2024 NORTHEAST POTATO TECHNOLOGY FORUM

March 20 - 21, 2024

Rodd Royalty Hotel, Charlottetown, PE Canada

Wednesday, March 20, 2024

1:00 pm Welcome

Session A: Agronomy/Environment
Moderator: Judith Nyiraneza, AAFC Charlottetown

1:15 **A study on the impact of climate change on eleven potato varieties**
Ziwei Chen*, Lord Abbey, Mason MacDonald, Suqi Liu, and Gefu Wang-Pruski

1:30 **Cost-benefit analysis of supplemental irrigation for potato production in Prince Edward Island**
Yefang Jiang*, Tobin Stetson, John Philips, and Ana Kostic

1:45 **Use of constructed wetlands and mini-wetlands for remediation of agricultural runoff from potato fields**
Audrey Murray*, Tobias Laengle, Jennifer Klaus, Mary Finch, Jake Mackinnon, Keilla Miller, and Virginia Everett

2:00 **Winter cover crops before and after potato crop: environmental and economic benefits**
Judith Nyiraneza*, Yefang Jiang, Mohammad Khakbazan, Danielle Murnaghan, Jessica Matheson, Ana Kostić, and Ryan Barrett

2:15 **Response of new processing potato varieties to different nitrogen rates**
Newton Yorinori*, William Hardy, Rory MacLellan, and Sandra Yorinori

2:30 **Short term effects of rotation length and plant diversity in potato production systems on the abundance of nitrogen cycling communities**
Leah MacIntyre*, Claudia Goyer, David Burton, Ikechukwu Agomoh, and Louis-Pierre Comeau

2:45 **Does size really matter – what's in your planter?**
Steve Watts*

3:00 BREAK AND POSTER SESSION

Session B: Pest Management
Moderator: Steve Watts, Genesis Crop Systems Inc.

3:30 **Effects of cultural practices on weed community and seedbank dynamics in a potato rotation**
Andrew McKenzie-Gopsill*, Judith Nyiraneza, and Sherry Fillmore

3:45 **Effect of in-furrow application of Minuet biopesticide for control of common scab in PEI**
Ryan Barrett*, Humna Khan, and Rick Peters

4:00 **Phenotypic characterization of *Phytophthora infestans* populations on potato and tomato in Canada reveals high diversity and metalaxyl-m insensitivity**
Segun Babarinde*, Rick Peters, Khalil Al-Mughrabi, Rishi Burlakoti, Anne MacPhail, Amy Novinscak, Sanjib Sapkota, Fouad Daayf, and Balakrishnan Prithiviraj

4:15 **Development and application of simultaneous qPCR for *Verticillium* and Root Lesion Nematode in greenhouse and field studies**
Tyler MacKenzie*, Khalil Al-Mughrabi, Dahu Chen, and Mathuresh Singh

4:30 **Preliminary survey of wireworms in potato fields adopting regenerative agricultural practices and examination of wireworm life-stage markers**
Rachel R. Rix*, Gefu Wang Pruski, G. Christopher Cutler, Yves LeClerc, and Manphool Fageria

4:45 **Does russeting and silver patch affect bacterial and fungal communities associated with potato tubers?**
Claudia Goyer* and Tracy Shinners-Carnelley

5:30 **HOSPITALITY SUITE** courtesy of Syngenta

Thursday, March 21, 2024

7:30 – 8:00 Breakfast

Session C: Modeling and Breeding/Genetics
Moderator: Newton Yorinori, Cavendish Farms

8:15 **A model-based approach for determining potato ecophysiological nitrogen requirements and recommending optimal rates for specific soil and climate conditions**
Morteza Mesbah*, Kristen Murchison, and Mariaelisa Polsinelli

8:30 **Crop disease modelling using machine learning and artificial intelligence**
Avneet Kaur*, Aitazaz Farooque, Ryan Barrett, and Gurjit Randhawa

8:45 **Quantifying and predicting carbon dioxide emissions using advanced modeling techniques for sustainable potato production in Prince Edward Island, Canada**
Muhammad Hassan*, Aitazaz Farooque, Khabat Khosravi, Evan Macdonald, and Ryan Barrett

9:00 **Forecasting of SPEI (Standardized Precipitation Evapotranspiration Index) meteorological drought over Atlantic Canada using machine learning algorithms**
Chukwuemeka Eneh*, Aitazaz Farooque, Masoud Karbasi, Mumtaz Ali, and Gurjit Randhawa

9:15 **Genome-wide association studies revealed diploid potatoes with climate-resilient traits**
Bourlaye Fofana*, David Main, Mohsin Zaidi, and Benoit Bizimungu

9:30 **Case study: fresh tablestock intercepted in CFIA regulatory action**
Xiang Li*, Jingbai Nie, Desmond Hammill, Jiacheng Chuan, Qifan Yang, Huimin Xu, Phillip Maxwell, and Pamela Ross

9:45 **Preliminary analysis of potato wart genomic datasets**
Jiacheng Chuan* and Sean Li

10:00 BREAK AND POSTER SESSION

Session D: Precision Agriculture
Moderator: Andrew McKenzie-Gopsill, AAFC Charlottetown

10:30 Influential factors for estimating Pan Coefficient using machine learning and deep learning models
Saad Javed Cheema*, Aitazaz Farooque, and Mehdi Jamei

10:45 AgriScout: An autonomous robotic system for detecting and classifying healthy and PVY virus-infected potato plants
Charanpreet Singh*, Aitazaz Farooque, Gurjit Randhawa, Ryan Barrett, and Mathuresh Singh

11:00 Optimizing crop soil moisture estimation: A fusion of satellite thermal infrared bands and vegetation indices using Google Earth engine
Fatima Imtiaz*, Aitazaz Farooque, and Ryan Barrett

11:15 Assessing soil organic carbon using soil color captured with mobile phones
Fangzhou Zheng*, Sheng Li, Yulia Kupriyanovich, and Ray Carmichael

11:30 Satellite-derived bare soil mapping in Prince Edward Island – a potential tool for site specific field management
Evan MacDonald* and Aitazaz Farooque

11:45 Investigating soil compaction in potato fields using advanced technologies
Andrew Fraser*, Aitazaz Farooque, Evan Macdonald, Ryan Barrett, and Travis Esau

12:00 BUFFET LUNCH

POSTER SESSION

Variation in the Efficacy of Commonly Used and Novel Fungicides for the Control of the Late Blight Pathogen *Phytophthora infestans* in Canada
Babarinde, Segun O., Khalil I. Al-Mughrabi, Rick D. Peters, Samuel K. Asiedu, Rishi R. Burlakoti, Fouad Daayf, and Balakrishnan Prithiviraj.

Transcriptome and Gene Expression Analyses of Different Developmental Stages of Wireworm (*A. sputator*)
Joshi, Jyoti and Gefu Wang-Pruski.

Effect of Sugar Kelp (*Saccharina latissimi*) on Potato (*Solanum tuberosum*) Yield, Soil Health, and Greenhouse Gas Emissions
Khan, Arishma, Travis Esau, Kuljeet Grewal, and Gurpreet Selopal.

Water and Tillage Erosion under Conventional and Conservation Tillage
Li, Sheng, Fangzhou Zheng, Yulia Kupriyanovich, and Sylvie Lavoie.

Fall Greenhouse Gas Emissions in Relation to Cover Crops and Soil Health
Shim, So Yeon, Aitazaz A. Farooque, David Burton, Ryan Barrett, and Xiuquan Wang.

Effects of Shrub Willow Chips on Microbial Communities under Potato Cropping Systems
Uwituze, Yvonne, Tandra D. Fraser, Judith Nyiraneza, Jacynthe Dessureault-Rompré, and Yefang Jiang.

