. striiformis* f.sp. *hordei* (Psh), respectively, has devastated cereal production worldwide. Over the last decade, virulent pathotypes have shown up more often, and spread more aggressively on Alberta farms. The objective of this study was to differentiate the two pathogens and identify virulence in each formae *specialis.* From 2015-2017 in central Alberta 140 isolates collected from wheat, barley, foxtail barley and triticale were phenotyped on wheat and

barley differentials. Based on this phenotyping, 48 of the 55 isolates sampled from barley were classified to be Psh and seven were Pst; all 85 isolates from wheat were classified to be Pst using cluster analysis. These results indicate the occurrence of cross-infection between wheat and barley by the two pathogens. Fifty-four Pst and 26 Psh pathotypes were identified and a few new Psh and Pst pathotypes were also identified from the 140 isolates. Temporal changes in virulence frequency were apparent when Psh and Pst isolates collected from the period of 2007-2017 were compared. From 2015-2017, the virulence frequency increased on 6 barley differentials with the current Psh isolates, but from 2007-2014 there was less virulence on 5 of the 12 barley differentials. The Psh isolates from the 2015-2017 collection exhibited an increased virulence frequency in 24 of the 26 wheat differentials, as compared to the 2007-2014 collection.

AvrLm1 virulence function is through interaction with the *B. napus* MPK9. L. MA, M. DJAVAHERI, H. WANG, N. J. LARKAN, P. HADDADI, E. BEYNON, G. GROPP AND M. H. BORHAN. *Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, SK S7N 0X2, Canada; (H.W.) Center of Plant Disease and Plant Pests of Hebei Province, College of Plant Protection, Hebei Agricultural University, Baoding 071001, China; and (N.J. L.) Armatus Genetics Inc., Saskatoon, SK S7J 4M2, Canada*.

Leptosphaeria maculans (Desmaz.) Ces. & de Not., the causal agent of blackleg disease in canola (*Brassica napus* L.), secretes an array of effectors into the host to overcome host defense. To identify the host target of AvrLm1 we conducted Y2H screening using AvrLm1 as the bait. We identified the *B. napus* mitogen-activated protein (MAP) kinase 9 (BnMPK9) as the target protein for AvrLm1. Interaction of AvrLm1 with BnMPK9, causes increased accumulation and enhanced phosphorylation of BnMPK9. Transient expression of *BnMPK9* in *Nicotiana benthamiana* induces cell death, and this phenotype is enhanced in the presence of AvrLml. Induction of cell death is required for the establishment of necrotroph pathogens and indicates the initiation of necrotrophic phase of *L. maculans* infection.

The efficacy of fumigation and totally impermeable film for the control of clubroot of brassica crops. M. R. MCDONALD, B. D. GOSSEN, J. ROBSON AND F. AL-DAOUD. *Department of Plant Agriculture, University of Guelph, Guelph, ON, N1G2W1, Canada; and (B.D.G.) Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada, Saskatoon, SK S7N 0X2, Canada.*

Clubroot of Brassica crops, caused by the soil-borne protist, *Plasmodiophora brassicae* Woronin, persists as resting spores which can survive in soil for many years. Controlled environment and field studies were conducted to evaluate the efficacy of fumigation and sealing soil with plastic film, to reduce or eradicate resting spores. Treatments were metam sodium at 10, 75, 150 and 300 kg ai ha^{-1} and chloropicrin (field trials only) at 128, 164, 224, 280, 336 kg ai ha^{-1}. Soil in the field was covered with totally impermeable film (TIF) or polyethylene tarps. Efficacy was determined by bioassays with susceptible host Shanghai pak choi (*Brassica rapa* L. ssp. *chinensis*). In 2017, soil dilutions were assessed using qPCR or treated with propidium monoazide prior to qPCR to quantify viable resting spores. All rates of metam sodium reduced clubroot severity in the controlled environment study. In the 2015 field trial, chloropicrin, and metam sodium at rates over 75 kg ai ha^{-1}, reduced clubroot severity. Covering soil with TIF following fumigation improved the efficacy of the fumigants. Covering soil with TIF alone (solarization) for 2 weeks in June 2017 reduced clubroot severity from 82% in the untreated check to 35%. Adding fumigant did not further reduce clubroot severity. The number of viable resting spores was lower in all of the treatments compared to the untreated, uncovered check. Solarization using TIF may be more effective than with other plastic films and could be used to control small outbreaks of clubroot. Further research under various Canadian conditions is warranted.

Development of a *Pseudomonas syringae* based biocontrol agent for use against Canada thistle. D. L. MCDOUGALL, D. S. GUTTMAN AND J. STAVRINIDES. *Department of Biology, University of Regina,*

Regina, SK S4S 0A2, Canada; and (J.S.) Department of Cell & Systems Biology, University of Toronto, Toronto, ON M5S 3B2, Canada.

Canada thistle is a growing problem in Saskatchewan and abroad. It is responsible for significant yield loss in cereal crops and canola due to its hardiness and ability to spread through lateral roots. Apart from cultural practices, organic producers have limited options for controlling Canada thistle. *Pseudomonas syringae* pv. tagetis is a host-restricted phytopathogen with potential as a biocontrol agent due to its ability to cause rapid apical chlorosis, stunting, and inhibition of seed production. My research focuses on developing an organic, safe and effective *P. syringae*-based bioherbicide targeting Canada thistle. The effectiveness of single strains, polymicrobial mixtures, and phytotoxin enhanced mixtures will be evaluated directly on Canada thistle, dandelion, and sunflower. Efficacy is measured via the rate of chlorosis progression over a 14 day period, and by comparing biomass 4 weeks post inoculation. My results to date suggest that there are numerous candidate strains with excellent potential as bioagents. Development of a biocontrol formulation for Canada thistle will provide farmers with an effective organic bioherbicide that can be applied using existing equipment.

