Wednesday, 29th May 2024

(Abstracts)

Plants, pathogens and how it all works

Dr. Robin Cameron

This talk is aimed at non-experts to provide a brief introduction to plant immune responses and how pathogens manipulate plants to obtain nutrients and multiply in leaves, including the impact of the environment. The differences between plant and animal immunity will also be touched on. Finally, I will discuss the applied side of the research in my lab, where we investigate the immune-stimulating activity of treating plants with industrial formulations, to protect plants from viral infection

Sequence-based Analysis of Controlled Environment Agriculture

Dr. Trevor Charles

Controlled Environment Agriculture (CEA), particularly hydroponic fertigation systems, faces challenges with pathogen spread and outbreaks, and suboptimal microbial communities. The Healthy Hydroponics Project aims to enhance crop production by providing pathogen surveillance, with the goal of reducing disease outbreaks and optimizing microbial communities, with many potential benefits. To this end, we employ sequence-based analysis, specifically amplicon sequencing, to determine microbial community composition. The analysis identifies key bacteria that are present in the hydroponic system highlighting that the hydroponic microbiome is quite distinct from the soil microbiome. The goal is to develop a proactive approach to pathogen management, leveraging next-generation inoculants composed of multiple strains to improve hydroponic crop health and productivity to detect Fungi such as Olpidium and/or various bacterial lineages.

Pathogen Detection in Plants: Current and Emerging Sensing Techniques

Dr. Hans Rediers

Plant pathogenic microorganisms cause substantial yield losses in several economically important crops, resulting in economic and social adversity. Therefore, the early detection and identification of pathogens is extremely important to reduce the associated agricultural losses. In this presentation, techniques that are currently available to detect plant pathogens are discussed, including culture-based, PCR-based, sequencing-based, and immunology-based techniques. Their working principles are briefly explained, as well as the main advantages and disadvantages, and examples of their use in plant pathogen detection.

There's something in the water – filtering and disinfecting recirculated irrigation in controlled environment agriculture.

Dr. Fadi Al-Daoud

Controlled environment agriculture (CEA), including greenhouses, warehouses, and vertical farms, consumes a fraction of the water that field agriculture uses. One reason for this is the emergence of technologies that allow these production systems to recirculate their irrigation. However, recirculating irrigation without proper filtration and disinfection systems leads to the accumulation of microbes that may be harmful to crops. This presentation will introduce you to some of the filtration and disinfection systems used to treat recirculated irrigation in Ontario's commercial CEA facilities.

Finding the Needle in the Haystack: Disease Diagnostics in Greenhouse Food Crops

Cara McCreary

Greenhouse crops are threatened by many different crop pests each year. Greenhouse Integrated Pest Management (IPM) programs focus on maintaining pest levels below economically harmful thresholds using multiple strategies, emphasizing cost-effectiveness and environmental safety. Intensive monitoring programs, are essential for early detection of pests. Pathogen detection employs both proactive and reactive approaches. Proactive methods involve frequent, random sampling before symptoms appear, while reactive methods wait for symptom manifestation. Immediate testing of samples is crucial to avoid degradation and prompt reporting of results allow timely implementation of management tactics. One of our studies explored which surfaces in a greenhouse are likely to be contaminated with a stable and mechanically transmitted virus, tomato brown rugose fruit virus (ToBRFV). This study suggests that surfaces where employees frequently touch (such as door handles, forklift steering wheels and picking crate handles) should be cleaned regularly throughout production to minimize introduction and spread. Despite intensive scouting programs, due to emerging pathogens and limitations of diagnostic tools, early detection and accurate causal agent identification is not always possible. For example, proactive methods of detection for specific pathogens like *Fusarium oxysporum*, a ubiquitous fungus that can be pathogenic or nonpathogenic, as well as having crop-specific forms, have proven ineffective due to the inability to distinguish all forms with current diagnostic tools.

Developing Superior Pathogen-Resistant High-Yield Cultivars

Dr. Eskandari

To meet the food demands of a projected global population exceeding 9 billion by 2050, it is imperative to increase food production, primarily through crop cultivation, while simultaneously reducing the use of inputs like fertilizers and pesticides, which negatively impact the climate and accelerate global warming. Currently, over 30% of major crop productions is lost due to pests and diseases. Implementing pest- and disease-resistant crops stands out as the most effective and sustainable strategy to mitigate these losses from biotic stresses.