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A Study on the Impact of Climate Change on Eleven Potato Varieties

Ziwei Chen[1]*, Lord Abbey[1], Mason MacDonald[1], Suqi Liu[2], Gefu Wang-Pruski[1]

[1] Faculty of Agriculture, Dalhousie University, Truro, NS, Canada
[2]Department of Agriculture, Government of Prince Edward Island, Charlottetown, PEI, Canada

The impact of climate change on agriculture, and specifically on potato crops, has become increasingly significant, with environmental stressors such as drought and high temperatures posing substantial challenges. This study evaluated the resilience and adaptability of 11 potato varieties identified as of interest by the PEI Potato Board (AAC Red Fox, Alverstone Russet, Caribou Russet, Colomba, Dakota Russet, Goldrush, Highland Russet, Mountain Gem, Russet Burbank, Red Norland, and Satina) under such stress conditions in the greenhouse (GH) and growth chamber (GC) settings. The varieties underwent drought stress treatment for 14 days at three development stages (tuber initiation, bulking, and maturation), maintaining 50% water-holding capacity, and faced temperature stress conditions of 4°C above the control temperature regimes. The research measured various physiological and biochemical indicators, including photosynthesis rate, transpiration rate, stomatal conductance, chlorophyll index, leaf area, proline, superoxide dismutase (SOD), and catalase (CAT) activities, as well as yield, tuber greening, malformation, specific gravity, and contents of sugar, starch, and total soluble protein, to assess plant stress responses and overall health. In the GH experiment, AAC Red Fox, Alverstone Russet, and Dakota Russet responded to drought stress by altering SOD concentration, with Alverstone Russet and Dakota Russet showing faster responses than AAC Red Fox. AAC Red Fox and Alverstone Russet also demonstrated changes in CAT concentration. Alverstone Russet, Caribou Russet, Dakota Russet, and Russet Burbank all increased their proline content in response to drought stress, with Alverstone Russet and Caribou Russet showing quicker responses than the other varieties. Dakota Russet exhibited a significantly lower transpiration rate and stomatal conductance under drought stress, whereas Alverstone Russet plants tended to decrease their photosynthesis rate. Alverstone Russet and Dakota Russet both yielded lower after drought stress, but Dakota Russet maintained better tuber quality regarding tuber greening. Other varieties performed well in yield, but Red Norland and Highland Russet both encountered tuber quality issues. Red Norland exhibited a significantly higher greening percentage compared to its control group, and Highland Russet showed a higher potential for tuber malformation after drought stress. In the GC experiment, Satina was the only variety that responded to drought and heat stress with a faster proline accumulation rate. AAC Red Fox, Russet Burbank, Red Norland, Highland Russet, Colomba, and Satina all showed positive responses to drought and heat stress in SOD concentration. Red Norland, Colomba, AAC Red Fox, and Goldrush demonstrated a negative response to the stresses in CAT concentration, with Red Norland showing this trend more rapidly than the other varieties. The yield of Dakota Russet, Russet Burbank, Mountain Gem, Colomba, and AAC Red Fox was affected by the stresses. Goldrush was the only variety whose specific gravity was negatively affected by the drought and heat stresses.

Cost-benefit analysis of supplemental irrigation for potato production in Price Edward Island

Yefang Jiang[1], Tobin Stetson[2], John Philips[3], and Ana Kostic[1]

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This study investigated the economic viability of supplemental irrigation (SI) for potato cultivation in Prince Edward Island, Canada. The net benefit of SI was determined by subtracting the cost from the gross benefit, calculated as the increase in marketable yield due to SI multiplied by the potato sale price. On-farm trials were conducted annually in four to five commercial fields in Prince Edward Island (PEI) from 2019 to 2022 to measure the rise in marketable yield resulting from SI. SI significantly increased marketable yields in 2019 and 2020, which was mainly attributed to droughts during tuber initiation and bulking stages. In contrast, SI yielded negligible marketable yield responses in 2021 and 2022, when farmers either refrained from irrigating or employed minimal irrigation due to sufficient and evenly distributed rainfall. Because tuber yield response to SI varies yearly with rainfall , a long-term cost-benefit analysis was conducted to determine whether the economic gains from SI during dry years are enough to offset the losses incurred during wet years. Briefly, a per-hectare benefit was calculated over a 23-year period, roughly corresponding to the typical lifespan of current irrigation systems. Rainfall during this 23-year period was assumed to be consistent with observations at New Glasgow, PEI from 2000 to 2022. The annual marketable yield increase from SI was extrapolated from the observed values from 2019 to 2022 by matching historical rainfall rates from 2000 to 2022 with those observed from 2019 to 2022. The costs associated with four representative irrigation systems, namely pivots I and II, a hose reel sprinkler, and a hose reel boom cart, each irrigating approximately 40 ha per year, were used in the analysis. Costs included ownership (equipment depreciation, water supply, and interest) and operational costs. Potato sale prices and the purchase prices for establishing and maintaining the irrigation systems were standardized to 2018 prices for comparative analysis. Comparing costs with gross benefits showed that pivots I and II would yield profits of $68/ha/year and $264/ha/year in the long term, respectively, while the reel sprinkler and boom cart systems would incur losses of $143/ha/year and $6/ha/year, respectively. A 20-ha pivot moving back and forth to cover two 20-ha fields in one year, using a shared water supply system and a low-cost power source (e.g., pivot II), could generate $264/ha/year. The same pivot would incur a $100/ha/year loss in the long term if used to irrigate only one 20-ha field per year. In conclusion, the cost-benefit analysis indicates that the economic viability of SI is mainly contingent on factors such as irrigation equipment costs, the water supply system used, operational aspects, field scale, and rainfall distribution. These findings have significant implications for decision making in water management for potato production in humid environments.

Use of Constructed Wetlands and Mini-Wetlands for Remediation of Agricultural Runoff from Potato Fields

*Audrey Murray (Agriculture and Agri-Food Canada (AAFC)), Tobias Laengle (AAFC), Jennifer Klaus (AAFC), Mary Finch (PEI Watershed Alliance), Jake Mackinnon (Government of PEI), Keila Miller (Souris Wildlife), Virginia Everett (Kensington North Watersheds Association)
Agriculture and Agri-Food Canada, 440 University Ave., Charlottetown, PE C1A 4N6, Canada

Wetlands are an integral part of natural ecosystems where they provide a variety of ecosystem services such as water purification, sediment removal, groundwater recharge, carbon sequestration, surface water augmentation, drought and flood protection, wildlife habitat and shoreline stabilization. However intensification of agriculture and drainage of natural wetlands for agriculture and other purposes has reduced the number and scale of wetlands. In Southern Canada, more than 50% of the original wetlands have been drained, 85% of these for agriculture. At the same time as a reduction in wetlands has reduced the capacity of the natural environment o filter water, intensification of agriculture has led to greater inputs of synthetic fertilizers and pesticides into the natural environment. Restoring wetland capacity in agricultural ecosystems has the potential to restore some of these ecosystem services and increase the resilience of agro-ecosystems. In this project, began in 2019 under Living Labs Atlantic, four constructed wetlands and one mini-wetland were installed on low-lying and unused portions of farm properties in PEI. Wetlands have been monitored for water quality (nutrients, sediment, pH) as well as biodiversity. Preliminary results for the full-scale wetlands show removal of phosphate, chloride, nitrate, ammonia, total phosphorus, total nitrogen, and total suspended solids. Amphibian surveys indicated the presence of leopard frogs and spring peepers, and the Simpson Diversity Index for the full-scale wetlands was good with the presence of different functional feeding groups. The mini-wetland was installed in June 2023, and is a small, linear wetland (ditch-shaped) at the side of an agricultural field. Similar to the full-scale wetlands, this wetland was installed in a wet, low-lying area of the field that has not been historically farmed, so no land was taken out of production. The idea behind this strategy is that installing smaller wetlands will increase the overall wetland capacity of the ecosystem, providing valuable ecosystem services while providing flexibility to growers, to allow for more wetland installations. Additionally, wetland mesocosms were installed at Harrington Research Farm to investigate the performance of three native plant species (cattails, joe-pye weed, and swamp milkweed) on nitrate removal and to compare the performance to that of bioreactors. Results of the mesocosm study showed good removal of nitrates, with cattails and the bioreactor exhibiting the best removal of up to 100% with a 2-day stagnation time. Under the new Living Labs PEI project, these wetlands will continued to be monitored for water quality and hydrologic characterization will allow loading calculations and percent reduction assessments to be made. Additionally, work will be completed to measure greenhouse gas emissions as well as carbon sequestration by the wetlands in comparison to alternative buffer zone or agricultural land use.

Winter cover crops before and after potato crop: environmental and economic benefits

Judith Nyiraneza[1*], Yefang Jiang[1], Mohammad Khakbazan[2], Danielle Murnaghan[1], Jessica Matheson[1], Ana Kostić[1], and Ryan Barrett[3]

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Under humid and cold climate conditions found on Prince Edward Island, keeping the ground covered is important during the spring and fall to mitigate nitrate leaching risk and soil erosion. Ground cover is especially important after primary tillage in the fall or following potato harvest, in which there is a significant amount of residual soil nitrate remaining. The objectives of this study were to evaluate the role of fall cover crops seeded after red clover plow-down prior to potato planting (study 1), and the role of fall cover crops seeded after potato harvest (study 2). The treatments compared in study 1 included: winter rape, oats, winter rye, and a control (no cover crop). The treatments in study 2 included: winter rape followed by oats the following spring, broadcast or drilled; winter rye, winter wheat, and winter barley, all of which were broadcast before potato harvest or drilled after potato harvest; and a control (no cover crop) followed by barley the following spring. Results will focus on the effects of the above cover crop treatments on soil nitrate adsorbed by anion exchange membranes over the winter, on soil particles collected by splash pans in fall and spring (detached by rainfall impact), and on net revenue.