Developing a droplet-digital PCR-based protocol for rapid screening of quantitative resistance against blackleg of canola. L. MCGREGOR, X. LIU, E. LEMKE AND G. PENG. *Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, SK S7N 0X2, Canada.*

Blackleg, caused *by Leptosphaeria maculans* (Desmaz.) Ces. & De Not, is a serious disease of canola in western Canada. Cultivar resistance, including quantitative resistance (QR), is the key for blackleg management. The current methods of screening QR rely mostly on extensive field trials, which can be laborious and sometimes give inconsistent results. In earlier work, we used droplet-digital PCR (ddPCR) to quantify *L. maculans* DNA in inoculated petioles and stems of canola, and found that the amounts correlated well with the severity of stem infection on four cultivars with variable levels of QR under greenhouse conditions. The aim of this project was to assess the relevance of pathogen colonization and development in canola stem (based on ddPCR) to blackleg resistance, especially QR, in commercial canola cultivars/lines based on multi-year field trial data. Cotyledon or petiole (1 cm from the stem) was inoculated with a *L. maculans* isolate carrying *AvrLm6,7* at 7 days (cotyledon) or 14 days post seeding (petiole). The resistance gene *Rlm6* or *Rlm7* was generally absent in these canola cultivars /lines. Stem tissues close to the inoculated cotyledon or petiole were sampled 14 days post inoculation for fungal DNA quantification using ddPCR. About 50 lines were tested and the data were compared against the resistance performance in field trials using correlation and regression analyses. Preliminary results have shown a positive correlation between the amount of *L. maculans* DNA in stem tissues and the average field disease ratings against the standard susceptible control 'Westar'.

Climate change and its impact on diseases of winter wheat in the northwestern U.S.A. T. D. MURRAY. *Department of Plant Pathology, P.O. Box 646430, Washington State University, Pullman, WA 99164-6430, U.S.A.*

Washington State has the fourth highest wheat production in the U.S. Wheat is the third most valuable crop produced in the state. High yields result from moderate temperatures and favorable distribution of rainfall during the growing season. Regional climate is strongly influenced by the Pacific Ocean, which results in relatively mild winter temperatures for this latitude and is transitional between southerly temperate climates. Consequently, changes in climate have potential to impact wheat production through its impact on biotic stresses. More than eight diseases regularly impact wheat production in Washington. Among these is speckled snow mold, caused by *Typhula ishikariensis*. Snow mold is prevalent in the north-central wheat-producing area of Washington where snow falls on unfrozen or lightly frozen soil and persists for 100 days or more. Persistent snow cover does not occur every year in this area; therefore, increasing winter temperatures and decreasing snow cover resulting from climate change will result in less frequent occurrence of snow molds. Other chronic diseases in the Pacific North West including Cephalosporium stripe (*Cephalosporium gramineum*), eyespot (*Oculimacula yallundae,*

O. acuformis), and stripe rust (*Puccinia striiformis*) are also strongly influenced by winter weather and will likely become more prevalent in areas where snow molds now occur as winter temperatures increase. Interactions between plant diseases and environmental conditions are complex; shifts in geographic distribution, frequency of occurrence, and severity of other diseases should be expected in response changes in winter climate. Anticipating changes and developing varieties with effective resistance are important strategies to prevent future losses.

Detection and evaluation of the residual effect of defeated stripe rust resistance genes (*Yr* genes) in wheat. K. NABETANI, K. WIEBE, C. J. POZNIAK, R. ABOUKHADDOUR AND H. R. KUTCHER. D*epartment of Plant Sciences, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8, Canada; (R.A.) Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, 5403 1st Ave South, Lethbridge, AB T1J 4B1 Canada.*

.

Race-specific stripe rust resistance genes (*Yr* genes) have been deployed into wheat cultivars against stripe rust caused by *Puccinia striiformis* f. sp. *tritici* Eriks. (*Pst*); however, in many cases the resistance has broken down only a few years after its introduction. Near isogenic lines (NILs) with defeated *Yr* genes in the susceptible cv. Avocet background were used in this study to evaluate residual effects of these genes. The parental NILs with the single *Yr* genes, *Yr10*, *Yr26* and *Yr32*, the NILs with gene combinations of *Yr32*/*Yr10*, *Yr32*/*Yr26* and *Yr26/Yr10* and 'Avocet' were inoculated under controlled conditions with *Pst* isolates, W020, W049, and mixture of T034/W052, all virulent to all three *Yr* genes. The infection type (IT), infection area (IA) and latent period (LP) were recorded. The same NILs were tested in stripe rust nurseries at Saskatoon, SK and Lethbridge, AB in 2018 and disease incidence and severity were recorded. Under the controlled conditions the range of IT scores tended to be lower in NILs with *Yr32*/*Yr10* and *Yr32*/*Yr26* gene combinations with the isolate combination T034/W052. The IA was reduced more often in the NILs carrying *Yr32*/*Yr10* and *Yr32*/*Yr26* gene combinations than the *Yr26/Yr10* gene combination. Increased LP was negatively correlated with reduced IA. In field disease nurseries, genotypically identical NILs varied in resistance level; however, NILs with *Yr32*/*Yr10* and *Yr32*/*Yr26* combinations usually had lower disease incidence and severity than NILs with *Yr26/Yr10*. These data suggest that there may be a residual effect of defeated *Yr* genes in wheat.

