PALSA 2023

Report of Contributions

https://indico.classe.cornell.edu/e/2114

Contribution ID: **1** Type: **Oral Presentation**

Directors' Welcome

Wednesday, 12 July 2023 09:15 (5 minutes)

Organizing Committee welcomes attendees of PALSA

Presenter: BROCK, Joel (Cornell University)

Session Classification: PALSA & Workshop Check in: Coffee and light breakfast fare provided.

Contribution ID: **2** Type: **not specified**

PALSA Goals & Outline

Theme: Grand Challenges in Ag, including multi-scale science

Presenters: WOLL, Arthur (CLASSE); SMIESKA, Louisa

Session Classification: PALSA & Workshop Check in: Coffee and light breakfast fare provided.

Contribution ID: **4** Type: **Oral Presentation**

Delivering Cassava modified with RNAi technology for Resistance to Cassava Brown Streak Disease to Benefit East African Smallholder Farmers

Food and economic security for smallholder cassava farmers in sub-Saharan Africa is threatened by Cassava brown streak disease (CBSD). CBSD is caused by the two Ipomoviruses, Cassava brown streak virus (CBSV) and Ugandan cassava brown streak virus (UCBSV) and transmitted by African cassava whitefly Bemisia tabaci, and by farmers who plant infected stem cuttings to establish the next cropping cycle. CBSD causes brown necrotic lesions within the storage roots, rendering them inedible and unmarketable. RNAi technology was applied to develop cassava with durable, high-level, resistance to CBSD. Sequences from the coat proteins (CP) of CBSV and UCBSV were fused to produce an inverted repeat construct and transgenic plants regenerated. Resistance to CBSD in the greenhouse and under field conditions in East Africa was correlated with the level of CP-specific siRNAs accumulated, with the best performing lines remaining disease free across multiple years in multiple locations in Kenya and Uganda. Best performing RNAi events underwent breeding programs, with the resulting F1 progeny lines inheriting the T-DNA and expressing CP-specific siRNAs in the predicted 1:1 ratio. F1 lines were cultivated over five 12-month growing cycles across six locations in Kenya and Uganda and selected for resistance to CBSD, Cassava mosaic disease and plus other farmer-required traits. A regulatory application was submitted to, and approved by the Kenyan National Regulatory Authority, to establish elite F1 lines within National Performance Trials. Parallel work has been initiated to develop the seed systems required to multiply and distribute CBSD resistant RNAi cassava to smallholder farmers in East Africa. Additional work has successfully stacked RNAi-mediated CBSD resistance with technology to elevate levels of iron and zinc in cassava storage roots to levels that would beneficially impact the nutritional status and health of cassava consumers. The presentation will illustrate the steps, processes and hurdles encountered in developing and delivering a modified orphan crop to smallholder farmers in Africa.

Presenter: TAYLOR, Nigel (Donald Danforth Center Plant Science Center)

Session Classification: Grand Challenges in Agricultural Science

Track Classification: Focus on Food: Security, Toxicity, and Sustainability

Contribution ID: **6** Type: **Oral Presentation**

Shedding Light on Metal Uptake, Distribution and Storage in Plants

Wednesday, 12 July 2023 11:00 (30 minutes)

Deficiencies of metal micronutrients commonly limit plant growth and crop yields. Furthermore, as most people rely on plants as their dietary source of micronutrients, plants that serve as better sources of essential nutrients would improve human health. We combine genetics, high throughput elemental analysis via inductively coupled plasma mass spectrometry (ICP-MS) and high-resolution imaging via synchrotron X-ray fluorescence (SXRF) to identify and characterize genes involved in metal uptake, distribution and storage. We had previously uncovered unique patterns of iron and manganese localization in seeds of the model plant Arabidopsis and have shown that the transporters VIT1 and MTP8, respectively, are responsible for setting up these patterns, allowing storage of iron and manganese in vacuoles. In addition to showing that storage of iron in the seed vacuole is essential for successful seedling establishment, we now have evidence that suggests iron is also required for successful germination. During germination, endosperm cell walls must weaken to allow the embryonic root to protrude. The endosperm accumulates iron close to the site of radicle protrusion in both Arabidopsis and tomato seeds. Using a combination of physiological experiments on wild type plants and mutants with defects in iron transport, we have confirmed that proper iron localization is indeed required for timely germination. Seed quality traits include fast transition to the seedling stage and enhanced tolerance to stresses including metal deficiencies. Both of these traits require proper iron localization in the seed and are of great importance for achieving higher yields in agriculture.

Primary authors: MANDEBERE, Deon (Department of Biological Sciences, METU, Ankara, Turkey); GUERINOT, Mary Lou (Dartmouth College); EROGLU, Seckin (Department of Biological Sciences, METU, Ankara, Turkey)

Presenter: GUERINOT, Mary Lou (Dartmouth College)

Session Classification: Grand Challenges in Agricultural Science

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **7** Type: **Oral Presentation**

Edible synchtrotron science: cheese, chocolate and meat

Presenter: MARANGONI, Alejandro (University of Guelph)

Session Classification: Grand Challenges in Agricultural Science

Track Classification: Focus on Food: Security, Toxicity, and Sustainability

Contribution ID: **9** Type: **Oral Presentation**

Developing (field-relevant) synchrotron techniques to support agricultural innovation

Wednesday, 12 July 2023 14:00 (30 minutes)

Synchrotron techniques have been used to investigate a range of processes in soils and plants. While these applications were initially addressing environmental issues related to pollution, recent years have seen increasing interest in using synchrotron approaches for agricultural research. This presentation will focus on new methodologies developed to address some major challenges related to (i) food production, with a particular focus on fertiliser efficiency (ii) soil constraints and (iii) the nutritional value of crops.

Fertiliser efficiency: the fertiliser use efficiency of conventional fertilisers is limited with most applied nutrients either remaining in the soil or being dispersed in the environment. However, understanding the reactions of nutrients in the fertosphere is challenging given the extreme gradients present around the point of fertiliser applications and the lack of analytical techniques to explore such gradients at large scale and high spatial resolution. In recent years, we have developed techniques enabling us to assess nutrient availability in the fertosphere using a combination of novel large scale and robust diffusive gradients in thin-films devices (DGT) and tandem X-ray Fluorescence Microscopy (XFM). Using these techniques, we have been able to visualise gradients in phosphorus availability in both laboratory and field trials.

Soil constraints: Approximately 75% of Australian soils have one or more constraints such as high pH, high concentrations of boron, deficiencies in macro and micronutrients, soil acidity, salinity and sodicity as well as compacted soils that limit root growth and function and crop utilisation of subsoil water. The ability of roots to grow through soil unhindered by physical or chemical constraints is key to making full use of the available water and nutrient resources. However, understanding how roots develop and respond to soil amendments is challenging. Here, we will report on the development of tomographic techniques that have enabled visualisation of roots in large soil cores from glasshouse and field trials.

Nutritional value of crops: food staples like cereals have been bred to increase yield but their nutritional value, for instance in terms of micronutrients, remains limited. One major challenge is the lack of efficient methods to screen libraries of mutated plants to identify individuals which have desirable elemental characteristics. In the last 4 years we have developed XFM techniques and analysis pipelines to quickly determine the concentration of micronutrients in a large number of seed libraries in a non-destructive manner. Examples for both rice and wheat studies will be shown.