Response of New Processing Potato Varieties to Different Nitrogen Rates

Newton Yorinori, William Hardy, Rory MacLellan, Sandra Yorinori[1]

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Nitrogen is an essential nutrient for the plant growth and has a significant impact to deliver optimal yields and tuber quality of potatoes. Traditionally potato farmers on PEI use to base their fertilization on the variety Russet Burbank, which they believe requires higher fertilization rates, given that it is a late maturity variety. Previous studies at Cavendish Farms Research Station had indicated that Russet Burbank does not respond to rates above 150 lbs/ac, which triggered a discussion about the negative impact of excessive use of Nitrogen fertilizer on Russet Burbank and other processing varieties, knowing that application of more than the plant requires can cause losses to ground and surface water and emissions of nitrous oxide, a very potent greenhouse gas. High N rates can also negatively impact tuber quality and reduce profitability with increasing costs of fertilizer.

To evaluate the potential to reduce the amount of Nitrogen fertilizer to apply on potato crops using the new processing varieties, field trials were installed in 2019, 2020 and 2021, where different rates of Nitrogen fertilizer were applied in 4 different varieties (Alverstone Russet, Campagna, Mountain Gem Russet and Targhee Russet).

Knowing that most common rates used by farmers on PEI for Russet Burbank are around 180 – 200 lbs/ac of Nitrogen, and assuming that these new processing varieties would be more efficient on the use of Nitrogen fertilizer based on previous exploratory trial results, rates of 110, 140, 170 and 200 lbs/ac of N were established in these trials in order to determine the optimal rate of N fertilizer required for each variety.

Results from trials in 2019 and 2020 (Dry growing seasons) indicated that for the variety Mountain Gem Russet there was no significant difference between any of the treatments when yield (total and pay yield), quality (defects, smalls, > 10 oz) and financial (grower payout in $/ac) parameters were assessed.
Similar results were obtained with varieties Alverstone Russet and Targhee Russet on 2020 (Dry growing season) and 2021 (Regular growing season) trials.

Those results allowed to establish some pilot tests in commercial fields with reduced rates of Nitrogen fertilizer, where positive results were observed (no difference vs. higher rates) which ended up with a technical recommendation to processing potato farmers to reduce by at least 25% the total amount of Nitrogen applied for these new varieties, resulting in an important reduction in the cost of the fertilizer and a very positive impact to the environment due to the reduction of N losses.

Short Term Effects of Rotation Length and Plant Diversity in Potato Production Systems on the Abundance of Nitrogen Cycling Communities

Leah MacIntyre[1,2*], Claudia Goyer[1], David Burton[2], Ikechukwu Agomoh[1], Louis-Pierre Comeau[1]

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Increasing plant diversity, soil coverage, and rotation length in potato production systems can improve soil quality and productivity, but may result in increased nitrogen (N) losses as nitrous oxide from nitrification and denitrification. The objective of this study was to compare the short-term effects of four potato crop production systems (CPS) established in 2021 with and without N fertilizer on soil properties, nitrous oxide emissions, and the abundance of N-cycling functional genes including nitrifying bacterial and archaeal *ammonia monooxygenases* (AOB and AOA), and denitrifying nitrite reductases (*nirS* and *nirK),* and nitrous oxide (N_2O) reductases (*nosZI* and *nosZII)*. The treatments included 1) conventional potato-barley (PBP), 2) potato - multi-species mix (PMP), 3) corn – spring wheat under seeded with clover and timothy-potato (CSWctP), and 4) corn under seeded with ryegrass - spring wheat under seeded with alfalfa and timothy - potato (CrSWatP). There were no effects of CPS on N_2O emissions, but there were significant effects of CPS in all genes in at least one of the three years, but they were not consistent across genes or years. For example, nitrite reductases (*nirS* and *nirK*) had the lowest abundances in the conventional two-year potato-barley rotation, but this was only observed in 2021 and 2022 for *nirS,* and only for *nirK* in 2023. There were significant effects of N on N_2O emissions, with cumulative growing-season N_2O emissions ranging from 72% to 135% higher under the fully fertilized treatments compared with the unfertilized control over three years. Similarly, significant effects of N were reported for all N cycling genes, but the direction of this shift changed between genes and years. For instance, the abundances of *nirS* and *nosZII* were greater in soil with N fertilization compared to soils without N fertilization in 2021 and 2023, but the reverse was observed in 2022, suggesting the occupation of separate competitive niches under varying environmental conditions or N fertilization. The results showed that the CPS may not significantly influence N_2O emissions over the growing season in the short-term, but changes in the abundance of denitrifiers and nitrifiers may influence the capacity for nitrogen cycling.

Does Size Really Matter - What's in Your Planter?

Steve Watts
Genesis Crop Systems Inc

Canadian potato farmers and their agronomic advisers continue to seek out ways to improve tuber yield & quality with the ultimate goal of increasing the overall profitability of the farm enterprise. There are many means of achieving these objectives including improvements in soil health & productivity, enhanced crop rotations, refined crop fertility strategies and numerous others. The concept of ideal potato seed piece size has been evaluated in numerous studies in the past; in general, most present day potato farmers strive for an average seed piece size of 2.25-2.5 ozs. This target size would be considered substantially higher than that used by growers in the Atlantic region 25 or more years ago. Many newer emerging varieties do not share the generous uniform eye distribution that a number of their older variety predecessors have; consider for example Kennebec, Ranger Russet & Russet Burbank vs Caribou Russet, Dakota Russet, Prospect, etc.

Regardless of the farms' seed piece size aspirations, use of mechanical seed cutters, regardless of manufacturer, result in a portion of the finished product has a certain percentage of seed pieces less than 1.5– 1.75 ozs. These smaller seed pieces often result in smaller, less productive plants or plant "doubles" that reduce overall seed piece planting accuracy and ultimately reduce crop yield and profitability. Agronomists and farm advisers are always identifying ways to minimize the amount of these smaller sized seed pieces this situation.

The presenter will discuss results of a two year study evaluating various seed piece sizes on yield and quality of Russet Burbank under Prince Edward Island conditions. Aspects including incremental costs associated with larger sized seed pieces and effect on in row stem populations will be considered.

Effects Of Cultural Practices On Weed Community And Seedbank Dynamics In A Potato Rotation

Andrew McKenzie-Gopsill[a*], Judith Nyrianeza[b], Sherry Fillmore[c]

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Stagnant yields and declining soil health are common characteristics of high-intensity, low-residue cropping systems, such as potato, particularly in northeastern North America. Incorporating cultural practices including cover cropping and manure application is a way to combat declines in agroecosystem health and potato productivity. However, manure application and the use of cover crops may exacerbate weed issues through seedbank additions. This study was aimed at investigating how the cultural practices of cover cropping and manure application and their associated management activities can alter weed community dynamics and weed seedbank composition in a northeastern North American potato rotation. The study evaluated the use of eight cover crop mixtures—annual and perennial grasses and legumes—grown over two years with/without manure added in year one of the rotation. It also examined the effects of the cover crop mixtures and the presence/absence of manure on the weed community and on seedbank dynamics within a three-year potato rotation between 2019 and 2021. In year one of the study and directly after application, manure plots had greater weed seedbank density and species richness; however, this did not result in greater in-season weed biomass. Manure application resulted in a gradual decline in weed seedbank density over time regardless of cover crop treatment. Further, manure application increased the in-season competitive ability of cover crops, resulting in greater weed suppression per unit of cover crop biomass. In contrast, in the absence of manure, weed seedbank density remained largely unchanged through time regardless of cover crop treatment. We found that management practices associated with annual and perennial cover crops had distinct ecological filtering effects throughout the rotation on the weed community and prevented the dominance of any particular species. Together, our results demonstrate that combining the cultural practices of annual or perennial cover cropping and manure application contributes to weed suppression and should be considered an important component of sustainable potato production.