Managing blackleg of canola in western Canada -An integrated approach. G. PENG, W. SOOMRO, M. HUBBARD, C. ZHAI, X. LIU, L. MCGREGOR, W. G. D. FERNANDO, R. LANGE, F. YU AND D. MCLAREN. *Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada (AAFC), 107 Science Pl. Saskatoon, SK S7N 0X2; (D.W.G.F.) Department of Plant Science, University of Manitoba, Winnipeg, MB R3T 2N2; (R.L.) InnoTech Alberta, P.O Bag 4000, Vegreville, AB, T9C 1T4; and (D.M.) Brandon Research and Development Centre, AAFC, 2701 Grand Valley Rd, Brandon, MB R7C 1A1, Canada.*

Blackleg of canola (*Brassica napus* L.), caused by the fungal pathogen *Leptosphaeria maculans* (Desmaz.) Ces. & de Not. increased noticeably in western Canada in the past several years. While most canola cultivars are registered as resistant to blackleg, *Rlm1* and *Rlm3* have been the only specific resistance (*R*) genes found in commercial varieties. Field monitoring has found that the avirulent genes *AvrLm1* and *AvrLm3* are at very low levels in most areas, while *AvrLm4*, *AvrLm6* and *AvrLm7* ware relatively abundant at about 60-100% in pathogen populations. This indicates additional resistant mechanisms at works in commercial fields. When inoculated with *L. maculans* isolates carrying no *AvrLm1* and *AvrLm3*, most canola cultivars showed a moderate level of resistance to infection relative to Westar (susceptible); pathogen spread from infected cotyledons to stem was limited and infection development in stem was also reduced. This indicates quantitative resistance (QR) for these cultivars. RNA-seq data indicate that the resistance mediated by *Rlm1* showed that jasmonic-acid and salicylic-acid pathways were activated, whereas QR or race-nonspecific resistance seemed to be related to genes involved in programmed cell death and ROS. QR was also stable under high temperature conditions (~32°C daytime high). Due to a much shorter growing season (75-100 days), relative to many other canola-growing regions in the world,

early infection is probably the key to causing severe blackleg impact in western Canada. This underscores the importance of fungicide timing for blackleg management. These issues will be discussed in light of new data.

White mould (*Sclerotinia sclerotiorum*) intensity and ascospore release in dry bean fields in southern Alberta in 2018. J. REICH AND S. CHATTERTON. *Faculty of Forestry, University of British Columbia, Forest Sciences Centre, 2424 Main Mall, Vancouver, BC V6T 1Z4 Canada; and (S.C.) Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, 5403 1 Ave S, Lethbridge, AB T1J 4P4 Canada.*

One of the main biotic constraints to dry bean (*Phaseolus vulgaris*) production in Canada is white mould, caused by the fungal pathogen *Sclerotinia sclerotiorum.* The fungus releases ascospores which are spread via air currents and infect senescent host tissue and can lead to reduced quality and/or yields. In 2018, weekly disease surveys were performed in 15 dry bean fields in southern Alberta during the R1 to R7 growth stages (end of July to end of August). Disease severity was assessed on a 4-point scale (1 = healthy, 4 = main stem dead). Burkard 7-day volumetric spore samplers were placed in three of the surveyed fields and collected daily aerosol samples, from which DNA was extracted for molecular quantification of *S. sclerotiorum* ascospores. Weather stations in the same fields collected data on temperature, relative humidity, soil moisture, and leaf wetness. Overall, disease incidence was very low at the end of July (0 to 15% of plants diseased, mean = 2%) and peaked by mid-August (2 to 85% of plants diseased, mean = 25%). Severity followed a similar pattern from July (ratings from 1.0 to 1.3, mean = 1.0) to August (ratings from 1.1 to 2.9, mean = 1.6). Work is currently under way with quantitative PCR to determine the daily airborne ascospore release and correlate it with disease intensity and weather conditions.

Production of single-spore isolates of *Plasmodiophora brassicae* using micromanipulation of resting spores. A. SEDAGHATKISH, B. D. GOSSEN, J. SINGH AND M. R. MCDONALD. *Department of Plant Agriculture, University of Guelph, 50 Stone Rd E, Guelph, ON N1G 2W1, Canada, (B.D.G.) Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, SK S7N 0X2, Canada; and (J.S.) Veterinary Biomedical Sciences, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK S7N 5B4 Canada.*

Clubroot, caused by *Plasmodiophora brassicae* Wor., is an important disease of Brassicaceae crops. The molecular basis of clubroot pathogenicity and resistance are poorly understood. Extraction of high quality DNA of single spores for genomic and genetic studies is a challenge because *P. brassicae* often occurs as a mixture of pathotypes, is associated with other soil microbes, and cannot be cultured in the absence of host tissue. The objective of this study was to isolate single spores for inoculation and high quality DNA for downstream applications. A technique was developed to isolate and culture single resting spores of *P. brassicae* using micromanipulation. Spores were extracted from clubbed roots, were isolated using a micromanipulator and inoculated individually onto the root of three-day-old seedling of the highly susceptible 'Mei Qing Choi' (*Brassica rapa* var. *chinensis*) grown in sterile Hoagland's solution media. Clubroot formation was visible in 8% of inoculated plants at 6 weeks after inoculation. This is a high rate of success compared with other published methods for inoculation with single spores. The approach was also effective for inoculation of root tissue sections that had been plated onto solid MS media. This method is fast and efficient and results in clean single-spore isolates of *P. brassicae* for molecular and genomic studies.