Primary author: LOMBI, Enzo (University of South Australia)

Co-authors: DOOLETTE, Casey L. (Future Industries Institute, University of South Australia, Australia); KOPITTKE, Peter M. (School of Agriculture and Food Sustainability, The University of Queensland, Australi)

Presenters: DOOLETTE, Casey L. (Future Industries Institute, University of South Australia, Australia); LOMBI, Enzo (University of South Australia); KOPITTKE, Peter M. (School of Agriculture and Food Sustainability, The University of Queensland, Australi)

Session Classification: Fundamental research and in vivo studies

Contribution ID: **14** Type: **Oral Presentation**

Tuning C-phycocyanin properties via pressure-driven assembly-disassembly

Thursday, 13 July 2023 10:00 (30 minutes)

Presenter: ABBASPOURRAD, Alireza (Cornell University)

Session Classification: Focus on Food: Security, Toxicity, Sustainability

Contribution ID: **21** Type: **Oral Presentation**

Achieving global food security by tracing nanoparticle transformations in terrestrial crops using synchrotron techniques

Friday, 14 July 2023 11:00 (30 minutes)

At the nanoscale, materials acquire unique physico-chemical properties that can be manipulated for tailored purposes and as such, there has been an important increase in nanoparticles (NPs) used in a range of sectors, including agriculture. Nano-enabled agriculture is at the early stages of development but we strongly believe it is a road that may lead directly to sustainable global food security. Our group has been studying, for some time, the effects of metal NPs (nano-CeO2, nano-TiO2, nano-ZnO, and nano-CuO) on terrestrial plants, specifically, crop plants. Different plant species have been exposed to NPs at varying concentrations. Synchrotron-based techniques including X-ray absorption near edge structure (XANES), and micro-X-ray fluorescence (μ-XRF), have been used to study the mechanisms of transformation of NPs in some major crops. By using XANES we demonstrated, for the first time, that nano-CeO2 were taken up and stored, with little or no transformation, in roots of soybean (Glycine max), while no presence of nano-ZnO was detected in seedlings' roots. Tissue analysis with μ-XRF, combined with micro XNANES (μ-XANES) showed that cucumber (Cucumis sativus) plants absorb nano-TiO2 through the roots and translocate them into the fruit. μ-XANES analyses have also shown differences in the biotransformation of weathered and unweathered nano-CuO in lettuce (Lactuca sativa). While weathered particles were almost completely transformed from CuO to Cu (I)-sulfur and oxide complexes, roots exposed to unweathered particles showed Cu as CuO. These studies have shown different levels of biotransformation of metal oxide NPs in plants. In addition, we have found that some of them including nano-TiO2 and nano-CeO2 can be stored in fruits and seeds, while others, like nano-ZnO, have been observed only in roots.

In summary, our results show that the mechanisms of transformation of metal NPs are different and depend on several factors. It is true that broadly speaking the small size and high surface-area-to-volume ratio in NPs can be extremely beneficial. However, using this justification without properly understanding the mechanisms of interaction between NPs and crops, hence leading to the tailored design of new nanoagrochemicals, may in the long run undermine the potential of nanotechnology in agriculture, as has perhaps already happened in other fields.

Primary author: Dr GARDEA-TORRESDEY, Jorge (University of Texas at El Paso)

Presenter: Dr GARDEA-TORRESDEY, Jorge (University of Texas at El Paso)

Session Classification: Agricultural Engineering & Systems Modeling

Contribution ID: **31** Type: **Oral Presentation**

Multiscale Image Based Modelling of Plants and Soil

Friday, 14 July 2023 09:30 (30 minutes)

We rely on soil to support the crops on which we depend. Less obviously we also rely on soil for a host of 'free services' from which we benefit. For example, soil buffers the hydrological system greatly reducing the risk of flooding after heavy rain; soil contains very large quantities of carbon, which would otherwise be released into the atmosphere where it would contribute to climate change. Given its importance it is not surprising that soil, especially its interaction with plant roots, has been a focus of many researchers. However the complex and opaque nature of soil has always made it a difficult medium to study.
In this talk I will show how we can build a state of the art image based model of the physical and chemical properties of soil and soil-root interactions, i.e., a quantitative, model of the rhizosphere based on fundamental scientific laws. This will be realised by a combination of innovative, data rich fusion of structural and chemical imaging methods, integration of experimental efforts to both support and challenge modelling capabilities at the scale of underpinning bio-physical processes, and application of mathematically sound homogenisation/scale-up techniques to translate knowledge from rhizosphere to field scale. I will also describe how imaging and image based modelling can help understand devastating plant bacterial diseases like Xylella fastidiosa in olives.

Primary author: ROOSE, Tiina (University of Southampton)

Presenter: ROOSE, Tiina (University of Southampton)

Session Classification: Agricultural Engineering & Systems Modeling

Track Classification: Agricultural Engineering and Systems Modeling

Contribution ID: **32** Type: **Oral Presentation**

Synchrotron-based techniques as powerful tools for addressing fundamental issues on Soil and Food Security

Wednesday, 12 July 2023 11:30 (30 minutes)

Concerns about **Food Security** and on how to address issues relevant to this global challenge are recurrent and had a worldwide landmark during *The World Food Summit*, in 1996. Meanwhile, **Soil Security** is a new concept that has been treated as crucial to guarantee Food Security only after the declaration of the *International Year of Soils*, in 2015. The assessment and proposition of actions to ensure global Food Security require continued studies that could develop better indicators to more assertively represent and solve problems related to the five dimensions of Food Security: 1) Quantity, 2) Quality, 3) Acceptability, 4) Safety, 5) Certainty/Stability. Similarly, the concept of Soil Security is also multidimensional and recognizes the importance of appropriately tackling the following dimensions: 1) Capacity, 2) Condition, 3) Capital, 4) Connectivity, 5) Codification. Concerning Food Security, light sources could help us unravel many aspects concerning the **quality** and **safety** of food and agricultural inputs, and, later, food **acceptability** as well as the evaluation of the **resilience** (sustainability) of agroecosystems. Considering Soil Security, relevant information regarding **capacity** (soil functions), **condition** (change in capacity), and **codification** (public policies and regulation) can also be obtained via resources and capabilities provided by synchrotron facilities. Our talk will discuss the use of synchrotron-based techniques for addressing issues concerning Food Security - namely food quality and safety - while also relating these aspects with relevant aspects of Soil Security that are essential to assuring the sustainability of agroecosystems.

Primary author: GUIMARAES GUILHERME, Luiz Roberto (Federal University of Lavras)

Presenter: GUIMARAES GUILHERME, Luiz Roberto (Federal University of Lavras)

Session Classification: Grand Challenges in Agricultural Science

Track Classification: Focus on Food: Security, Toxicity, and Sustainability

Contribution ID: **33** Type: **Oral Presentation**

Visualization and quantitative evaluation of functional structures of soybean root nodules using synchrotron-based X-ray mCT and X-ray fluorescence

Friday, 14 July 2023 12:00 (15 minutes)

Legume-rhizobia symbiosis, the most efficient plant N2 fixing system, has been long recognized as a sustainable alternative to the use of nitrogen (N) fertilizers. Previous histological studies have provided a detailed description of anatomical structure of root nodules in 2 dimensions. Nodules consist of two functionally important tissues: (1) a central infected zone (CIZ), colonized by rhizobia bacteria, which serves as the site of N2-fixation, and (2) vascular bundles (VB), connecting the nodule with the root and plant, serving as conduits for the transport of the water and nutrients from plant to nodules, also for the translocation of the fixed-N compounds from nodule to plant. Visualizing these tissues by traditional microscopic methods involves using destructive and labor-intensive approaches for thin sectioning of nodules and staining sections. Therefore, we used synchrotron-based X-ray micro-CT (S-XRCT) and X-ray fluorescence (S-XRF) techniques for non-invasive and fast visualization of these important structures in intact soybean root nodules in both 3D and 2D. The S-XRCT imaging of root nodules at 0.7 microns spatial resolution allowed us to visualize the nodule vessels (> 7 microns diameter), and to automatically segment the VB and CIZ in the 3D reconstructed images. The elemental maps, generated by S-XRF of root nodules at 20microns resolution, revealed the unique localization of Zn and Fe within the VB and CIZ tissues, and enabled the 2D visualization of these tissues. To better understand the physiological basis of the differences observed in N-fixation of soybean genotypes, a quantitative evaluation of these tissues is essential. This study, for the first time, introduces the application of S-XRCT for volume quantification of the CIZ and VB tissues in intact soybean root nodules. The proposed methods allow for high-throughput phenotyping of the functionally important nodular structures by simultaneously imaging of multiple root nodules, enhancing the applicability of these methods.