Effect of In-Furrow Application of Minuet® Biopesticide for Control of Common Scab in PEI

Ryan Barrett*[1], Humna Khan[1], Rick Peters[2]

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2: Agriculture & Agri-Food Canada, Charlottetown Research & Development Centre, 440 University Ave, Charlottetown, PE C1A 4N6

Common scab is an economically significant source of reduced marketable yield and tuber quality for potato producers. It is caused primarily by *Streptomyces spp*., but species diversity and population intensity can vary greatly from field to field. Few effective management strategies are available to producers to control common scab, with selecting resistant varieties, irrigation at tuber initiation, and maintaining relatively low soil pH the most commonly used mitigation strategies. Previous research completed under the National Potato Cluster by Goyer et. al. showed that the in-furrow biopesticide product Serenade Soil® provided a level of reduction of common scab symptoms in some trials and varieties. The Seed and Tuber Quality Working Group of the Agronomy Initiative for Marketable Yield (AIM) wanted to investigate whether this could be replicated under Prince Edward Island growing conditions in grower fields. In 2023, Bayer released a new formulation of *Bacillus subtilis* strain QST 713 under the trade name Minuet®. In 2023, three split field trials were initiated by PEI growers. In each field, approximately ten acres (4 ha) of potatoes treated with Minuet® applied in-furrow at 379 mL/acre was compared with the grower standard practice, with the addition of Minuet® being the only difference at planting. Cultivars evaluated included Ranger Russet at two fields and Kennebec in one field. Two fields were located in eastern Prince County, while the other was in western Prince County. At harvest, six 10-foot harvest strips with equal plant count per strip were harvested from each treatment from the two East Prince fields, while four strips per treatment were harvested from the West Prince field. Tubers were then graded for Canada #1 yield as well as for tuber blemishes, with 25 tubers from each sample graded for common scab %, scab severity (0 to 3 scale), *Rhizoctonia* %, and silver scurf %. At all three sites, there was no significant difference ($p < 0.05$) for total or marketable yield between the Minuet treatment and the control. At the West Prince site, there was significantly greater ($p=0.02$) percentage of common scab in the Minuet treatment (1.9%) than in the control (0.7%); however, sampling frequency was lower for this location and the amount of common scab symptoms was overall quite low. At the other two East Prince sites, there was a significant reduction in common scab % and severity in the Minuet treatment compared with the control. On Ranger Russet, % common scab coverage was reduced from 3.6% to 1.4% ($p < 0.001$), while on Kennebec, % common scab was reduced from 6.6% to 2.4% ($p < 0.001$) in the Minuet treatment. The AIM Seed and Tuber Quality Working Group intends to replicate on-farm trials with this product again in 2024.

Phenotypic Characterization of *Phytophthora infestans* Populations on Potato and Tomato in Canada Reveals High Diversity and Metalaxyl-m Insensitivity

Segun O Babarinde[1,2], Rick D Peters[3], Khalil I Al-Mughrabi[4], Rishi R Burlakoti[2], Anne MacPhail[3], Amy Novinscak[2], Sanjib Sapkota[2], Fouad Daayf[5] and Balakrishnan Prithiviraj[1]

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Late blight caused by *Phytophthora infestans* is an economically important disease of potato and tomato worldwide. In Canada, increases in late blight incidence and severity coincided with changes in the genetic composition of *P. infestans*. We monitored late blight incidence on tomato and potato crops in Pacific western and eastern Canada between 2019 and 2022, identified genotypes of *P*. *infestans*, and examined their phenotypic characteristics, including mating type, sensitivity to metalaxyl-m, and allozyme genotype. We identified four major previously-characterized genotypes, US11, US17, US8, and US23, as well as 26 new genotypes. The US11 genotype was predominant in Pacific western Canada, while the US23 was predominant in eastern Canada. We also discovered the US17 genotype for the first time in Canada. All tested *P. infestans* isolates from ON and QC (n = 6) and BC (n = 60) were of the A1 mating type, including the US11, US17, US23, and a few new genotypes. Allozymes of glucose phosphate isomerase of *P. infestans* isolates from BC banded as either 100/100/111 or 100/100 whereas all isolates from QC and ON banded as 100/100. Approximately 95% of *P*. *infestans* isolates (n = 181) originating from BC between 2019 and 2021 were resistant (MMR or MHR) to metalaxyl-m, whereas the US23 and CAE1 isolates (n = 2) originating from both ON and QC were sensitive to metalaxyl-m. Considering the number of disease incidences, the detection of diverse known genotypes, the emergence of novel genotypes, and the high number of isolates resistant to metalaxyl-m (95%) from Pacific western Canada, sexual recombination leading to diverse populations may be occurring. This could ultimately pose challenges for late blight management. Therefore, continuous monitoring of *P. infestans* populations in the Pacific western region and across Canada is warranted.

Development and Application of Simultaneous qPCR for Verticillium and Root Lesion Nematode in Greenhouse and Field Studies

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The fungus *Verticillium dahliae* and nematode *Pratylenchus penetrans* are two soil-borne pathogens that synergistically cause Potato Early Dying (PED) syndrome. Traditionally, slow, labour-intensive methods were required to count these pathogens in soil samples, which requires specialized expertise for their identification under the microscope. Our new qPCR system simultaneously quantifies both, using species-specific DNA probes and routine laboratory techniques that are easily trained and standardized. This qPCR technique was applied in greenhouse and field to measure pathogens' concentrations, and correlate that with effects on potato growth and yield, and to directly compare its quantification accuracy with that of traditional counting techniques. Greenhouse-grown potatoes (cv. Russet Burbank) were inoculated with *V. dahliae* and *P. penetrans* in sterile soil and fresh soils from fumigated and non-fumigated fields. Inoculated plants grew normally for 60-80 days despite high pathogen levels, before wilting, slowing growth and becoming senescent weeks before control plants. Both pathogens reduced tuber yields, with combined infections being the most detrimental. Pathogen-induced growth and yield reductions were less severe in field soils, particularly in those previously fumigated. The lasting effect of previous-year fumigation caused initial reduction in *V. dahliae* in the pots, but it later matched or exceeded growth in non-fumigated soils. This effect of previous-year fumigation was also evident with *P. penetrans*, though with more variability than *V. dahliae*. Ongoing soil microbiome research will examine how fumigation impacts beneficial microbes and subsequent more rapid pathogen recolonization of previously fumigated soil. In 2023, field application of our qPCR tools revealed a correlation between reduced potato yields and soil concentrations of *V. dahliae*, but yields were not correlated with *P. penetrans*. Traditional measurements of nematode concentrations in the field samples from two independent labs were compared to our qPCR measurements. Traditional nematode counts and our qPCR measurements demonstrated a good correlation among all samples from our main study field, but varied across other fields. Other fields with high traditional counts showed low or zero *P. penetrans* DNA; subsequently, other nematodes of lesser or no known pathogenic threat to potato, notably *P. crenatus*, was found by DNA sequencing in fields where traditional counts and qPCR were not correlated. Also concerning, discrepancies in traditional nematode counts from independent labs were significant, to a degree that would likely prompt diverging management decisions. Especially for *P. penetrans* detection, and given the variability and broad species range of traditional methods, the specificity and consistency of qPCR present a strong case for its adoption. Furthermore, the multiplexing of *P. penetrans* and *V. dahliae* measurements simultaneously in a small soil sample offers a simple but comprehensive tool for measuring these PED pathogens in the field.

Preliminary Survey of Wireworms in Potato Fields Adopting Regenerative Agricultural Practices and Examination of Wireworm Life-stage Markers

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Wireworms, larvae of the click beetle (Coleoptera: Elateridae), are among the most serious and challenging pests to manage in agriculture, causing significant economic damage to a variety of high value crops. Wireworms are of particular concern in potato causing damage by creating small holes and tunnels in tubers, scarring the periderm. This reduces tuber yield, quality, and marketability, even at 10-15% damage. The subterranean distribution of wireworms makes detection and damage prediction challenging, and unlike above-ground pests that often immigrate to crops, wireworms may already be established in the soil at the time of planting. Larvae require several years to complete their development, where compounding generations may overwhelm a field. Modern agriculture is moving toward more sustainable farming approaches that improve crop quality and yields, reduce inputs with high carbon footprints, and improve farm biodiversity and farm resiliency in the face of climate change. These include regenerative agricultural approaches which aim to increase agricultural biodiversity by diversifying and increasing crop rotations and cover crops, improve soil health by reducing soil disruption and degradation through reducing or eliminating tilling, and reduce or alter the use of agrochemical inputs including fertilizers and pesticides. Movement away from traditional pest management practices can result in pest resurgence. It is thus imperative to monitor pest populations so proactive measures can be taken to prevent considerable crop damage. Furthermore, improved understanding of insect developmental stages and processes may help inform future pest management strategies. We present preliminary findings of our work focused on these two areas of wireworm study. We conducted a preliminary survey of click beetle/wireworm populations in regenerative potato fields at McCain's Farms of the Future in Florenceville-Bristol, NB. We sampled 12 field site locations, 5 of which were in rotation having recent potato crop the previous year (2022), 7 had potato this year (2023). Sampling methods included light trapping for adults, and bait traps and soil coring for larval stages. We expected to find click beetles from the prolific *Agriotes* genus. Interestingly, we instead found click beetles from the *Hypnoidus* genus which are found to be in NB, and prolific in Quebec and the Prairies and known pests of agricultural crops. Therefore, further examination and monitoring of click beetles in these fields is warranted. We also examined gene expression data generated from a transcriptome analysis of the most prolific wireworm species in the Maritimes, *Agriotes sputator*, to identify potential molecular signatures for early, middle, and late-stage larvae. We have identified 10 potential marker genes involved in developmental processes including those involved in lipid synthesis, cytoskeletal and nervous system development, moulting and stage transition processes, and reproductive development. These could serve as targets for future gene-driven methods of pest control.

Does Russeting and Silver Patch Affect Bacterial and Fungal Communities Associated with Potato Tuber?