The impact of barley variety rotation, mixtures, and intercropping on leaf disease and silage production. T. K. TURKINGTON, K. XI, H. KLEIN-GEBBINCK, K. N. HARKER, J. T. O'DONOVAN, R. BLACKSHAW, T. MCALLISTER AND N. LUPWAYI. *Lacombe Research and Development Centre, Agriculture and Agri-Food Canada (AAFC), Lacombe, AB T4L 1W1, Canada; (K.X.) Field Crop Development Centre, Alberta Agriculture and Forestry, Lacombe, AB T4L 1W1, Canada; (R.B, T.M., N.L.), Lethbridge Research and Development Centre, AAFC Lethbridge, AB, Canada T1J 4B1.*

Western Canadian barley silage producers, whether they are meeting on-farm needs or local market opportunities, will often look at continuous barley production, which leads to productivity issues related to leaf disease development. Although fungicides can be used, they represent an added input cost for silage producers. The objective of the current study was to determine the effects of monocultures, mixtures, intercropping and rotational diversity on crop health and productivity in a cereal silage production system. Three year rotational treatments were established in 2008 at Lacombe, Alberta with a final combined comparison for 2010, 2013 and 2016. Treatments included: continuous barley, same variety; a mixture of the same three barley varieties each year; a mixture of three different barley varieties each year; an intercrop of barley, oat, and spring triticale with the same or different crop varieties each year; and an intercrop of barley, oat, and winter triticale with the same or different crop varieties each year. In 2010, 2013 and 2016, all treatments had the six-row barley variety 'Sundre'. Leaf disease severity on 'Sundre' was highest for continuous 'Sundre', and lowest for mixtures or intercrops with different varieties. Silage yields were lowest for continuous 'Sundre', highest for the intercropping treatments with the same or different varieties each year, and intermediate for barley mixtures where the variety components changed each year. Results suggest that adding diversity in crop types and/or barley genetics may reduce leaf disease and improve silage productivity.

Performance of Lumisena™ fungicide seed treatment for the control of *Phytophthora sojae* in soybean. M. VANHIE AND D. FEHR. *Corteva Agriscience™, Agriculture Division of DowDuPont™ Calgary, AB T2P 1M4, Canada.*

Soybean (*Glycine max*) production is becoming increasingly popular in Western Canada, and growers and extension personnel need to understand the disease threats and the control options to grow a healthy industry. Phytophthora root rot, caused by the pathogen *Phytophthora sojae*, is a disease of significant concern in the current major soybean growing regions of North America, including production areas in Western Canada. Phytophthora reduces plant stand, in some instances severe enough to require a replant, and has been shown to decrease yield by more than 50%. Corteva Agriscience™, Agriculture Division of DowDuPont™, conducted multiple lab and field trials between 2011 and 2015 using a novel fungicide, oxathiapiprolin, applied as a seed treatment (trade name Lumisena™ Fungicide Seed Treatment), to evaluate control of phytophthora root rot in soybean. Lumisena at 12 µg a.i./seed improved plant stand by 4–800% compared to the untreated check. Under heavy disease pressure, Lumisena at 12 µg a.i./seed yielded up to 2.5 times more than the check and conferred an average yield gain of 81%. In summary, Lumisena at a rate of 12 µg a.i./seed will provide soybean growers in western Canada with effective control of phytophthora root rot.

Screening of *Brassica* species for resistance to *Plasmodiophora brassicae* (clubroot) pathotype 5X. J. WANG, Y. ZHANG, M. KEHLER, A. DAKOURI, S. E. STRELKOV, S. F. HWANG, B. D. GOSSEN, G. PENG AND F. YU. *Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada, Saskatoon, SK S7N 0X2, Canada; (S.E.S.) Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB T6G 2P5, Canada;(S.F.H.) Crop Diversification Centre North, Alberta Agriculture and Rural Development, Edmonton, AB T5Y 6H3, Canada.*

Clubroot, caused by the soil-borne parasite *Plasmodiophora brassicae* Wor., is associated with the formation of clubs or galls on the roots of susceptible hosts. The disease is a significant problem on *Brassica* crops worldwide, and is most commonly managed by planting resistant cultivars. In recent years, however, new pathotypes of *P. brassicae* have been identified that can overcome the resistance in most cultivars. A screening study was conducted to identify sources of resistance to one of these new pathotypes, 5X. Two hundred and eighty-six *B. napus* lines, 43 *B. oleracea* lines, and 57 *B. nigra* lines were tested for resistance by inoculation with resting spores of pathotype 5X under controlled environmental conditions. A total of 15 *B. napus*, 3 *B. oleracea*, and 3 *B. nigra* lines were found to be resistant, with a disease severity index (DSI) <20%. Further research is being carried out to determine the genetic basis of this resistance, while additional lines and accessions are being screened.

LC-MS/MS based mycotoxin/deoxynivalenol (DON) diagnostic platform for FHB research and breeding programs. L. WANG, D. MICHEL, A. EL-ANEED AND H. R. KUTCHER. *Department of Plant Sciences / Crop Development Centre, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8, Canada; and (D.M., A.E.) College of Pharmacy and Nutrition, University of Saskatchewan, 107 Wiggins Rd., Saskatoon, SK, S7N 5E5, Canada.*

Fusarium head blight (FHB), caused by *Fusarium* spp., is a destructive disease of small grain cereals, such as wheat, barley, oat and canaryseed. Apart from grain yield losses and reduced baking and seed quality, a major concern with FHB is crop contamination with Fusarium-produced trichothecene mycotoxins, specifically deoxynivalenol (DON), also known as vomitoxin, and its derivatives. These mycotoxins accumulate in the grain making it unfit for consumption by humans and animals. Significant DON contamination may render a crop unmarketable, or reduces the market value by 40-65%. The ultimate goal in FHB resistance breeding is to develop productive cultivars with disease resistance and low mycotoxin contamination despite high infection pressure. At the Cereal Pathology Laboratory, we have established two mycotoxin diagnostic platforms using liquid chromatography coupled with triple quadrupole mass spectrometry (LC-MS/MS) to support FHB breeding and research programs: 1. a rapid, accurate and low cost DON quantification platform for high-throughput DON phenotyping; and 2. a state-of-the-art analytical platform to simultaneously quantify DON and its derivatives: 3-acetyldeoxynivalenol (3-ADON), 15-acetyldeoxynivalenol (15-ADON), and deoxynivalenal-3-glucoside (D-3-G); and the toxins: nivalenol (NIV), HT-2 and T-2.