Primary author: NAKHFOROOSH, Alireza

Co-authors: Dr HALLIN, Emil (Global Institute for Food Security); Dr KARUNAKARAN, Chithra (Canadian Light Source); Dr KORBAS, Gosia (Canadian Light Source); Mr STOBBS, Jarvis (Canadian Light Source); Prof. LEON, Kochian (Global Institute for Food Security)

Presenter: NAKHFOROOSH, Alireza

Session Classification: Agricultural Engineering & Systems Modeling

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **34** Type: **Poster**

Synchrotron-based X-ray fluorescence spectroscopy unfolding the pathway of Zn and Mn absorption by coffee leaves

Thursday, 13 July 2023 15:30 (1 hour)

The foliar fertilisation with zinc (Zn) and manganese (Mn), essential micronutrients on vegetal metabolism, contributes to increasing crop species' productivity. Due to their widespread deficiency in weathered soils, this is particularly important in Brazil, the most important producer of coffee worldwide. Although foliar-based strategies often regard the use of chelates, such as EDTA, their uptake movement and tissue-partitioning dynamics in coffee leaves are not understood. In this regard, the apical leaves of 6-month-old coffee (Coffea arabica) plants were herein harvested 48-h past the exposure either to Zn: Mn-EDTA or Zn: Mn-IDHA solutions (1:1 Zn: Mn atomic ratio), then cryofixed through rapid plunging in supercooled isopentane, cross-sectioned in a cryo microtome at -25°C, and measured through high-resolution X-ray fluorescence spectroscopy yielded by a ca. 0.15x0.15 μm X-ray beam at Zn K-line excitation energy (9750 ev) at the Tarumã endstation of the Carnaúba beamline at the Sirius Brazilian Synchrotron Light Source, Brazil. The results revealed that the Zn and Mn signals throughout the whole leaf-cross sections were ca. 2-fold higher for the Zn: Mn-EDTA compared to Zn: Mn: Mn-IDHA complex. It also displayed reveals Ca hotspots in the palisade parenchyma, likely related to calcium oxalate crystals usually found in this tissue. Moreover, a clear Zn: Mn gradient exhibited from the fertilised regions up the vascular bundles pinpoint their translocation towards other organs. Curiously, regardless of the applied compounds, the Zn and Mn intensities were mostly found surrounding the cells, thereby suggesting its transport takes place solely through the apoplastic pathway, i.e., between the cell wall and the cell plasmalemma. These findings unveil that apoplast might play an important role in the foliar absorption of nutrients by controlling the leaf cell's ionic balance.

Primary authors: Mr SGARBIERO MONTANHA, Gabriel (University of São Paulo (Brazil), Sapienza University of Rome (Italy)); COAN PEREZ, Lucas (University of São Paulo); Prof. JOÃO PAULO, Rodrigues Marques (University of São Paulo); Prof. PEREIRA DE CARVALHO, Hudson Wallace (University of São Paulo)

Presenter: Mr SGARBIERO MONTANHA, Gabriel (University of São Paulo (Brazil), Sapienza University of Rome (Italy))

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **35** Type: **Oral Presentation**

Plant metallomics: Are metal distribution patterns a cause or a consequence of plant tissue fate?

Wednesday, 12 July 2023 14:45 (15 minutes)

Seeds undergo a tightly regulated developmental program throughout their germination. Although mineral nutrients are crucial during all phases of a plant's life cycle, little is known regarding their role in tissue differentiation. Herein, both synchrotron and benchtop-based X-ray fluorescence spectroscopy approaches revealed that manganese (Mn) and iron (Fe) exhibit particular 'stripe-like' distribution patterns in the radicle of mature soybean seeds, where Fe signals are found as quadrupole structure surrounded by Mn. Spatio-resolved X-ray fluorescence spectroscopy of soybean seed's radicle cross-sections at the Tarumã endstation of the Carnaúba beamline at the Sirius Brazilian Synchrotron Light Source, Brazil, revealed that these patterns are not artefacts induced by constating cell densities across different tissues. Furthermore, a 72-h microscopical assessment of the cell's fate on germination soybean seeds points that the radicle's Fe quadrupole is associated with the proto and meta-xylem procambial tissues. These findings suggest that the polarised Fe and Mn distribution might play an important role in the differentiation of the radicle cells during the early development of soybean plants.

Primary authors: MONTANHA, Gabriel (University of São Paulo); Mr SANTOS, Eduardo (University of São Paulo); Prof. RODRIGUES MARQUES, João Paulo (University of São Paulo); Prof. PEREIRA DE CARVALHO, Hudson Wallace (University of São Paulo)

Presenter: MONTANHA, Gabriel (University of São Paulo)

Session Classification: Fundamental research and in vivo studies

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **36** Type: **Poster**

Effects of humidity and amino acids on the translocation of manganese and zinc applied to the leaves soybean (glycine max) crop.

Wednesday, 12 July 2023 16:30 (1 hour)

Amino acids are part of the primary structure of proteins. Additionally, they are precursors of several chemicals and, in plants, they are able to mitigate the deleterious effects of stress. In Brazil, several companies have been trading commercial products based on amino acids as stimulants of plant metabolism. They also claim that the amino acids contribute to the absorption and transport of micronutrients sprayed on leaves. However, scientific studies supporting those arguments are scarce. Hence, we decided to employ in vivo analysis X-ray fluorescence spectroscopy strategy to determine the translocation rate of Mn and Zn complexed with histidine. For this, 0.3 ml in a ratio of 2:1:1 M of histidine, manganese and zinc, respectively, was sprayed on the leaves of soybean. Measurements were performed on the petiole and evaluated during one week under high (80-90%) and low humidity (30-45%).

The analysis carried out on the petiole showed that the application of Mn and Zn with and without histidine were similar in high humidity, i.e, the amino acid had no influence on the translocation of micronutrients. Differently, in low humidity conditions, the amino acid increased the combined uptake+transport of Zn. One should also highlight that the metal-amino acid complexes presente little phytotoxic effects on the leaves compared to sulfate based metals. In the next phase of the project, cross sections of the treated leaves will be mapped under sub-micron lateral resolution at the Carnauba beamline of the LNLS. There, we expect to determine how much of the absorbed nutrient remains in the apoplast, in the cell wall, and how much enters in the simplast, i.e. in the citosol. Then, we will be able to verify weather metal-amino acid complexes induce, or facilitate, the entrance of metals in the cell. The same procedures will be carried out for the coffee culture.

Primary author: Mr PIRES REZENDE, Vinicius (University of São Paulo)

Co-author: Prof. PEREIRA DE CARVALHO, Hudson Wallace (University of São Paulo)

Presenter: Mr PIRES REZENDE, Vinicius (University of São Paulo)

Session Classification: Poster Session 1

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **37** Type: **Poster**

"Growing" Sulfur and Phosphorus X-ray Absorption Spectroscopy and Imaging Capabilities at the Canadian Light Source

Thursday, 13 July 2023 15:30 (1 hour)

The Canadian Light Source (CLS) has four beamlines capable of measuring sulfur and phosphorus X-ray absorption spectroscopy (XAS): the Industry, Development, Education, Applications, Students (IDEAS) beamline, the Soft X-Ray Microcharacterization Beamline (SXRMB), the Soft X-ray Spectromicroscopy (SM) beamline and the Variable Line Spacing Plane Grating Monochromator (VLS-PGM) beamline. Sulfur and phosphorus K-edge X-ray absorption spectra can be obtained using the SXRMB and the IDEAS beamline, K-edge and L-edge using the SM beamline, while the VLS-PGM beamline has the energy range for L-edge spectroscopy.

In this contribution, we show the detection limits for these beamlines using sulfur and phosphorus standards, including NIST standards such as peach leaves and New Jersey soil. In addition to bulk XAS, the SXRMB is equipped with a microprobe endstation that can provide imaging at a resolution of 10 μm. In this work we present X-ray Fluorescence (XRF) mapping of canola seeds with varying phytate levels. These maps show elemental distribution, allowing for insight into locations of micronutrients and their correlations with each other. This endstation can also be used to collect micro-XAS data at specific locations of interest, providing insight into speciation. Here, we present phosphorus micro-XAS data.

Overall, the CLS can provide great value to agriculture and environmental researchers due to its complementary K- and L-edge spectroscopy and imaging capabilities.

Primary author: Dr PATERSON, Alisa

Co-authors: Dr TU, Kaiyang (Canadian Light Source); VU, Miranda (Canadian Light Source); Dr SHAKOURI, Mohsen (Canadian Light Source); Dr MUIR, David (Canadian Light Source); Dr WANASUNDARA, Janitha (Agriculture and Agri-Food Canada); Dr KARUNAKARAN, Chithra (Canadian Light Source); Dr ZUIN, Lucia (Canadian Light Source)

Presenter: Dr PATERSON, Alisa

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **38** Type: **Oral Presentation**

Chemical Imaging of Plant-Soil-Microbe Systems: Examples from SSRL

Thursday, 13 July 2023 11:30 (15 minutes)

The Structural Molecular Biology resource at SSRL develops, operates, and supports three dedicated XRF imaging beamlines that cover a range of spatial scales (μm to cm) and elements of biological importance. These beamlines can perform μ-XAS to characterize the oxidation state, or chemical species, at a single point within a sample. Chemical imaging using synchrotron XRF imaging lends itself to rhizosphere and phyllosphere research due to the ability to track transformations of key nutrients (P, S, K, Fe) and/or toxic heavy metals (As, Hg) in a complex and heterogenous sample.