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Blemishes on potato skins including russeting and silver patch are problematic for selling potato tubers for the fresh market. Abiotic and biotic factors increase the presence of blemishes and induce plant stress response that leads to changes in metabolic pathways resulting in changes in structural and chemical compounds in the cells of potato tubers. However, how the bacterial and fungal communities associated with russeting and silver patch blemishes are affected is not known. The objective of this study was to evaluate the diversity of bacterial and fungal communities of Dark Red Norland tubers with silver patch or russeting blemishes using amplicon-next-generation sequencing. Potato peels were collected from 1) tubers without blemishes (control), 2) tubers with russeting, 3) healthy areas of tubers with russeting, 4) tubers with silver patch and 5) healthy areas of tubers with silver patch in 2019 and 2020. Most bacterial and fungal phyla had a change in their relative abundance between 2019 and 2020. The β-diversity of bacterial and fungal communities was different between years suggesting that the differences in environmental conditions and length of storage could influence these communities. In general, the β-diversity of bacterial and fungal communities did not change among treatments in 2019 and 2020 except for a few differences among in fungal community diversity in 2020. The possibility that russeting and silver patch blemishes were caused by a biological factor was also evaluated by comparing operational taxonomic units (OTUs) present in blemishes to the healthy tuber (control). The criteria used to select the OTUs were 1) that the OTUs should be in high relative abundance in the blemishes, and 2) that the OTUs should be the same in 2019 and 2020. This approach was used with lesions of common scab and using these criteria, the most abundant OTUs were classified as *Streptomyces*. Most of the very abundant OTUs in russeting and silver patch were also found in the control however, one bacterial and fungal OTU met these criteria. This study demonstrated that it was possible to use next-generation sequencing to identify OTUs that are repeatedly found in high abundance in blemishes compared to healthy potatoes. However, further investigation is required to determine if these species are simply favored by the change in plant cell metabolite composition structure associated with the blemishes or if they are the cause of the blemishes.

A Model-Based Approach for Determining Potato Ecophysiological Nitrogen Requirements and Recommending Optimal Rates for Specific Soil and Climate Conditions

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Identifying the optimum rate of nitrogen fertilizer is crucial for sustainable production, especially for high nitrogen-demanding crops like potatoes. However, determining this rate is challenging due to its dependency on climate variations and soil types. Furthermore, the predominant focus on maximizing profitability in optimum N identification, without considering adverse environmental consequences, poses a barrier to sustainability. In this study, we propose a novel model-based approach, termed Nitrogen Ecophysiologically Modelled Optimum (NEMO), to recommend environmentally friendly nitrogen rates for specific agroclimatic regions and soil types for potato cultivation. In this approach, we utilize the process-based crop model, STICS (Simulateur mulTIdisciplinaire pour les Cultures Standard), calibrated for potato crops in Canada. Through simulations employing small N increments, we construct yield-to-N-rate response curves using historical climate data from four agroclimatic regions across Prince Edward Island (PEI), focusing on predominant soils. Subsequently, using the simulated yields, we identify the optimum nitrogen use efficiency by analyzing the tradeoff curve between profitability and environmental benefits, leading to the determination of the optimum N rate. To facilitate the utilization of this method by users, we developed a user-friendly web tool. This tool enables users to select their region of interest, soil type, and targeted yield, providing insights into the likelihood of achieving such yields, the recommended rate for optimal yield attainment, and associated environmental benefits. Overall, our findings suggest that utilizing nitrogen rates lower than currently recommended can be advantageous for potato production. Not only does a lower rate result in cost savings associated with nitrogen fertilizer application, but it also yields environmental benefits with minimal compromise in yield.

Crop Disease Modelling Using Machine Learning and Artificial Intelligence

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Agriculture plays an important role not only for human survival but also for the economic prosperity of nations. In recent years, the agricultural sector has emerged as the primary contributor to national income, globally. Pests and diseases, liable for 20-40% of crop losses, pose a substantial risk to worldwide agriculture, compounded by the unpredictable nature of climatic changes, introducing pathogens, viruses, and illnesses. Recognizing food as an elemental human need, ensuring food security is indispensable. For developed countries like Canada, besides food availability, the major concern is a healthy lifestyle because intake of the foods incorporated by diseases can result in various health problems. Despite the challenges confronted by all 10 Canadian Provinces in potato production, Prince Edward Island (PEI) stands as a formidable leader. Divided into 3 counties— Prince, Queens, and Kings— PEI's essential enterprise revolves around agriculture, with potatoes reigning as its single biggest agricultural commodity. Early ailment detection in crops is crucial for ensuring the long-term sustainability of agriculture and mitigating the economic effects of diseases. This examination specifically targets 4 potato crop diseases— Late Blight, Early Blight, Stem Rot, and Gray Mold in PEI, the usage of climatic variables recorded from weather stations, and historical disease occurrences across PEI's counties. Furthermore, the study also centralizes on providing the severity index for the predicted diseases. The study focuses on leveraging advanced technology which includes Artificial Intelligence (AI), Machine Learning (ML), and Computer Vision, in predicting crop diseases. In Crop manufacturing, those traits have opened the door for promising solutions. The proposed study not only does early identity of crop diseases but also warns the farmers to take preventive measures if their crops are liable to sickness on the behalf of climatic modifications, and reduce the use of agrochemicals, pesticides, fertilizers, and excessive watering via increasing profits, ensuring food security, healthy way of life, reasonably priced food fees. This early detection of crops results in agricultural sustainability by strengthening economic, environmental, and social pillars.

Quantifying and Predicting Carbon Dioxide Emissions Using Advanced Modeling Techniques for Sustainable Potato Production in Prince Edward Island, Canada

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Applying machine learning (ML) in predicting complex environmental phenomena has attracted the attention of researchers globally. In this study, the potential of three novel ML-based algorithms of additive regression-random forest (AR-RF), iterative classifier optimizer (ICO-AR-RF), and multi-scheme (MS-RF) were explored for carbon dioxide (CO2) flux rate prediction from two agricultural fields in Prince Edward Island (PEI) Canada. To build the dataset, 401 samples were collected from two fields in PEI. In addition, soil moisture (SM), temperature (ST), and electrical conductivity (EC), alongside eight climatic variables including wind speed (WS), solar radiation (SR), relative humidity (RH), precipitation (P), air temperature (AT), dew point (DP), vapor pressure difference (VPD) and reference evapotranspiration (ET0) were also collected. Greedy stepwise (GS) and correlation coefficient approaches were implemented for feature selection. Finally, different qualitative (scatter plot, line graph, Taylor diagram, box plot, and Rug plot), and quantitative (uncertainty analysis, root mean square error (RMSE), percent of BIAS (PBIAS), Nash Sutcliff efficiency (NSE) and RMSE-observations standard deviation ratio (RSR)) techniques were used for model evaluation and comparison. Results of feature selection approaches revealed that DP, AT, SM, and ST are the four most effective variables at CO2 prediction in PEI. For optimum input scenario, the GS algorithm was applied, and results showed that a combination of DP, AT, ST, SM, and ET0 was the best for the PEI study area. Our analysis, for prediction of CO2 fluxes, confirmed that the ICO-AR-RF model performed the best at PEI (RMSE=0.70, NSE=0.76, PBIAS=-5.11, RSR=0.48) followed by MS-RF and AR-RF. Uncertainty analysis showed that CO2 prediction is more sensitive to input scenario selection than models in both study areas. Results revealed that climatic variables are more effective in CO2 prediction than soil characteristics. The study will be valuable for greenhouse gas mitigation in PEI and beyond. Furthermore, it will help Canada's goal of reaching carbon net-zero targets in 2050.

Forecasting Of SPEI (Standardized Precipitation Evapotranspiration Index) Meteorological Drought Over Atlantic Canada Using Machine Learning Algorithms

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The implications of current global warming are concerning because they may cause drought events, which can have devastating effects on the world economy, society, agriculture, and the environment. Although many of the southern regions of the Canadian prairies and interior British Columbia have been more susceptible to drought, some occurrences have been recorded in the last two centuries in Atlantic Canadian provinces. This study aims to describe the temporal characteristics of meteorological drought features in the Atlantic Canadian region, apply different artificial intelligence models to forecast the Standardized Precipitation Evapotranspiration Index (S.P.E.I.) – a type of drought index – some months ahead and compare their accuracies towards determining best models that could be applied in irrigation scheduling. Daily precipitation and temperature data have been collected from five (5) regional synoptic weather stations. SPEI time series has been plotted to assess and describe the temporal characteristics of drought which include duration (D), severity (S), and intensity (I). From the results so far, there was an increase in the duration of drought events for SPEI time scales of 3-month, 6-month, and 12-months recorded in Charlottetown, St John's, and Yarmouth stations. More intense drought events occurred in the 6-month time scale (-1.26 to -1.41) for all but the station at Fredericton. Moreover, the historical data showed an increase in severity from the 3-month to the 12-month SPEI time scales, for all the stations.