Plants employ two different types of programmed cell death in response to low temperature stress and pathogen invasion. L. WANG, R. WEN AND W. XIAO. *Department of Plant Sciences, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8, Canada; (R.W., W.X.) Department of Microbiology and Immunology, University of Saskatchewan, Saskatoon, SK, S7N 5E5 Canada.*

In nature, not only do plants face extreme environmental conditions, but also they are continuously threatened by diverse microbial pathogens. To survive, plants have evolved unique and sophisticated defense mechanisms that act simultaneously against multiple external stresses. In this study, we revealed a novel mechanism in which plant employs an ubiquitin-conjugating enzyme, UBC13, to differentially regulate two programmed cell death (PCD) pathways in response to low temperature stress and pathogen invasion. The *ubc13* knockout mutant spontaneously produced cell death lesions and was hypersensitive to low temperature stress. This low temperature induced lesion mimic phenotypes were dependent on the Salicylic Acid (SA) pathway. However, unlike typical lesion mimic mutants, low temperature-induced PCD in *ubc13* did not cause enhanced disease resistance and differs from pathogen-induced hypersensitive response (HR)-associated PCD. Indeed pathogen induced PCD and reactive oxygen species burst were delayed or diminished in the *ubc13* mutant. Furthermore, the *ubc13* mutant displayed enhanced disease susceptibility to avirulent bacterial pathogen regardless of temperature, indicating that UBC13 positively regulates a temperature-independent disease resistance. Together, these results demonstrate that UBC13 is required for both of PCD pathways by repressing low-temperature-induced PCD to alleviate the negative effect of SA on plant growth while activating HR-associated PCD to establish disease resistance against pathogens. To our knowledge, this is the first report to distinguish these two types of PCD in response to low temperature and pathogen infection.

New sources of resistance to fusarium head blight in spring wheat. L. WANG, W. ZHANG, A. DIEDERICHSEN, A. SHARPE AND H. R. KUTCHER. *Cereal & Flax Pathology Lab, Department of Plant Sciences / Crop Development Centre, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8, Canada; (W.Z., A.S.) National Research Council of Canada, 110 Gymnasium Place, Saskatoon, SK, S7N 0W9, Canada; and (A.D.) Agriculture and Agri-Food Canada, Saskatoon Research and Development Centre, 107 Science Place, Saskatoon, SK, S7N 0X2, Canada.*

Fusarium head blight (FHB or scab) caused by *Fusarium* spp. is a destructive disease of wheat. Host resistance, coupled with other integrated pest management practices, is considered the best approach to control FHB. In an effort to identify novel sources of FHB resistance, we evaluated wheat germplasm in a Fusarium disease nursery in 2016 and 2017. Four thousand accessions from the Plant Gene Resource of Canada (PGRC), which has a world-wide collection of *Triticum aestivum*, were evaluated in a field FHB nursery for two seasons; 400 lines with highest resistance were selected for genome-wide association study (GWAS) to confirm the new resistance genes. In addition, 412 lines were evaluated from a synthetic hexaploid wheat association mapping (SHW AM) panel, which were created by crossing durum wheat (AABB) and *Aegilops tauschii* (DD) at the International Wheat Research Centre in Mexico (CIMMYT). The SHW AM panel was genotyped with wheat 90K Infinium SNP chips. A high density haplotype map was developed with markers identified by anchoring into the bread wheat consensus map. With the field data from 2016 and 2017, several novel FHB alleles/or QTLs were identified by GWAS in SHW AM panel.

Yield losses of canola caused by blackleg and pyraclostrobin sensitivity in populations of *Leptosphaeria maculans.* Y. WANG, S.F. HWANG[2], A. AKHAVAN , H. AHMED, G. D. TURNBULL AND S.E. STRELKOV. *Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB T6G 2P5, Canada; (S.F.H., H.A., G.D.T.) Crop Diversification Centre North, Alberta Agriculture and Forestry, Edmonton, AB T5Y 6H3, Canada.*

Blackleg of canola (*Brassica napus* L.), caused by *Leptosphaeria maculans* (Desm.) Ces.& de Not., is an important disease worldwide. In Canada, blackleg is managed mainly by the cultivation of resistant or moderately resistant canola hybrids and fungicide application. A field experiment was conducted in central Alberta to determine the relationship between blackleg severity and yield in two moderately resistant hybrids '73-15RR' and '1950RR'. Seed yield per plant was found to decrease as a consequence of *L. maculans* infection, with regression analysis showing that the relationship between yield and disease severity was best explained by second degree quadratic equations. Sensitivity to the fungicide pyraclostrobin, a strobilurin that is commonly applied as a foliar and seed treatment for blackleg and other diseases, was evaluated in 12 and 250 isolates of *L. maculans* collected in Alberta in 2011 and 2016. The half-maximal effective concentration (EC_{50}) of pyraclostrobin was determined, and two discriminatory doses of the fungicide were used to identify highly insensitive isolates in the collection. The mean EC_{50} value was significantly higher for the isolates collected in 2016 (0.28 mg L^{-1}) versus those collected in 2011 (0.07 mg L^{-1}). Nonetheless, while all isolates were still sensitive to pyraclostrobin, the increase in mean EC_{50} observed in the more recent *L. maculan*s collections suggests that proper fungicide stewardship is warranted.