Potassium is a critical nutrient for plants and microbes, playing important roles in osmoregulation, enzyme activation and mitigates the effect of drought. However, K is limited in most environments, even when K is supplied by fertilizer. In collaboration with SSRL, researchers from EMSL are using synthetic soil habitats (SSH) to visualize the organic and inorganic processes controlling fungal sourcing, transport, and transformation of K during C-limitation, including: (i) XRF imaging of fungal hyphae on SSH in the presence and absence of an inorganic K source to determine forms of bioavailable K and (ii) XAS and theoretical calculations to determine the K bonding environment in organic K compounds. Data indicate the importance of fungal exuded tartaric and citric acids, which are likely responsible for sensing K rich minerals and uptake/storage of K by fungi, respectively. Secondary clay mineral formation on the SSH provides insight into fungal mineral degradation over environmentally relevant scales. We applied potassium XRF imaging to an agriculturally relevant field example to observe changes in the spatial distribution of non- vs. readily bioavailable K within rice paddy soil treatments. Under anoxic, flooded conditions, there was a greater abundance of readily bioavailable K compared to non-flooded conditions. These differences may be a result of differing microbial processes under each condition.

Primary authors: RICHARDSON, Jocelyn (SLAC National Accelerator Laboratory); Dr SARANGI, Ritimukta; Dr BHATTACHARJEE, Arunima; Dr ANDERTON, Chris; Dr SEYFFERTH, Angelia

Presenter: RICHARDSON, Jocelyn (SLAC National Accelerator Laboratory)

Session Classification: Focus on Food: Security, Toxicity, Sustainability

Track Classification: Focus on Food: Security, Toxicity, and Sustainability

Contribution ID: **39** Type: **Oral Presentation**

Foliar absorption of calcium by tomato plants: Effects of calcium source & adjuvant

Thursday, 13 July 2023 11:45 (15 minutes)

The deficiency of calcium can have a detrimental effect on the quality and shelf life of fruits. In addition to appropriate soil fertilization, foliar sprays containing Ca2+ sources present an alternative solution to prevent and address this issue. X-ray fluorescence microanalysis was utilized to observe the foliar absorption of CaCl2, Ca-citrate complex, and Ca3(PO4)2 nanoparticles, with and without mineral oil as an adjuvant. The foliar absorption of Sr2+ was utilized as a physiological tracer for Ca2+. The impact of treatments on the cuticle structure was measured via scanning electron microscopy. For this study, 45-day-old tomatoes (Solanum lycopersicum L., cv. Micro-Tom) were employed as the model plant species.

During the 100-hour period, the leaves absorbed 90%, 18%, and 4% of aqueous CaCl2, Ca-citrate, and Ca3(PO4)2 nanoparticles, respectively. The addition of an adjuvant increased the absorption of Ca-citrate to 28%, decreased that of CaCl2 to 77%, and did not affect Ca3(PO4)2. CaCl2 demonstrated an exponential decay absorption profile, with t50% of 15 hours and 5 hours without and with adjuvant, respectively, while Ca-citrate and Ca3(PO4)2 exhibited a linear behavior. Sr2+ proved to be an appropriate tracer for Ca2+ since their absorption profiles were similar. The adjuvant disrupted the epicuticular crystals, and the movement of Ca inside of the leaf was limited to a few millimeters away from the deposited spot. The findings of the study suggest that CaCl2 was more effective than the other sources of Ca2+. The effects caused by the adjuvant imply that CaCl2 and Ca-citrate were mainly absorbed through hydrophilic and lipophilic pathways, respectively.

Primary authors: Dr SANTOS, Eduardo (University of Sao Paulo); MONTANHA, Gabriel (University of São Paulo); Prof. PEREIRA DE CARVALHO, Hudson Wallace (University of São Paulo)

Presenter: Dr SANTOS, Eduardo (University of Sao Paulo)

Session Classification: Focus on Food: Security, Toxicity, Sustainability

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **40** Type: **Poster**

Preparation of fresh and dry plant tissue samples for Synchrotron-based XRF analysis

Wednesday, 12 July 2023 16:30 (1 hour)

Synchrotron-based X-ray fluorescence spectroscopy techniques are useful for understanding the ionome of biological materials, including plants, at the tissue or cellular level. Nevertheless, sample preparation is crucial and challenging as both tissue structure and elemental composition need to be preserved. In this study, we explored the Synchrotron Laboratory to establish suitable cryofixation methods for high-resolution XRF analysis of plant tissues. Leaves from coffee (Coffea arabica), soybean (Glycine max (L.) Merrill), and tomato (Solanum lycopersicum) plants were detached, and 5 x 5 mm pieces were immersed in optimal cutting temperature (OCT) medium and frozen through rapid-plunging in supercooled isopentane. The resulting blocks were fixed on an adhesive cellophane film (Fitar, Brazil) and cut using a cryostat at -25℃ to yield 30-µm thick cross sections. We also evaluated the preservation of tomato fruit tissue structure, where analyzing fresh tissue was unnecessary. The samples were cut with a single-blade razor (carbon steel), and the sample slides were placed on the XRF cup sample holder between two layers of 6 µm thick polypropylene XRF film. The samples were stored in the freezer for 12 hours, followed by the freezing-dry process. The results showed that the structure of coffee, maize, and tomato leaves was preserved during the cryofixation process, indicating that the procedures employed are suitable for the fresh leaf tissues of different species. Furthermore, no evidence of radiation damage, sample dehydration, or structural collapse within the measurement timeframe was observed, suggesting that these analyses might be accomplished without the use of a cryojet. Similar results were obtained for tomato fruit, which is suitable for measuring low mobile nutrients regarding their redistribution as Ca.

Primary authors: SANTOS, Eduardo (University of Sao Paulo); MONTANHA, Gabriel (University of São Paulo); Prof. PEREIRA DE CARVALHO, Hudson Wallace (University of São Paulo)

Presenter: SANTOS, Eduardo (University of Sao Paulo)

Session Classification: Poster Session 1

Track Classification: Poster Session

Contribution ID: **41** Type: **Poster**

Enabling PALSA synchrotron users through a unique collaboration: the MAPLE project

Thursday, 13 July 2023 15:30 (1 hour)

Phosphorus (P) and sulfur (S) are some of the essential elements for agriculture and environmental sciences research. The VLS-PGM beamline at the Canadian Light Source (CLS) is one of the few beamlines in the Americas that is built to optimize the delivered flux below 250eV, to access the L-edges of those elements. The beamline endstation has also been improved to perform XANES measurements over the Boron K-edge, and P and S L-edges by the use of a recently commissioned silicon drift detector (SDD) for partial fluorescence yield (PLY), a multichannel plate detector (MCP) for total fluorescence yield (FLY) and total electron yield (TEY). Micro image capability is presently under commissioning.
The CLS has recently started a collaboration, the MAPLE project, which provide to the Sirius Users access to the VLS-PGM beamline through a rapid mechanism. The capabilities of the beamline and the potential use of this beamline for CHESS users are highlighted in this poster with relevant examples.

Primary author: Dr ZUIN, Lucia (Canadian Light Source)

Co-authors: Dr KARUNAKARAN, Chithra (CLS); Prof. BOTTON, Gianluigi (CLS)

Presenter: Dr ZUIN, Lucia (Canadian Light Source)

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **42** Type: **Poster**

Phosphorus Spatial Distribution and Speciation in Brassica Oilseeds on the Spectromicrocopy (SM) Beamline at the Canadian Light Source

Thursday, 13 July 2023 15:30 (1 hour)

Canola contributes around $30 billion to the Canadian economy each year, from oil processing and as an animal feed due to the high protein content of the meal by-product. Protein and oil occur as discrete bodies in canola seed cells, however, information on the compartmentalization of these discrete bodies (e.g., size, number, arrangement) within cellular ultrastructure to changes in overall oil/protein content is limited. Moreover, phytates and phosphorus have a strong association with proteins, tending to concentrate with protein purification. Former is considered as an anti-nutritive component of proteins. Understanding the relationships between the protein/phytates/phosphorous and the oil/protein ultrastructure is important to further breeding efforts. Imaging techniques, with chemical sensitivity and on sub-cellular spatial resolution are thus required to examine these relationships.