Genome-wide association studies revealed diploid potatoes with climate-resilient traits

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Crops adaptation and production to current agroclimatic conditions is becoming a challenge in the context of climate change. We have recently conducted a genome-wide association study using a panel of 384 diploid potato germplasm to dissect and uncover the genetic architecture for maturity and drought tolerance traits. We identified genomic regions and genes associated with the traits and detected potato clones that are early or late maturing while being tolerant to drought. The data suggest that some of the clones herein identified can be used as climate adaptation solutions for short and long season growing areas.

Case study: Fresh tablestock intercepted in CFIA regulatory action

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Numerous fungi, viruses, nematodes and bacteria can infect potato plants and tubers, and cause various diseases, many of which are regulated for protecting potato production in the EPPO and NAPPO countries. In Canada, the CFIA is responsible for the Potato Post-Entry Quarantine (PPEQ) Program, which guarantees the supply of seed of high varietal integrity and free of potato diseases. Prior approval is required to import field-grown seed potatoes and fresh potatoes from areas other than the continental US. Field-grown seed potato tubers can only be imported through PPEQ.

In this presentation, we revisit a specific case where in 2015, CFIA intercepted the illegal import of fresh table stock potatoes originating from Bangladesh in three retail locations in Toronto. The shipments were seized for quarantine disposal and samples were analyzed for the presence of soil and potato diseases for research purposes including Potato Cyst Nematodes (PCN) (*Globodera rosrochiensis* and *Golbodera pallida*), Bacterial Ring Rot (*Clavibacter sepedonicus*), Blackleg (Erwinia spp.), Brown Rot (*Ralstonia solanacearum* race 3 biovar 2), and common potato viruses X (PVX), Y (PVY), S (PVS), A (PVA) and Leafroll (PLRV). Sub samples were also provided to the PPEQ program for grow-out and testing for additional common and exotic potato viruses M (PVM), V (PVV), Potato latent virus (PotLV) and potato mop-top virus (PMTV). Diagnostic testing using PCR, qPCR and reverse transciptase (RT-)PCR analyses confirmed the presence of potato viruses PVS, PVX, PLRV and PVYO, PVYNTN and the presence of *R. solanacearum* race 3 biovar 2 (R3Bv2). *R. solanacearum* R3Bv2 was detected using real time PCR specific to Race 3 Biovar 2 of *R. solanacearum* and further confirmed using immunostrip testing and bacterial isolation of colonies that were confirmed as *R. solanacearum* Phylotype II and race 3 biovar 2 using multiplex PCR assays, multiple real-time PCR assays, and biotyping. Next genearation sequencing analysis was conducted and a number of viruses including PAMV, PVS, PVX, PotLV, PVM, PLRV, PVYO, NTN were revealed using NGS with in-house bioinformatics toolkits. The NGS results were validated and supported by bioassay, conventional and real-time RT-PCR and some other diagnostic methods (e.g. ELISA, RFLP). Other potato pests were also revealed by NGS including viruses (Tomato chlorosis virus and Pepino mosaic virus) and phytoplasmas with PCR and Sanger sequencing confirmation. NGS followed by validation provides a rapid strategy (~5 weeks) that can significantly reduce the time required for general PPEQ program (55 weeks).

Preliminary analysis of potato wart genomic datasets

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The unculturable obligate fungus *Synchytrium endobioticum* is the causal agent of potato wart disease. It is one of the most important quarantine pathogens that can cause significant economic losses on cultivated potatoes. *S. endobioticum* produces resting spores that endure harsh environmental stresses and can remain viable in soil for decades. Currentlly, more than 40 pathotypes have been identified mainly based on the resistant phenotyping profiles on selected potato varieties, and Pathotypes 1, 2, 6, 8, and 18 are relatively defined for their resistant phenotypes (van de Vossenberg et al 2022). However, the pathotyping of *S. endobioticum* can only be determined by bioassay, and is still very challenging to associate with the numerous pathotypes using the genomic data, and a recent study on whole genome amplification (Nguyen et al. 2024) provided a leap forward to a final solution.

Because the pathogen is unculturable and its resting spores are not prevalent or dominant in soil or plants, it is challenging to recover the complete genome of *S. endobioticum*. The current reference sequence of *S. endobioticum* was assembled from meta-omics datasets from resting spores after eliminating potato and bacterial genomics sequences and enriching chytrid-like sequences based on bioinformatics inference. Analyzing meta-omics data always incorporates various levels of complexity regarding metagenomic composition and complicated biodiversity, and it is hard to recover a complete genome. Due to those limitations, the reference sequence of *S. endobioticum* (GCA_006535955.1) is still fragmented, containing 786 scaffolds (genomic fragments), even though the sequencing depth reaches 229.0x.

The complete mitochondrial genome of *S. endobioticum* was assembled to a 72,775 bp linear consensus sequence from multiple *S. endobioticum* isolates using both Illumina and PacBio sequencers. The mitochondrial genome was used as a reference to construct a phylogenetic tree based on 172 sequence samples (van de Vossenberg et al. 2023). A total of 166 samples were clustered in one of six haplogroups based on the intron-excluded mitochondrial genome, however, the haplogroup system is not a perfect reflection of the phenotype-based pathotypes system for intraspecies classification. Mitogenomic variation is not a measure of nuclear genome diversity, but it still indicates a similar trend for the nuclear genome. We believe that enhanced deep sequencing and genome assemblies will facilitate the identification of pathotype-specific SNPs or other pathotype-specific variants and provide solid evidence and knowledge of the pathogenicity of *S. endobioticum* to different potato varieties.

Influential Factors For Estimating Pan Coefficient Using Machine Learning And Deep Learning Models

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Estimating crop water requirements is important for sustainable soil and water productivity. There are different approaches to measuring the crop water requirement such as lysimeter, soil moisture sensor, time domain reflectometer (TDR), and Penmann-Monteith equation by using the climatic parameters. The current study focuses on calculating the reference evapotranspiration using the Pan Evaporation method. Pan evaporation (Ep) is one of the acceptable methods for estimating reference evapotranspiration (ETo) due to its convenience and without meteorological parameters data. Accuracy of estimating the pan coefficient (Kp) becomes vital since it applies to converting the Ep value to the ETo value. To date, many Kp equations have been proposed to estimate the Kp value. In this study, the performance of the five Kpan models was compared with four machine learning methods, namely Gaussian processes, AMT, IBK, and Random Forest, and two deep learning methods, namely LSTM and simple RNN for the estimation of Kp under environmental conditions given by FAO-24 Kp table for Class A pan under dry fetch condition surrounding by more than 50 m greet green crop (Case B). ETo values estimated by Kpan models were compared against those obtained by the FAO-56 PM equation. The proposed models have evaluated their performance with various statistical indexes and then compared them to the previous existing equations and other models. It is found that observed reference evapotranspiration using the pan evaporation method satisfies the results calculated from deep learning and machine learning methods as well as empirical models. Developing an efficient approach for site-specific crop water requirements is the first step towards developing a real-time irrigation management information system for real-time irrigation scheduling and sustainable soil and water productivity.

AgriScout: An Autonomous Robotic System for Detecting and Classifying Healthy and PVY Virus-Infected Potato Plants

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In precision agriculture, the early detection and classification of plant diseases remain pivotal for ensuring crop health and yield optimization. This study introduces an innovative approach to managing Potato Virus Y (PVY) infection in potato crops through the deployment of an autonomous electric robot. This robot, equipped with advanced RGB cameras, navigates through potato fields capturing high-resolution images of the plants at various growth stages. The study involved planting both PVY-infected and healthy potato plants across 35 distinct plots, each housing 200 plants with varying infection rates up to 30%, ensuring a comprehensive dataset by isolating each plot to prevent cross-contamination. Utilizing the precise coordinates of each plant, we meticulously labelled the captured images as either healthy or infected, creating a robust dataset for model training. The heart of this system lies in its utilization of the ResNet 50 Convolutional Neural Network (CNN) model, renowned for its deep learning capabilities and efficiency in image classification tasks. The model was trained on this meticulously curated dataset, demonstrating a remarkable classification accuracy of 85%. This high level of accuracy not only underscores the model's effectiveness in distinguishing between healthy and PVY-infected plants but also highlights its potential for large-scale implementation in real-world agricultural settings. With more training data we can further improve the accuracy of our classification algorithm. The "AgriScout" system represents a significant leap forward in agricultural technology, offering a scalable and efficient solution for monitoring plant health and disease management. Its autonomous nature reduces the need for manual labor, allowing for continuous monitoring and early disease detection, which is crucial for mitigating the spread of PVY and ensuring the health of potato crops. Furthermore, this system exemplifies the potential of integrating robotics and deep learning in agriculture, paving the way for more advanced disease detection methods and reinforcing the importance of precision agriculture in modern farming practices. By leveraging state-of-the-art technology, "AgriScout" not only enhances the accuracy and efficiency of plant disease management but also contributes to the sustainability and productivity of agricultural operations. This study's findings have significant implications for the future of crop monitoring and disease management, offering a promising solution to one of the most pressing challenges in agriculture today.