Transcriptome analysis of *Brassica napus* lines carrying single and double clubroot resistance genes against the *Plasmodiophora brassicae* pathotype X-LG2 (5X). R. WEN, J. LEE, K. HORNADAY, N. TONU, T. SONG, F. YU AND G. PENG. *Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, SK S7N 0X2, Canada.*

Clubroot, caused by the obligate biotrophic pathogen *Plasmodiophora brassicae* Woronin, is one of the most important diseases of Brassica crops worldwide. Growing cultivars carrying clubroot resistance (CR) genes is the most effective and practical approach to managing clubroot disease on canola, but the CR sources are limited. Transcriptome analysis of three *Brassica napus* L. lines carrying a single CR gene located in i) chromosome A03 (*Rcr1*, line 16), ii) A08 (similar to *Crr1*, line 20), or iii) carrying both CR genes (line 15) against *P. brassicae* pathotype X-LG2 (previously 5X). Bioassay results showed that line 16 was susceptible, while both lines 15 and 20 were moderately resistant to the X-LG2. Functional annotation of the differentially expressed genes (DEGs) involved the biological processes such as response to stress, biosynthesis and signal transduction. Venn diagram analysis showed that lines 15 and 20 shared many DEGs, but these DEGs often were not found in line16. Enrichment analysis revealed that 286 DEGs were involved in defense responses, including those associated with pathogen-associated molecular patterns (PAMPs), activation of innate immunity, hormone signaling, transcription

factors, and cell wall modification. These results indicate that the intermediate level of resistance against pathotype X-LG2 conferred by the CR gene on A08 may function via activated PAMPs and effector trigged immunity. Interestingly, the transcription levels for the most DEGs involved in defense responses were much higher in line 15 than in line 20, indicating that the two CR genes together trigger a stronger defense response than either gene alone.

Genome-wide-association studies on the resistance of rutabaga accessions to *Plasmodiophora brassicae* isolates from Alberta, Canada. Z. YU, R. FREDUA-AGYEMAN, S.F. HWANG AND S.E. STRELKOV. *Department of Agricultural, Food and Nutritional Sciences, University of Alberta, Edmonton, AB T6G2P5, Canada; and (R. F.-A., S.F.H.) Alberta Agriculture and Forestry, 17507 Fort Road NW, Edmonton, AB T5Y6H3, Canada.*

Clubroot, caused by *Plasmodiophora brassicae* Wor., is a devastating soil-borne disease of *Brassica* crops worldwide. In this study, genomic regions associated with resistance to five single-spore isolates (classified as pathotypes 2F, 3H, 5I, 6M, and 8N) and 12 field isolates (classified as pathotypes 2B, 3A, 3O, 5C, 5G, 5K, 5L, 5X, 8E, 8J and 8P) were investigated using 125 *Brassica napus* L. spp. *napobrassica* (swede or rutabaga) accessions. The accessions were screened for resistance in greenhouse inoculation experiments, while genotyping was carried out with a 15 K *Brassica* SNP array. The rutabaga accessions exhibited differential reactions towards the 17 isolates with 4.8–67.2% found to be resistant, 4.0–16.8% moderately resistant and 22.4–86.4% susceptible. About 32% of the 13714 of the SNP markers used for genotyping were included in the association studies, while those that did not meet specific filtering criteria were discarded. One-hundred and twenty SNPs (78 on A_{01}-A_{10} and 42 on C genome scaffolds) were found to be significantly ($p = 0.05$) associated with resistance to the 17 *P. brassicae* isolates. The largest number (34) of SNPs associated with clubroot resistance was found on the A_{03} chromosome, which is consistent with the identification of at least four clubroot resistance genes on this chromosome. Between 3–10 SNPs were found on chromosomes A_{01}, A_{02}, A_{06} and A_{08}, which also have mapped CR genes. The SNPs identified in this study will be important in the marker-assisted breeding of clubroot-resistant canola.

Introgression of disease resistance from *Brassica nigra* into canola. Y. ZHANG, J. WANG, M. KEHLER, G. PENG, B.D. GOSSEN AND F. YU. *Saskatoon Research and Development Centre, Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, SK, S7N 0X2 Canada.*

Brassica nigra L. (genome BB) lines were identified to carry resistance to two important diseases of canola (*B. napus* L., genome AACC); clubroot caused by *Plasmodiophora brassicae* Wor., and blackleg caused by *Leptosphaeria maculans* (Desmaz.) Ces. & De Not. Current sources of resistance to clubroot in Canadian canola cultivars were derived mostly from *B. rapa* L. (genome AA). Resistance genes from the A-genome of *B. rapa* or *B. napus* have also been used to develop canola cultivars resistant to blackleg. New sources of clubroot and blackleg resistance are required to manage these important diseases because virulent pathogen populations have been reported in western Canada that are able to overcome the resistance of canola cultivars for both diseases. In this study, a total of 497 F_1 or BC_1 embryos from interspecific crosses between the resistant *B. nigra* line CR2716 and the susceptible *B napus* line DH 16156 were rescued by tissue culture to overcome pre-fertilisation issue. Clubroot resistance genes against pathotype 2, 3, 5, 6, 8 and 5X were identified in this *B. nigra* line. Four SNP markers tightly linked to the resistance genes were developed and used for marker associated selection in the backcross population. For blackleg, cotyledon inoculation was used for resistance assessment. To date, BC_4 populations with putative resistance to clubroot (17 lines) and blackleg (9 lines) have been developed and additional analyses are in progress.