Scanning transmission X-ray microscopy (STXM) which uses X-ray absorption near edge spectroscopy (XANES) as its contrast mechanism, providing element specific information meets both the chemical sensitivity and ultrastructure preservation criteria. With a spatial resolution better than 25 nm STXM is suitable for imaging individual cells in canola seeds. In addition, with a spectral resolution on the order of 100 meV, STXM is sufficient to provide good differentiation of chemical species. Recently, the spectromicroscopy (SM) beamline at the Canadian Light Source (CLS) has commissioned a new monochromator, increasing the photon flux and energy resolving power in the 1800 to 3000 eV energy range. Phosphorous and sulfur K-edges have thus become practical for mapping P and S species, respectively. Cross-sections of canola seeds with high and low oil content and with high and low phytate content were examined at the P K-edge. The distribution of P species in individual cells within the canola seed are reported. This information is expected to help in breeding selection and to facilitate in the development and improvement of oil and protein recovery.

Primary authors: DYNES, James (Canadian Light Source); Dr TU, Kaiyang (Canadian Light Source); Dr KARUNAKARAN, Chithra (Canadian Light Source); Dr WANG, Jian (Canadian Light Source); Dr KUPPILI, Charan (Canadian Light Source); Mr LU, Yingshen (Canadian Light Source); PATERSON, Alisa (Canadian Light Source); VU, Miranda (Canadian Light Source); Mr STOBBS, Jarvis (Canadian Light Source); Dr WANASUNDARA, Janitha (Agriculture and Agri-Food Canada)

Presenter: DYNES, James (Canadian Light Source)

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **43** Type: **Oral Presentation**

Mogno, A Versatile Micro and Nano X-ray Imaging Beamline: Applications in Agrigultural Sciences

Tuesday, 11 July 2023 13:45 (20 minutes)

MOGNO beamline, from the 4th generation Light Source in Brazil, Sirius, will be focused on high throughput, time resolved experiments and multi-scale analysis. This beamline will work in high energies (22, 39 keV, and 67.5 keV), with a cone beam geometry that enables continuous magnification of the image, from ~55 μm to ~120 nm, known as zoom-tomography. In addition, MOGNO will be equipped with a high-Z direct area-detector that provides a maximum field of view of ~85x85 mm2. In the agricultural sciences, this means it is possible to measure a soil monolith in a large field of view, aiming to detect for instance macropores and primary roots, and zooming into inter- and intra-aggregate pore zones, where most of the micropores are found, often near root hairs, defining the rhizosphere region. In addition, the high photon flux and the direct area-detector will allow fast data acquisition, in which experiments are resolved both in space and time (4D). This will benefit studies of soil functions such as storage and distribution of water. The other relevant aspect to be considered for innovative soil studies relies on the possibility to scan samples in contact and phase contrast image regimes. The phase contrast regime arises as the sample to detector distance increases, due to the free propagation of the X-ray wave refraction caused when it crosses any material interface, thus greatly benefiting biological samples. This configuration, allied with robust phase retrieval algorithms which are under development by the Scientific Computing Group (GCC/LNLS), are hoped to allow the identification of organic matter inside soil samples without the need of staining procedures. Therefore, the goal of this work is to present the new opportunities that are becoming available with this cutting-edge technique applied in agricultural studies. MOGNO is currently open to scientific commissioning with external users.

Primary author: Dr ROSAS FERREIRA, Talita (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM))

Co-author: Dr LOPES ARCHILHA, Nathaly (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM))

Presenter: Dr ROSAS FERREIRA, Talita (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM))

Session Classification: X-ray Methods & Resources for Agricultural Science

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **44** Type: **Poster**

Opportunities for Agricultural Research at the Canadian Light Source Mid-IR Beamline

Thursday, 13 July 2023 15:30 (1 hour)

Infrared (IR) spectroscopy at the Canadian Light Source (CLS) Mid-IR beamline provides a suite of analytical options for investigation of biological samples which include bulk IR, IR imaging, and attenuated total internal-reflectance (ATR) IR-imaging capabilities. Protein, lipids, carbohydrates and other organic molecules possess distinct vibrational band features within the Mid-IR spectrum which provide chemical compositional and conformational information. For instance, IR allows for analysis of lipid acyl chain length or degree of unsaturation on leaf cuticle structure or oilseed crops. Another application area example are investigations into protein secondary structure composition and alteration due to composition and environmental conditions such as adiabatic stress, storage and processing techniques.

This poster aims to provide a brief overview of analytical techniques available at the Mid-IR beamline to highlight relevant agricultural science applications using canola seeds as an example. Particularly with focus on IR imaging capabilities present at the beamline, which combine IR spectroscopy with IR array detectors to provide powerful tools to simultaneously spatially map biomolecular composition of samples with micrometer spatial resolution. As an example, IR imaging can non-destructively measure lipid / protein / carbohydrate distribution simultaneously to map whole plant tissue cross-sections without the use of labeling agents that could alter the chemical composition. Combining IR imaging with high brilliance synchrotron IR radiation allows for further improvement for investigation of minor compositional differences with sub-cellular resolution, such as evaluation of protein secondary structure at an individual protein storage vacuole site within a canola seed. Lastly, the poster will showcase how IR imaging can greatly compliment x-ray techniques measured at other beamlines at CLS (micro computed tomography at the Biomedical Imaging and Therapy (BMIT) beamline and x-ray fluorescence imaging at the Soft X-ray Microcharacterization Beamline (SXRMB) and the BioXAS beamline) with spatially resolved chemical composition on the same or replicate samples.

Primary author: Dr TU, Kaiyang (Canadian Light Source)

Co-authors: Mr STOBBS, Jarvis (Canadian Light Source); VU, Miranda (Canadian Light Source); PATERSON, Alisa; Dr READ, Stuart (Canadian Light Source); Dr ROSENDAHL, Scott M. (Canadian Light Source); Dr VENGLAT, Prakash; Dr WANASUNDARA, Janitha; Dr KARUNAKARAN, Chithra (Canadian Light Source)

Presenter: Dr TU, Kaiyang (Canadian Light Source)

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **45** Type: **Poster**

Unique capabilities of the BioXAS-Imaging beamline to investigate the distribution of elements in plants

Wednesday, 12 July 2023 16:30 (1 hour)

The distribution of elements within plant tissues can provide important information for a wide range of plant science studies, for example, functional characterization, improving nutrition or plant health, climate adaptation, or contaminants' effects and movement. Synchrotron-based X-ray fluorescence imaging surpasses other methods suitable to determine elemental and chemical species distribution in multiple aspects, such as sensitivity, resolution, tuneability, speed, and minimal sample preparation.
The BioXAS-Imaging beamline at the Canadian Light Source is a recently commissioned hard X-ray (5 - 21 keV) fluorescence imaging beamline with two spatial resolution modes currently in operation. The X-ray source of the beamline is an in-vacuum undulator providing a high spectral brilliance. The primary optics of the beamline consists of a collimating mirror, a fixed-exit double crystal monochromator, and a post-monochromator vertically focusing mirror. The macro mode can deliver a range of apertured beam sizes between 20 um to 100 um with photon fluxes (at 10 keV) 1.3 x 1011 ph/s and 2.0 x 1012 ph/s, respectively. An array of samples of different dimensions or a single large sample of 25 cm x 25 cm can also be accommodated. In the micro mode, the beam is focused with the Kirkpatrick-Baez (K-B) mirrors yielding 5 um x 5 um beam size with flux (at 10 keV) reaching 3.3 x 1011 ph/s. Bi-directional fly scanning and short dwell time enable rapid scanning in both resolution modes.
The BioXAS-Imaging beamline stands out among other synchrotron beamlines because of its capability to provide several techniques (X-ray fluorescence imaging; in situ X-ray absorption spectroscopy (u-XAS) and XAS imaging) in two resolution modes with a high-level of performance. To showcase the BioXAS-Imaging beamline's capabilities and applications in the plant science field, a few examples of recently collected data will be presented.

Primary authors: Dr BONDICI, Viorica (Canadian Light Source Inc.); Dr KORBAS, Malgorzata (Canadian Light Source Inc); CARRIERE, Shawn (Canadian Light Source Inc); BEAUREGARD, David (Canadian Light Source Inc); STEEL, Garth (Canadian Light Source Inc); SCHNEIDER, Brian (Canadian Light Source Inc); BREE, Mike (Canadian Light Source Inc); BOYLE, Connor (Canadian Light Source Inc)

Presenter: Dr BONDICI, Viorica (Canadian Light Source Inc.)