Optimizing Crop Soil Moisture Estimation: A Fusion of Satellite Thermal Infrared Bands and Vegetation Indices using Google Earth Engine

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Soil moisture and vegetation water content are essential to maintain and uphold the equilibrium of the natural environment and hydrological and agricultural processes. This parameter's spatial and temporal variation is imperative, as it plays a significant role in drought monitoring and understanding climate change. Prince Edward Island (PEI) is the dominant potato-producing province of Atlantic Canada, facing irregular precipitation patterns that stress crop water supplies. This study aims to estimate field-scale soil moisture using satellite-based reflective and thermal infrared bands. Some of the indicators used in this study are land surface temperature (LST), normalized difference vegetation index (NDVI), normalized difference water index (NDWI) and normalized difference moisture index (NDMI) were retrieved from Landsat 8 for two crop seasons (2021 and 2022). NDVI and LST was used to calculate soil moisture index (SMI) which represent the real time soil moisture at field scale. The thermal data gives significant results to predict soil moisture. The study found a weak negative correlation between NDVI and LST in both 2021 (R^2 = 0.25) and 2022 (R^2 = 0.38). As the LST increases, the vegetative cover reduces due to the record of high temperatures in the study area. Second, a significant ($p < 0.05$) negative correlation existed between SMI and LST (R^2 = 0.74 in 2021 and R^2 = 0.82 in 2022), which indicates that the surface soil moisture reduces with LST. The NDMI value ranges from 0.02 to 0.21 in 2021 and 0.1 to 0.26 in 2022. In 2021 and 2022, the NDWI ranges from -0.28 to -0.42 and -0.3 to -0.45, respectively. Therefore, the current study gives a clear understanding of considerable variations in soil moisture and vegetation water content in the PEI during the study period and can be useful as a good indicator for irrigation control.

Assessing Soil Organic Carbon Using Soil Color Captured With Mobile Phones

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Soil Organic Carbon (SOC) is essential for agricultural productivity, providing vital plant nutrients, enhancing soil structure, and mitigating erosion. In the region like New Brunswick, characterized by rocky, shallow soils and declining SOC levels, frequent assessment and monitor of SOC levels are crucial. However, current assessments of SOC levels heavily relying on lab analyses and difficult for farmers to use. Thus, an easy-to-use method for assessing SOC levels is necessary. Soil color is often considered indicative of SOC, making color measurements a valuable proxy for estimating SOC levels. Our goal is to establish a simple method to estimate SOC levels using soil color. We aimed to establish an approach by extracting color information from mobile phone images of soil samples and correlating color parameters to SOC measurements. To achieve this objective, the experiment comprised three steps:

The first step was to establish the relationship between color parameters of soil samples to their SOC levels. We used soil colors measured with a FieldSpec4, an industry-standard soil color measurement device, on air-dried ground soil samples with known SOC content from various NB sites. Considering factors like soil moisture, particle size, and surface roughness, we compared different conditions: dry versus wet soil, soil samples passing through 2 mm versus 63 µm sieves, rough surfaces with pressed smooth surface. Munsell value (color lightness) is known to be strongly affected by SOC level so correlation analysis were conducted between the obtained Munsell values and the known SOC contents. Results indicated a significant correlation between soil color and SOC in most cases. Notably, the highest R^2 value, reaching 0.9, was observed under the conditions of dry, 2 mm sieved, and a smooth surface, suggesting that soil color measured by the FieldSpec4 accurately estimated soil carbon content under these specific conditions.

The second step was to validate the color parameters extracted from mobile phone images with a true color measurement (FieldSpec4). This was done by using a commercial color plate with 24 colors as the reference. Each color square in the color plate was measured with the FieldSpec4 and mobile phone, respectively. The color values obtained from both methods were compared. The results show a strong correlation with a Pearson correlation coefficient of 0.95 between these two methods.

The last step was to test if SOC content can be successfully predicted using mobile phone images directly. This was tested by taking images of soil samples under dry, 2 mm sieved, and a smooth surface conditions. The soil sample was placed together with the color plate and mobile phone images were taken. The soil color were corrected using the color plate. The corrected soil color value were correlated with known SOC content. The results show that the R^2 for the relationship between SOC content and soil color value was 0.8, which was slightly lower than that obtained for the FieldSpec4. Despite this, the results suggested that mobile phone images hold promise as a convenient tool for farmers to capture soil color, ultimately facilitating the prediction of SOC levels.

Satellite-Derived Bare Soil Mapping in Prince Edward Island – A Potential Tool for Site Specific Field Management

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Site specific management of inputs such as seed, water, herbicides, and fertilizer has the potential to increase farmer profitability and mitigate environmental impacts in the potato industry. To properly manage these inputs, we need to understand within-field variability by collecting, analysing, and manipulating spatial information. Variable rate (VR) application of soil-applied inputs rely on understanding chemical and physical characteristics of the soil. Existing provincial soil surveys do not provide enough detail for site-specific management of inputs. Manual soil sampling is too time consuming and expensive to produce accurate maps of chemical and physical soil properties throughout a field. Grid soil sampling methods have been used extensively as a base for VR applications of lime and potash in Prince Edward Island (P.E.I.) in the past, with samples typically taken on a one-hectare grid. This process relies on interpolation between sampling points to estimate soil characteristics and does not account for water-based variability driven by differences in topography and soil texture. Electrical conductivity (EC) mapping is suitable for understanding soil texture differences within a field, but it is expensive to collect and is susceptible to interference in low EC sandy soils that are prominent in P.E.I. This project focuses on exploring the relationships between near infrared (NIR) bare soil satellite imagery and several physical soil parameters, such as organic matter, aggregate stability, available water content and more. Remotely sensed (RS) satellite imagery is freely available, and we have suitable imagery dating back to 2017 from Sentinel-2 satellites. In this project we have combined multiple years of early-season (April-June) bare soil imagery into composites for six fields in P.E.I. Each field was divided into three zones based on soil colour: dark, medium, and light. Each zone was soil sampled in spring 2023 in eight locations (24 samples per field) and analysed with the soil health package at P.E.I. Analytical Laboratories. Early results indicate that bare soil imagery can be used to understand differences in soil-water holding capacity, organic matter, and could be a substitute for EC mapping in P.E.I. and other potato growing areas. Bare soil imagery can be used in the development of management zones (MZs) for site specific management of fertilizer, seed, water and more. Optimizing nutrient allocation within the field will increase farmer profitability and prevent over-application.

Investigating Soil Compaction in Potato Fields Using Advanced Technologies

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Soil compaction poses a significant challenge in potato fields across Prince Edward Island. It often goes unnoticed, and due to its complex nature, it can be difficult for farmers to detect and eliminate. With the increasing size and weight of agricultural machinery, repeated movement and tillage practices contribute to a decline in soil quality and accelerate the formation of hardpan layers in the soil. These hardpans restrict root penetration and growth, causing reduced water and nutrient uptake in crops while causing other issues to form, such as waterlogging, runoff, and erosion, all of which impact crop yield. The objective of this research is to explore the relationship between soil compaction in the top 30 cm of the soil surface and the apparent electrical conductivity (ECa) of the soil using electromagnetic induction (EMI) technology. Extensive surveys were conducted over two potato fields using the EMI instruments DUALEM-II and SWATBOX. The compaction levels were assessed by collecting soil samples, bulk density measurements, penetrometer readings, and time domain reflectometry (TDR) readings at two specific depths: 0-15 cm and 15-30 cm. All collected data was georeferenced using global positioning system (GPS) technology to accurately estimate the extent of compacted zones. The ECa data obtained from the surveys underwent analysis using modelling software to assess the variation and depth of ECa at the two specified depths. This can provide valuable insight to farmers, enabling them to target specific areas and depths of compaction, reducing the overall disturbance and degradation of soil. Ultimately, this can help farmers conduct sustainable farming practices by enhancing soil health, reducing costs and emissions, and increasing crop production.

Variation in the Efficacy of Commonly Used and Novel Fungicides for the Control of the Late Blight Pathogen *Phytophthora infestans* in Canada

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Phytophthora infestans is the most economically important pathogen of potato and tomato worldwide. Preventative fungicide spraying remains the most effective management option for controlling late blight caused by *P. infestans*. Worldwide, plant protection products against late blight are costing producers several billions of dollars annually. Increased disease incidence and severity have coincided with changes in pathogen composition in Canada and elsewhere, resulting in new genotypes with distinct characteristics, including differences in their sensitivity to commonly used fungicides. This study determined the sensitivity of *P. infestans* US23 and US8 genotypes against eight oomycete-based fungicides with different modes of action and diverse active ingredients using *in vitro* (agar plate and spore germination) assays. We observed increased insensitivity of US8 to fluazinam, chlorothalonil, fenamidone, and metalaxyl *in vitro* with IC50 values ranging between 7 and 71 µg/ml. Other tested fungicides were highly effective in inhibiting US8 mycelia growth and spore germination. The US23 genotype was generally sensitive with IC50 values ranging between 0.009 and 6.5 µg/ml to the tested fungicides except for chlorothalonil. The findings from this study further emphasize the need for continued monitoring of *P. infestans* sensitivity to commonly used fungicides in Canada. Resistance to these fungicides might limit late blight management options and further complicate disease control.