Business Meeting Minutes – 39th Annual Meeting of the PPSA

October 16, 2018, Days Inn and Suites, Lloydminster, Alberta

Introductions: President – Bruce Gossen; Vice President – Kequan Xi; Secretary –Syama Chatterton; Treasurer – Noryne Rauhala; Directors – Robyne Bowness, Krista Zuzak, Reem Aboukhaddour, Jackie Busaan, CPS Representative, guests.

Number of attendees 60-65.

1. **Adoption of the Agenda**
   Moved - Noryne Rauhala, Second - Dustin Burke

2. **Adoption of the Minutes of the 2017 Business Meeting**
   Moved - Mike Harding, Second - Ron Howard

3. **In Memorium** – none.

4. **Interim Financial Report (**Noryne Rauhala)
   - **a.** Noryne presented the financial report (Appendix 1) and moved acceptance of financial report – seconded by Kelly Turkington
   - **b.** After some discussion, Noryne moved that the bank account be transferred to another facility that will be chosen by the treasurer after review of options and fees available at various banking facilities – seconded - Kelly Turkington.
   - **c.** There was support for obtaining a credit card for the PPSA to make meeting organization more simple. No motion was required as this action will be at the discretion of the treasurer.
   - **d.** Discussion on moving meeting registration to an online system such as Eventbrite – Noryne will look into it.

5. **Update on CPS Activities**
   - **a.** Dilantha Fernando (CPS president) discussed a request from the CPS audit report that regional societies should provide an annual summary financial report to CPS. PPSA would not be required to participate because it is a distinct group, but it does receive funds periodically from CPS, e.g. $2000 in 2018.
   - b. CPS Publications
   - i. DFCC – Mike Harding. Specific diseases are being updated to include as an insert into a new printing. A call has gone out looking for editors and crop chapter teams. Dilantha suggested that Canola Council pamphlets can be included as an insert.
   - ii. DPVCC – Ron Howard. The original version of DFCC, published in 1994, has been out of print for several years but is available online as a pdf. This large book being split into 8 books based on crops. Volunteer effort –progress being made but slowly. Editorial committee updating existing material, 1st draft may be available by next spring.

6. **Reports of Standing Committees**
   Disease Survey Committee (Kelly Turkington): No report.
   Historical Committee: No report. Steve is custodian of materials at the U of A.
   Awards Committee (Michael Harding):

In 2018 there were a total of six awards to students and technicians for presentations First, second and third place awards were presented for both a student and a technician competition. All of the recipients received a copy of the book "History of Plant Pathology in Canada". First place award winners received a cheque for $150 and second place winners received a cheque for $50. The judges were Dilantha Fernando, Yu Chen and Barb Ziesman.

Best Student Presentations:

First place Nicole Fox for a presentation entitled 'Evaluation of clubroot disease development in canola in response to variable lime products and rates'. Nicole is a graduate student at the University of Alberta working with Drs. Strelkov and Hwang.

Second place Keisha Hollman for a presentation entitled "'Evaluation of the impact of hydrated lime on clubroot severity in canola over multiple growing seasons'. Keisha is a graduate student at the University of Alberta working with Drs. Strelkov and Hwang.

Third place Yixiao Wang for a presentation entitled 'Yield losses of canola caused by blackleg and pyraclostrobin sensitivity in populations of *Leptosphaeria maculans*'. He is a graduate student at the University of Alberta working with Drs. Strelkov and Hwang.

Best Technician Presentations:

First place Daniel McDougall for a presentation entitled 'Development of a *Pseudomonas syringae* based biocontrol agent for use against Canada thistle'. Daniel works at the University of Regina with J. Stavrinides.

Second place Linda McGregor for a poster entitled 'Developing a droplet-digital PCR-based protocol for rapid screening of quantitative resistance against blackleg of canola'. Linda works for Agriculture and Agri-Food Canada at the Saskatoon Research and Development Centre with Dr. Peng.

Third place Blake Hill for a poster entitled 'Survey for blackleg on canola in southern Alberta in 2018'. Blake works for Alberta Agriculture and Forestry at the Crop Diversification Centre South, in Brooks, AB, with Dr. Harding.

Scholarships:

In addition to presentation awards, the PPSA also awards two scholarships annually. Each award is valued at $1000.The PPSA Scholarship was awarded to Nicole Fox. Nicole is a graduate student at the University of Alberta with Dr. Strelkov. The Swanson Award went to the University of British Columbia in 2018. The recipient had not been named at this time (follows the Minutes).

Respectfully submitted by Michael Harding, Ron Howard and Denis Gaudet.

7. Conference Reports

Bruce Gossen provided a report on the International Clubroot Workshop that was held in Edmonton in August, 2018 with 195 attendees comprised of growers and scientists, and included two field tours. There was an after-meeting workshop to discuss areas of controversy that was very successful in setting new research protocols and priorities.

8. Reports on Unusual or Exceptional Disease Situations

None

9. **Nomination of Honorary Life Members**
   Dr. Sheau-Fang Hwang, Nominated by Mike Harding, seconded Bruce Gossen. Carried unanimously.
   Dr. Kan-Fa Chang, Nominated by Dustin Burke, seconded Bruce Gossen. Carried unanimously.