Session Classification: Poster Session 1

Track Classification: Poster Session

Contribution ID: **46** Type: **Oral Presentation**

Cellular nano-architecture unveiled by tomo-ptychography: perspectives on X-ray coherent imaging to plant biology and agricultural sciences

Friday, 14 July 2023 10:15 (15 minutes)

Knowledge of the nano-architecture of plant structures gives insights into basic physiological processes and is also useful for biotechnological purposes such as biomass deconstruction for industrial processing. High-resolution imaging techniques such as electron-based microscopies are crucial to access cellular ultrastructure. However, more precise quantification of structure at such level of detail is only possible with 3-dimensional imaging. In this presentation, we will demonstrate how X-ray tomo-ptychography unveils structural features, at 3D nanometric spatial scales, which can be correlated with plant phenotype. For example, such experiments were used to access cell wall morphology and quantify structures in specific cellular tissues of wild-type and transgenic/mutant grasses, as well as to investigate pollen grains under different conditions. We will discuss preparation conditions for plant specimens and 3D imaging that allows exploration of dissimilarities at cellular level between different plant genotypes and highly accurate quantification of intracellular structures. Finally, we will demonstrate how tomo-ptychography experiments carried out at the CATERETÊ beamline at the 4th-generation Sirius synchrotron in Brazil paves new ways to explore plants and other agricultural systems and provides a complementary tool for nanoscale structural studies.

Keywords: grasses, pollen, coherent X-ray scattering imaging

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Primary author: POLO, Carla Cristina (Brazilian Synchrotron Light Laboratory (LNLS), National Center of Research in Energy and Materials (CNPEM), Brazil)

Co-authors: FAIA FERNANDES, Francine (Brazilian Synchrotron Light Laboratory (LNLS), National Center of Research in Energy and Materials (CNPEM), Brazil); BIANCHONI MANOEL , Lais (Brazilian Synchrotron Light Laboratory (LNLS), National Center of Research in Energy and Materials (CNPEM), Brazil); ARAUJO KALILE, Tiago (Brazilian Synchrotron Light Laboratory (LNLS), National Center of Research in Energy and Materials (CNPEM), Brazil); Prof. CESARINO, Igor (Biosciences Institute (IB), University of São Paulo (USP), Brazil); MENEAU, Florian (Brazilian Synchrotron Light Laboratory (LNLS), National Center of Research in Energy and Materials (CNPEM), Brazil)

Presenter: POLO, Carla Cristina (Brazilian Synchrotron Light Laboratory (LNLS), National Center of Research in Energy and Materials (CNPEM), Brazil)

Session Classification: Agricultural Engineering & Systems Modeling

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **47** Type: **Oral Presentation**

Micro- to Nano-scale Soil and Rhizosphere Processes Analyzed Using Multiple Beamlines at the Sirius Synchrotron

Friday, 14 July 2023 11:45 (15 minutes)

Determining mechanisms that regulate plant-nutrient behavior in agricultural soils is often confounded by interactions between physical, chemical, and biological processes within these multicomponent, heterogeneous, and hierarchical systems. This presentation will focus on strategies and examples of addressing these complexities by using complementary techniques at multiple Sirius beamlines. For example, we hypothesize that diffusion and reaction of fertilizer phosphate inside soil microaggregates contributes to slowly reversible phosphate binding ("fixation"), which diminishes plant availability of this macronutrient. Micro and nanoscale imaging results from three beamlines were used to evaluate the 3D internal physical structure of soil microaggregates (CATERETÊ coherent diffraction imaging beamline), 3D spatial distributions of soil-matrix elements (CARNAÚBA coherent X-ray nanoprobe beamline), and the presence of biological components (IMBUIA infrared microprobe beamline). Results revealed accumulations of physical structures of high electron density that at least partially coincide with hotspots of iron and other metals, as well as structures of low electron density that are possibly of biological origin. We will also illustrate how a combination of chemical imaging around a living wheat root at CARNAÚBA and root-structural imaging at the MOGNO X-ray computed tomography beamline reveal root-induced chemical changes in the rhizosphere over time. Initial results show highly reproducible spatial structures of soil matrix elements in the rhizosphere over time and well-defined imaging of roots and root hairs. Integrating multimodal analyses from beamlines with unique capabilities to probe different aspects of a soil matrix is essential for determining how coupled processes affect agricultural nutrient behavior in such complex systems.

Primary authors: HESTERBERG, Dean (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM)); ROSAS FERREIRA, Talita (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM)); PÉREZ, Carlos (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM)); ROOSE, Tiina (University of Southampton); POLO, Carla Cristina (Brazilian Synchrotron Light Laboratory (LNLS-Brazil)); MADEIRO DA COSTA, Ohanna (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM)); RABELO, Renata (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM)); TOLENTINO, Hélio (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM)); BENEDETTI, Celso (Brazilian Biosciences National Laboratory (LNBio-CNPEM)); TISDALE, Ripley (U.S. Department of Agriculture and NC State University); WESTFAHL, JR., Harry (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM))

Presenter: HESTERBERG, Dean (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM))

Session Classification: Agricultural Engineering & Systems Modeling

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **48** Type: **Poster**

Characterizing Calcium Supply in Tomato Fruit Development Using Sr2+ as a Physiological Marker

Thursday, 13 July 2023 15:30 (1 hour)

Calcium is a macronutrient that plays in all stages of development of tomato fruit such as cell division, cell metabolism, cell wall formation, and fruit maturation. The Ca concentration in these stages showed a decreasing profile as the fruit developed. Since Ca reaches upper plant tissues through root-to-shoot uptake, its supply is strongly reduced as the xylem loses its functionality in fruits, thereby inducing several Ca-related physiological disorders, such as blossom end-rot, as well as a significant reduction in productivity. In this regard, we aim to characterize the Ca tomato supply during tomato fruit development using Sr2+ as a physiological marker. The roots of tomato plants were exposed to a nutrient solution with Sr spiked at 40 mg/L for 36h, afterward, fruits at different phenological stages were harvested. Synchrotron analysis carried out in longitudinal freezing dried slices of tomato fruits showed Sr2+ distributed throughout the fruit in the initial stages of development. On the other hand, fruits at the cell expansion stage showed Sr2+ concentration mainly at the base, indicating that the root supply of Ca2+ is reduced in the cell expansion phase which lowers Ca2+ at the top of the tomato fruit.

Primary author: SANTOS, Eduardo (University of Sao Paulo)

Presenter: SANTOS, Eduardo (University of Sao Paulo)

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **50** Type: **Oral Presentation**

CARNAÚBA: a Multi-analytical X-ray Nanoprobe Beamline of Sirius with Applications in Agro-environmental Sciences

Wednesday, 12 July 2023 16:00 (15 minutes)

CARNAÚBA is an acronym for Coherent X-ray Nanoprobe Beamline, which is a nanofocused, multi-analytical and coherent X-ray imaging beamline of Sirius, the 4th generation synchrotron source of the Brazilian Synchrotron Light Laboratory. Its design is all-achromatic mirror-based optics, with a 4-bounce Si(111) crystal monochromator (4CM) that provides resolving power of ⊠E/E =10-4 in monochromatic mode, and KB (Kirkpatrick-Baez) mirrors, which allows beam nanofocusing in two experimental stations: TARUMÃ (Tender-to-hard X-ray for sub-micro analysis), which works with submicrometric beam and variable sample environment; and, SAPOTI (Scanning Analysis by Ptycho for Tomographic Imaging), with nanometric beam (30 nm x 30 nm) working in cryogenic and ultra-high vacuum environment. CARNAÚBA covers the energy range from 2.05 to 15 keV and works in both pink (high flux) and monochromatic beams (high energy resolution) modes, with capabilities for 2D and 3D experiments based on X-ray absorption and X-ray scattering that includes: X-ray diffraction (XRD), X-ray absorption (XAS), X-ray fluorescence (XRF), X-ray excited optical luminescence (XEOL), Bragg and ptychographic coherent diffraction imaging (Bragg-CDI and ptycho-CDI). The TARUMÃ endstation is the first in operation, with innovative instrumentation solutions for experiments in-situ, in-operando, in-vivo, and cryogenic, covering a large scientific program that ranges from agriculture, soils and plant science, cultural heritage, biology, geophysics, catalysis, to energy materials, and other areas In this talk, a general overview of the Carnauba beamline along with a description of several dedicated arrangements for the TARUMÃ endstation will be presented. This presentation will also show a number of examples of 2D and imaging capabilities of the CARNAÚBA beamline for samples of relevance for agricultural sciences (minerals, plants, roots, etc.).