Developing high-yielding crop cultivars that are resistant to pathogens is essential for achieving food security. In this presentation, we will explore the critical role of crop breeding, with a focus on soybean as a case study, in enhancing sustainable food production. We will also discuss how advancements in technology can streamline the breeding process, making it more efficient and effective. By integrating these innovative approaches, we aim to showcase how the development of superior pathogen-resistant, high-yield cultivars can contribute to sustainable food security in the face of growing global challenges.

AI-based Sensing-Data Analytics

Dr. Farzad Khalvati,

This study investigates the use of machine learning (ML), particularly Artificial Neural Networks (ANNs) and Convolutional Neural Networks (CNNs) for analyzing complex biological data such as Surface-Enhanced Raman Spectroscopy (SERS) spectra.

We discuss traditional hypothesis-driven research and how using ML enables us to move away from a single hypothesis towards exploring a space of hypotheses where the goal evolves from proving or disproving a single hypothesis to discovering the best possible hypothesis namely the optimally trained ML model.

While traditional ML algorithms such as Random Forest (RF) usually require a feature selection applied such as Principal Component Analysis (PCA) or ANOVA to be applied to input data to reduce the feature space dimensionality, ANNs are capable of taking in all features and through training, optimizing their weights for optimal performance.

First-order statistical features are presented as potential predictive features for spectra classification, which can be fed into both traditional ML algorithms and ANNs. CNNs are introduced as methods to account for sequential dependency in spectra signal, and potentially generate new features for classification. The feature extractor and classification components of CNNs are discussed. The models are trained and optimized through multiple epochs, ensuring they do not overfit by memorizing the data. Hyperparameters configuration of ANNs/CNNs is also discussed.

The integration of advanced spectroscopy and ML/ANNs/CNNs demonstrates significant potential for accurate and efficient detection and analysis in various biological applications, highlighting the breakthrough capabilities of CNNs in handling spectral data.

Turbocharged Raman Spectroscopy for Lab, Factory, and Field

Dr. Bradford Behr

Raman spectroscopy is a powerful and increasingly popular method for analyzing molecular mixtures in real-time and in situ, but many applications are difficult because of the inherently weak signal strength of Raman-shifted photons. As detailed elsewhere in this symposium, advancements in surface-enhanced

Raman spectroscopy (SERS) technology can provide many orders of magnitude enhancement of the detectable Raman signal, enabling the detection of molecular species at exceedingly low levels of concentration. Complementing these SERS advancements, new optical design concepts in Raman spectrometer systems can also significantly boost the sensitivity and speed of Raman analyzers. I will provide an overview of the High-Throughput Virtual Slit (HTVS) concept which my colleagues and I have been developing and deploying for a plethora of laboratory and real-world sensing scenarios, with a particular eye towards modalities relevant to this symposium.

Enhancing the Effectiveness of Assisted Reproductive Technologies through Cutting-edge Technology Transfer

Dr. Svetlana Madjunkova,

Globally, ART-PGT (Assisted Reproductive Technology with Preimplantation Genetic Testing) is utilized to evaluate embryo quality, improve outcomes from IVF, and reduce the risk of having a child with a chromosomal abnormality. However, this method has limitations such as sampling bias, requiring skilled embryologists, and risk from the embryo biopsy itself as an invasive technique. Therefore, researchers are putting effort into exploring non-invasive preimplantation testing (NIPGT) to minimize the risks of the invasive procedure and add additional testing to improve the prediction of embryo development potential.

Key areas of research include the metabolic transition from aerobic to anaerobic conditions in embryos and the role of the reproductive microbiome. Advances in sequencing technology, spanning first, second, and third generations, are integrated to support comprehensive genomic analyses. This multidisciplinary approach aims to improve the effectiveness of ART procedures and provide deeper insights into embryonic development and health.

Recently, some researchers, successfully evaluated the embryo culture media, using Raman Spect. and SERS. This shed light on the possibility of using Raman and SERS technology as safe, fast, and cost-effective methods to distinguish between normal and abnormal embryos, which can consequently increase the implementation rate and successful pregnancy.

SERS-based Biomarker and Pathogen Sensing

Saba Ale Ebrahim

The development of plasmonic nanophotonic sensing elements, acting as SERS platforms, has enabled high-intensity electromagnetic fields localized at nanolength scales with applications in many fields including high-sensitivity molecular detection. In response to the urgent need for efficient biomarker and pathogen sensing, our group has developed label-free SERS platforms with enhanced sensitivity addressing limitations in current diagnostic tools and promising breakthroughs in early disease detection. Leveraging multiwavelength label-free SERS integrated with advanced machine learning algorithms, our platform has shown capability in simultaneous detection of a variety of pathogens and quantification of their concentrations.