Transcriptome and Gene Expression Analyses of Different Developmental Stages of Wireworm (*A. sputator*)

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Wireworms are one of the most damaging pests in agricultural crops worldwide. It is soil-dwelling larvae of the click beetles, which belong to the genus *Agriotes* and they can cause significant economic losses in a wide range of agricultural crops, including potatoes, wheat, barley, corn and strawberries. Prince Edward Island, the largest potato-producing province in Canada, incurs annual product damage expenses of more than $5 million due to wireworm. *Agriotes sputator* species is a predominant and destructive pest in Eastern Canada. Current control strategies include the uses of pesticides (such as the most currently used broflanilide) and alternative cover crops. However, reliance on pesticides can lead to resistance development, and they also pose a potential threat to the environment. Additionally, the effect of cover crops is not consistent. To date, high-quality transcriptome information for wireworm larvae of *A. sputator* is not publicly available, which limits the study of its biology and pest control methods. This study reported the first transcriptomic study of *A. sputator*. In this study, five different developmental stages, three instar larvae and adult male and female, were used for RNA sequencing. In total, 714.6 million pairs of 100 bp paired-end raw reads were generated using Illumina NovaSeq6000. After removing low-quality reads, a draft transcriptome was *de novo* assembled from 676.6 million clean reads combined from all life stages. A total of 564,561 contigs were generated and successfully annotated using NCBI-BLASTx against the non-redundant database. Differential gene expression analysis was also performed across the evaluated developmental stages, and a total of 19,132 differentially expressed genes (absolute log2 fold change > 2, padj < 0.05) were found. Gene ontology and KEGG pathway analysis revealed that a large number of genes are linked to crucial growth and development, signalling pathways, cellular mechanisms, drug metabolism (cytochrome p450) pathways, transcription factors and metabolic processes. These findings will facilitate future molecular studies aimed at understanding the biology of wireworms and related insects. This study will also help researchers and industry to develop novel pest control strategies such as RNAi or genome editing-based next-generation resistant crops.

Effect of Sugar Kelp (*Saccharina Latissima*) on Potato (*Solanum Tuberosum*) Yield, Soil Health, and Greenhouse Gas Emissions

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Efficient bioresource management of agricultural fields can alter soil biochemistry and physical properties, reducing greenhouse gas (GHG) emissions. This study aims to evaluate the role of organic amendment including sugar kelp (SK) and its combination with inorganic fertilizer (IF) in reducing GHG emissions and increasing crop productivity. Four soil amendments including SK, IF, SK + IF, and control (C) will be replicated four times under a randomized block design during the growing season of potatoes in Prince Edward Island (PEI), Canada. A LI-COR trace gas analyzer and LI-COR Portable Photosynthesis systems will be used to monitor emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from treatment plots and to monitor GHG exchange between plant leaves and the environment. Analysis of variance (ANOVA) results will depict which treatment plots have higher soil moisture-holding capacities which will be measured by Li-Cor Portable Photosynthesis system. Soil moisture will also be impacted by soil temperature and rainfall events. HOBO weather station will also be installed at the sampling site for the local and accurate measurement of the average temperature of the GHGs and harvesting events. ANOVA results will be used to understand the effect of each treatment and environmental factors on resulting GHG emissions and potato crop productivity.

Water and Tillage Erosion under Conventional and Conservation Tillage

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Tillage is often a necessary field operations for various purposes. However, tillage disturbs soil, leading to both water and soil erosion and degradation of many soil properties. In the New Brunswick Living Lab (LLNB) project, experiments were designed to quantify the differences between conventional and conservation tillage. Field site of this study was located near Riverview, NB. Conventional tillage (Mouldboard Plough – MP) was conducted along a strip in the middle of the field while the rest of the field was under conservation tillage (Chisel Plough – CP). Tillage translocation was measures by burying point tracers at two depths (5 cm and 15 cm) and tracking their movements. Drone images were taken a few days after tillage. The photos were processed for color detection to calculate Surface Coverage Ratio (SCR) and were analyzed using photogrammetry to generate a Digital Elevation Model (DEM). Elevations were extracted from transects, based on which Surface Roughness Index (SRI) was determined.
The experimental results show that conventional tillage (MP) moved tracers at both depths much further than conservation tillage (CP). Comparing the two depths, no difference was observed for MP but for CP, 5 cm tracers moved more than 3 times than the 15 cm tracers. Translocations for MP was significantly correlated with slope gradient but correlation between CP translocation and slope gradient was not significant. For slope curvature, only correlation for the 5 cm of MP was significant. Surface coverage and roughness were visually different for the two tillage methods. Based on the image analysis, SCR for CP was significantly greater than that for MP. However, the value was very low (30% is expected for conservation tillage). SRI for MP was greater than that for CP, but the difference was not significant. Overall, conservation tillage was found to have lower risk for tillage erosion due to the lower overall soil movement as well as its non-significant response to topography. It also had lower water erosion due to better soil coverage.

Fall Greenhouse Gas Emissions in Relation to Cover Crops and Soil Health

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Climate change is a global crisis brought on by rising global temperatures, which in turn is caused by human activities that increase greenhouse gas (GHG) concentrations in Earth's atmosphere. Reducing GHG emissions is critical in mitigating the effects of climate change. Therefore, as more PEI potato producers are adopting the practice of fall cover cropping, it will be beneficial to study how planting cover crops in the fall impact GHG emissions. This poster will cover the 1st year results of a 2-year project measuring soil GHG emissions (carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4)) of 2 fields. Emissions will be measured from the fall of 2023 to December of 2024 with both fields growing potatoes in the summer. In the fall, both fields are separated into 2 sections: a section planted with cover crops and a section that is not. In addition to GHG measurements, the following data are collected: drone images, weather data, percent plant cover, and soil samples (for nutrient content, bulk density, and nitrate leaching). Samples and measurements are taken based on management zones that are mapped using SWAT technology. The 1st year data has yet to be statistically analysed, but average emission fluxes showed the following patterns: N_2O and CO_2 fluxes were higher in cover cropped areas in both fields, and CH_4 showed similar patterns in one field but showed no pattern in the other. Results from this project will provide data to enhance models predicting GHG emissions in agricultural fields and provide local decision makers a better understanding of how cover crops may impact carbon crediting on farms.

Effects of Shrub Willow Chips on Microbial Communities under Potato Cropping Systems

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Incorporating shrub willow chips into soil could enhance the properties of light-textured soils with low organic matter. However, the impact of willow chips on soil microbial communities is not known. We evaluated the effects of shrub willow chips applied at increasing rates (0, 20, 40, and 60 Mgha^{-1}, fresh weight) on soil bacterial community dynamics over time. Sampling times were in the fall (November 2019) and monthly during the following growing season (May, June, July, August, and September 2020). Illumina sequencing of the 16S rRNA gene was used to analyze bacterial community diversity, composition, and potential functionality related to carbon, nitrogen and phosphorus cycling. Our results did not show a significant effect of willow chip application rate on bacterial alpha diversity, but sampling time significantly affected Chao-1 and Shannon indices with higher values observed in fall 2019 than during the following growing season, 2020. For beta diversity, there were no clear distinct groups between both willow chip rates and sampling times. *Proteobacteria* was the predominant bacterial phylum, and willow chips applied at high rates (40 and 60 Mg ha^{-1}) increased the relative abundance of copiotrophic groups, namely *Proteobacteria* and *Bacteroidota*, while decreasing the relative abundance of oligotrophic groups, such as *Chloroflexi.* Copiotrophic bacterial taxa showed declining temporal trends in their relative abundance, whereas oligotrophic taxa showed increasing temporal trends. Predicted bacterial functionality indicated a higher relative abundance of molecular markers *(*EC/KO terms*)* related to *Calvin cycle*, *methanogenesis, pectin degradation, nitrogen fixation, denitrification* and *phosphorus mineralization* when willow chips were added at rates of 40 and 60 Mg ha^{-1} than in the control and at a rate of 20 Mg ha^{-1}, whereas the relative abundance of *cellulose degradation* and *nitrification* molecular markers showed the opposite trend. Overall, these results indicated significant effects of willow chip application and sampling time on the soil bacterial communities under intensive potato production systems. Bacterial responses to willow chip addition were closely associated with willow chip quality as well as changes in soil properties and nutrient availability.