Primary authors: PÉREZ, Carlos (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM)); TOLENTINO, Hélio (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM))

Presenter: PÉREZ, Carlos (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM))

Session Classification: Fundamental research and in vivo studies

Contribution ID: **51** Type: **Poster**

High throughput mail-in operations for soft x-ray analysis of soils

Wednesday, 12 July 2023 16:30 (1 hour)

The speciation of C and N in soils using x-ray absorption spectroscopy is an important capability for soil research as it requires minimal sample pre-treatment and provides improved characterization of mineral associated organic material. One of the main limitations of the technique is the low throughput associated with limited synchrotron access, difficult sample transfer processes and the long data acquisition times that are typically necessary for high quality measurements. To address these issues, a high throughput mail-in service has been developed for the SGM Beamline at the Canadian Light Source. Standardization of the sample preparation and sample on-boarding processes have facilitated the measurement of large numbers of soils with minimal supervision from beamline staff. Several improvements in automation have greatly improved efficiency. Data access through the beamline website allows for remote access and on-line data reduction. This mail-in service is now available through the standard proposal submission system at the CLS and is provided at a nominal cost to users.

Primary author: REGIER, Tom (Canadian Light Source)

Co-authors: DYNES, James (Canadian Light Source); Dr ARTHUR, Zachary (Canadian Light Source); Mr PEDERSEN, Tor (Canadian Light Source)

Presenter: DYNES, James (Canadian Light Source)

Session Classification: Poster Session 1

Track Classification: Poster Session

Contribution ID: **59** Type: **Oral Presentation**

Agriculture research at the Advanced Photon Source: Current activities and future opportunities

Tuesday, 11 July 2023 14:05 (20 minutes)

Synchrotron light sources have provided x-ray-based tools that supported a wide range of research in biological, geological, geochemical, and environmental sciences for decades. The ongoing generational upgrade of the Advanced Photon Source (APS) facility takes advantage of a new light source design, better instrumentation, and novel methods. When completed, the upgraded APS will be one of the world's brightest light sources, delivering x-rays up to 500 times brighter than today. The upgrade project also includes the building of new feature beamlines to make use of the increased brightness and coherence of the x-ray beams, and various enhancements to most of the existing beamlines. The high energy will allow users to probe unaltered large bulk samples with scientific relevance. The high brightness will provide macroscopic fields of view with nanometer resolution. The high coherence will enable highest spatial resolution even in most heterogeneity environment. All these characteristics will position the APS to be one of the best x-ray light sources for imaging applications, revolutionizing many scientific disciplines. This talk will provide an overview of the relevant research projects carried out at the APS in agriculture research and address future opportunities after the APS upgrade.

Presenter: FINFROCK, Zou (Argonne National Laboratory)

Session Classification: X-ray Methods & Resources for Agricultural Science

Contribution ID: **63** Type: **Poster**

Plant cell wall structural studies during thermochemical deconstruction using neutron scattering

Thursday, 13 July 2023 16:30 (1 hour)

The Center for Structural Molecular Biology (CSMB) at Oak Ridge National Laboratory (ORNL) is a national user facility funded to support and develop the user access and science research program of the Biological Small-Angle Neutron Scattering (Bio-SANS) instrument at the High Flux Isotope Reactor (HFIR). Bio-SANS is dedicated to the analysis of the structure, function and dynamics of complex biological systems. The CSMB also operates a Bio-Deuteration Laboratory located at the Spallation Neutron Source (SNS) for deuterium labeling of biological macromolecules in support of the biology neutron scattering program. This resource complements capabilities at other Department of Energy (DOE) Office of Biological and Environmental Research (OBER) facilities for structural biology, and also supports studies of biomass recalcitrance and biomembranes as part of the DOE Genomic Science Program. In-situ small-angle neutron scattering (SANS) and molecular dynamics (MD) computer simulation were used in a combined approach to examine real-time breakdown of biomass through acidic, basic and ionic liquid thermochemical reactions. Cellulose, a major carbohydrate in biomass is understood to undergo significant change, between crystalline and non-crystalline states. Most enzymes optimally hydrolyze amorphous cellulose to ethanol than crystalline cellulose. Consequently, thermochemical reactions have been targeted to disrupt the crystalline state of cellulose. Here, we report real-time SANS experiments during dilute acid and alkali pretreatment of poplar using a bulky reaction cell. Dilute acid, like most acidic pretreatments exhibit an increase in the crystallite dimensions of the cellulose microfibril. While alkali pretreatment does not show a change in the cellulose microfibril dimension even though during the treatment significant shrinking and swelling in the cellulose microfibril was observed. Overall, these results highlight the evolution of cellulose microfibril structure when subjected to different thermochemical reactions.

Primary authors: Dr PINGALI, Sai Venkatesh (Oak Ridge National Laboratory); Dr O'NEILL, Hugh (Oak Ridge National Laboratory); Dr DAVISON, Brian (Oak Ridge National Laboratory)

Presenter: Dr PINGALI, Sai Venkatesh (Oak Ridge National Laboratory)

Session Classification: Poster Session 2

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **64** Type: **Poster**

High Resolution Soft X-ray Ptychography at the Cryo STXM endstation, Spectromicroscopy (SM) Beamline, Canadian Light Source.

Thursday, 13 July 2023 16:30 (1 hour)

Ptychography is a lensless X-ray diffraction microscopy technique [1,2,3] in which the sample is scanned at pre-defined positions collecting far-field diffraction patterns at each of these scanning positions. The diffraction patterns along with the information regarding the scan positions are then processed using iterative phase retrieval algorithms resulting in high resolution complex transmission function of the sample. Unlike techniques like transmission X-ray microscopy (TXM), Fourier transform holography (FTH) or scanning transmission X-ray microscopy (STXM), the resolution doesn't depend on the focusing optics or the reference aperture, but on the detectable signal contained in the measurable inverse space. While other parameters such as beam stability and stage accuracy play an important role, the fundamental limitation on obtainable resolution is the measurable inverse space. We have implemented an experimental geometry wherein the detector in the Cryo STXM endstation can be positioned at 35 mm behind the sample. This enabled us to carry out high resolution ptychography at the Cryo STXM endstation of the soft X-ray spectromicroscopy beamline, Canadian Light Source [4]. We will report on the experimental and algorithmic details of the imaging setup along with the results obtained. We will also take this opportunity to report on the newly acquired in-situ, in-operando capabilities of the SM beamline.

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Primary authors: KUPPILI, Venkata Sree Charan (Associate Scientist); DYNES, James (Canadian Light Source); Mr LU, Yingshen (Canadian Light Source); Dr KARUNAKARAN, Chithra (Canadian Light Source); Dr WANG, Jian (Canadian Light Source)

Presenter: KUPPILI, Venkata Sree Charan (Associate Scientist)

Session Classification: Poster Session 2

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **65** Type: **Oral Presentation**

Quantifying water fragmentation within soil pores by dual-energy X-ray CT

Friday, 14 July 2023 10:00 (15 minutes)

Soil pore structure plays a key role in transport and fate of soil chemicals, gases, microorganisms, and defines rates of biogeochemical reactions. Marked heterogeneity of soil solid and pore spaces and complexity of the pore networks lead to formation of highly spatially and temporally variable zones of enhanced microbial activity. Such zones are commonly referred to as "hot spots" and "hot moments" and their formation requires sufficient supply of water and oxygen to ensure enhanced microbial functioning. Classical capillary model of soil water retention, which assumes sequential filling and draining of pores according to their size distribution, cannot explain either occurrences of "hot spots" and "hot moments" or high spatial diversity of microbial communities at pore scale. A meniscus water retention model, free of assumptions about incremental saturation/drainage of different pore-size classes, is a recently developed alternative to the capillary model. Which of the two models is more appropriate for explaining mobility of soil microorganism within the pore networks is still debated due to the absence of methods for soil water quantification at pore scale. While visualizations of water distribution within the soil pore network have been conducted for decades, its quantification remains challenging. We developed an approach for quantifying pore saturation based on changes of iodine mass attenuation within increasing beam energy after introducing KI solution into the soil. We implemented this approach to quantify redistribution of water in soil pores at 5 levels of soil water saturation. Image analyses showed: (i) surprisingly high fragmentation (discontinuity) of soil moisture in highly connected pore systems; and (ii) partial saturation of multiple pore-size groups within a wide range of soil water contents. These results support the meniscus model and reject the capillary model of soil water retention, and better explain the spottiness of microbial activity in soils at a pore scale.