   Congratulations to both of these deserving recipients, and thanks for their long-term involvement and support of the PPSA!

10. **Resolutions –** Whereas the meeting organization, venue, program, food and sponsorship has been outstanding. Therefore, be it resolved to thank the PPSA executive and local arrangements committee, the Days Inn, the sponsors and participants for an excellent meeting. Moved - Mike Harding, Seconded Noryne.Rauhala.

11. **Locations and Dates of Future Meetings**
    a. 2019 Lacombe - Next meeting will be organized by AAF in Lacombe, with LAC composed of Kequan Xi, Krishnan Kumar, and Sasha. Moved - Kelly Turkington, seconded – Sasha.
    b. 2020 Lethbridge - (Reem as LAC chair)
    c. 2021 (Edmonton)
    d. 2022 (Brooks)

12. **Election of Officers for 2018-19**
    a. President: Kequan Xi (Lacombe)
    b. Vice President: Reem Aboukhaddour. Nominated by Syama Chatterton, seconded by Kelly Turkington. Reem was not present at the meeting, but confirmed to S. Chatterton that she accepts the nomination.

13. **Other Business** - None

14. **Adjournment** – Moved Kelly Turkington.

SWANSON AWARD FOR PLANT PATHOLOGY AND NEMATOLOGY

October 12, 2018

The 2018 Swanson Award for Plant Pathology and Nematology will be awarded to a Graduate Student at the University of British Columbia (UBC). At the time this report was prepared the student had been selected by the Faculty of Graduate Studies at UBC, but not yet named publicly. This is due, in part, to the fact that our annual meeting took place a few weeks earlier than usual this year. We will send out a notification to the PPSA membership as soon as the name of the Swanson Award recipient is available.

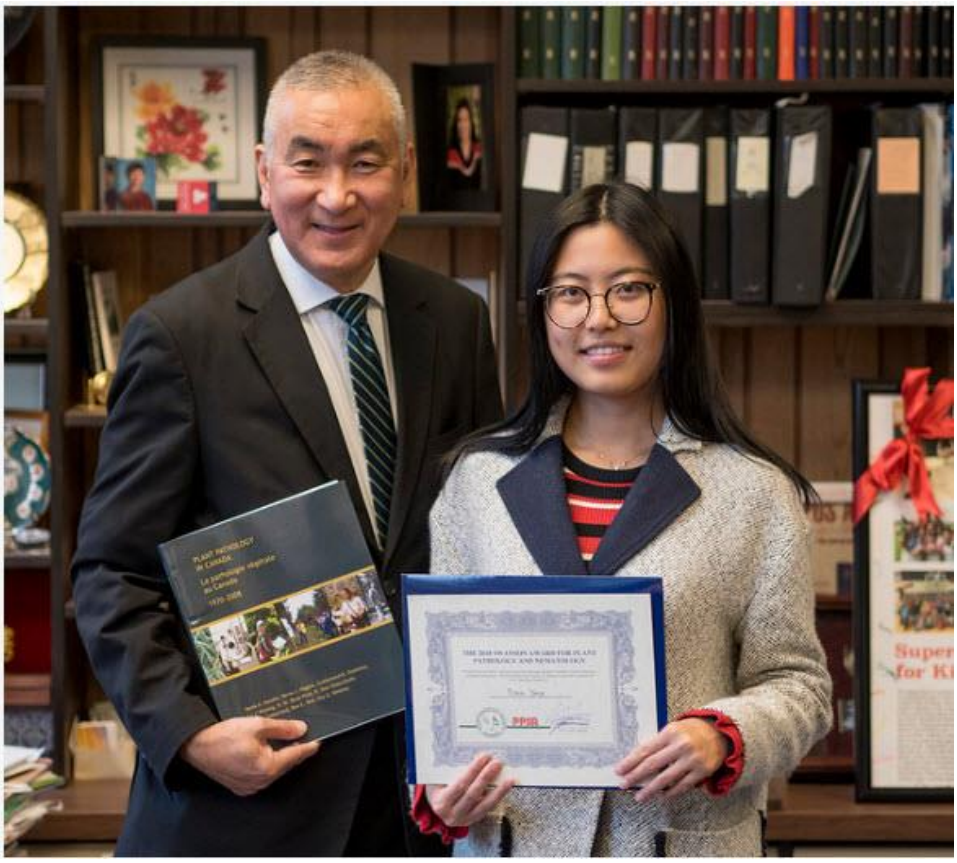
An updated financial statement for the Scholarship Fund for 2017-18 is given below.

Guaranteed Investment Certificates (Community Savings, Lacombe)

Donations from November 2017 meeting		$135.00
12 month GIC (matures August 12, 2018)	Opening Balance	$13028.77
Transfer from chequing		$199.97
Interest 0.5%		$ 86.12
	Balance to date	$ 13314.86

Respectfully submitted by D. Gaudet, R. Howard, and M. Harding (PPSA Awards Committee)

Update: The Swanson Award for 2018 went to Ms. Yifan Yan at the University of British Columbia. This decision was announced by UBC about one month after the meeting in Lloydminster. Ms. Yan's project is focused on studying the impact of climate change on grape production and her supervisor is Dr. S. Castellarin. The award consisted of a graduate student scholarship that includes a $1000 cheque, a certificate of recognition, and a copy of the book *Plant Pathology in Canada*. Yifan was presented with the award by Dr. R. Yada, Dean of the Faculty of Land and Food Systems at UBC.



Yifan Yan receiving the 2018 Swanson Award
Presenter: Dr. R. Yada, Dean of the Faculty of Land and Food Systems. UBC