Primary authors: Prof. GUBER, Andrey (Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI USA); Dr RIVERS, Mark (Department of Geophysical Sciences and Center for Advanced Radiation Sources, University of Chicago, USA); Prof. KRAVCHENKO, Alexandra (Department of Plant, Soil and Microbial Sciences Michigan State University)

Presenter: Prof. GUBER, Andrey (Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI USA)

Session Classification: Agricultural Engineering & Systems Modeling

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **66** Type: **Poster**

Characterizing Phosphorus in Agriculture and the Environment at the Nanoscale

Wednesday, 12 July 2023 16:30 (1 hour)

Characterizing Phosphorus in Agriculture and the Environment at the Nanoscale

Phosphorus (P) is a key nutrient in fertilizers. Yet it is sourced from non-renewable resources, is inefficiently utilized, and accumulates in terrestrial systems such as soils and freshwater resources, causing harmful algal blooms and fish kills. Advanced characterization techniques are needed to understand the cycle of P in the environment, the various forms in which it exists, and to facilitate its recovery and reuse as recycled fertilizers. This talk will introduce our work to advance the characterization techniques underpinning the identification and characterization of inorganic and organic phosphorus compounds using X-ray scattering and microscopy tools including but not limited to electron energy loss spectroscopy (EELS) in the transmission electron microscope and extended X-ray absorption fine structure (EXAFS). We will also introduce a recently-funded NSF Science and Technology Center, the Science and Technologies for Phosphorus Sustainability (STEPS) Center. STEPS is a convergence research center that addresses challenges in phosphorus sustainability by integrating disciplinary contributions across the physical, life, social, and economic sciences.

Primary authors: JONES, Jacob (North Carolina State University); Ms TRUBCHANINOV, Elizabeth (NC State University)

Presenter: JONES, Jacob (North Carolina State University)

Session Classification: Poster Session 1

Track Classification: Poster Session

Contribution ID: **67** Type: **Poster**

Optimizing Nutrient Use Efficiency via Manipulation of Their Reaction Pathways in Soils

Thursday, 13 July 2023 16:30 (1 hour)

Discoveries in soil chemistry have benefited human health by enhancing our food, water, and air quality and remediating contaminated soils and waters. Soil chemical principles-based discoveries have been deployed and adopted to solve agricultural and environmental problems, including developing new fertilizer technologies and science-based-management practices to improve fertilizer-use efficiency. Although tremendous improvements have been made in this area in recent decades, nutrient overloading causes environmental concerns at multiple scales. Also, the global scarcity of nutrients, such as phosphorus, is expected to be one of the most significant barriers to food production in the near future. To remedy this issue, extensive research has been conducted on increasing plant acquisition efficiency of nutrients applied to the soil. As a result, various commercial fertilizer sources and co-additives have been developed with the intention of controlling the reaction products of nutrients in the soil through the alteration of dissolution and other reaction pathways. Synchrotron X-ray-based techniques, such as bulk XAS and spatially resolved micro-XRF and micro-XAS, serve as a direct way to probe nutrient speciation at the point of application and in the bulk soil. Combining wet chemical, imaging, and spectroscopic techniques can enhance our understanding of reaction products and pathways with less uncertainty, facilitating the development of next-generation fertilizers better tuned to plant needs.

Primary author: Prof. HETTIARACHCHI, Ganga (Kansas State University)

Presenter: Prof. HETTIARACHCHI, Ganga (Kansas State University)

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **68** Type: **Poster**

Zn2+ ions are concentrated in the Euphorbia peplus laticifer network

Wednesday, 12 July 2023 16:30 (1 hour)

Euphorbia peplus (petty spurge, Euphorbiaceae) is an emerging developmental model system for the study of laticifers, the cells that produce and contain plant latex. In other plant families, synchrotron X-ray fluorescence has been used to image laticifers in intact plant leaves, e.g. to study hyperaccumulator species. Previous synchrotron X-ray fluorescence studies on *Euphorbia* latex exuded from a cut plant showed that Zn2+ ions are concentrated in the latex. We wanted to show that this was true *in vivo*, i.e. that Zn2+ ions are concentrated in laticifers in an intact *E. peplus* leaf. We imaged both lyophilized and fresh leaf samples, and confirmed that Zn2+ was concentrated in laticifers in leaves but not cotyledons. This result improves our knowledge of *Euphorbia* laticifers and paves the way for future experiments in hormonally-treated plants and/or transcriptomically silenced plants.

Primary authors: JOHNSON, Arielle (Cornell University); SMIESKA, Louisa; Dr FRANK, Margaret (Cornell University)

Presenter: JOHNSON, Arielle (Cornell University)

Session Classification: Poster Session 1

Track Classification: Poster Session

Contribution ID: **70** Type: **Oral Presentation**

μ-SXRF reveals the role of Arabidopsis Oligopeptide Transporter 3 (AtOPT3) in shoot-to-root copper signaling and copper-iron crosstalk

Wednesday, 12 July 2023 14:30 (15 minutes)

Micronutrients copper (Cu) and iron (Fe) are essential for plant growth but can be toxic when over-accumulated in cells. Thus, plants tightly regulate their root uptake systems to prevent deficiency while avoiding toxicity. This includes balancing Cu/Fe accumulation via the Cu-Fe crosstalk and systemic shoot-to-root signaling through the phloem to report the shoots' demand. However, only systemic Fe deficiency response has been documented. It involves *Arabidopsis thaliana* oligopeptide transporter 3 (AtOPT3) that transports Fe into the phloem companion cells to reflect the real-time Fe status of the shoots to the roots. Here, we show that AtOPT3 also plays an important role in delivering Cu into the phloem and is essential for the systemic signaling of Cu deficiency. Loss of OPT3 function restricted the Cu movement from the xylem to the phloem, and the images of confocal SXRF confirmed the altered distribution of Cu in the vascular tissues of the *opt3* mutant. Also, the 2D-SXRF analysis on different tissues shows that Cu remobilization via phloem is impaired in the *opt3* mutant. The mutant retained Cu in the mature leaves and failed to deliver Cu into the fast-growing tissues, e.g., developing seeds. We further found that the low abundance of Cu in the phloem of the *opt3* mutant triggered the shoot-to-root signals of Cu deficiency and caused the constitutive upregulation of the Cu uptake in the roots. Surprisingly, feeding the *opt3* mutant with Cu or Fe via the phloem in leaves suppressed both Cu- and Fe-deficiency responses in roots. These data suggest the existence of shoot-to-root Cu signaling, highlight the complexity of Cu/Fe interactions, and the role of AtOPT3 in fine-tuning root transcriptional responses to the plant Cu and Fe needs.

Primary author: CHIA, Ju-Chen (Plant Biology, School of Integrative Plant Science, Cornell University)

Co-authors: WOLL, Arthur (Cornell High Energy Synchrotron Source); SMIESKA, Louisa (Cornell High Energy Synchrotron Source); HUANG, Rong (Cornell High Energy Synchrotron Source); TAPPERO, Ryan (National Light Source II, Brookhaven National Laboratory); KISS, Andrew (National Light Source II, Brookhaven National Laboratory); YAN, Jiapei (Soil and Crop Sciences, School of Integrative Plant Science, Cornell University); FAULKNER, Marta (Soil and Crop Sciences, School of Integrative Plant Science, Cornell University); SIMONS, Eli (Soil and Crop Sciences, School of Integrative Plant Science, Cornell University); JIAO, Chen (Boyce Thompson Institute for Plant Research); FEI, Zhangjun (Boyce Thompson Institute for Plant Research); PIÑEROS, Miguel (Robert W. Holley Center for Agriculture and Health, USDA-ARS); VATAMANIUK, Olena K (Plant Biology, School of Integrative Plant Science, Cornell University)

Presenter: CHIA, Ju-Chen (Plant Biology, School of Integrative Plant Science, Cornell University)

Session Classification: Fundamental research and in vivo studies

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **71** Type: **Poster**

Climate vulnerability of iron-associated soil organic matter: insights from synchrotron-based X-ray absorption spectroscopy

Thursday, 13 July 2023 16:30 (1 hour)

Physicochemical interactions between soil organic matter (SOM) and iron (Fe) minerals contribute to long-term protection and storage of organic carbon in soils. However, the persistence of Fe-stabilized SOM depends on environmental controls on the redox state and solubility of Fe. In this work, we show that frequent wet-dry cycles in mineral soils result in distinct Fe-SOM interaction processes with implications for the microbial mineralization of Fe-associated SOM under changing moisture regimes. We used a suite of synchrotron-based X-ray absorption spectroscopy (XAS) measurements to probe Fe redox state, Fe crystallinity, Fe-SOM bonding, and chemical composition of SOM in model Fe-SOM systems and in soils with frequent wet-dry cycling. These analyses were conducted at the Canadian Light Source SGM endstation (C K-edge) and the CHESS F3 endstation (Fe K-edge). Paired with high spatial-resolution mapping of metal-SOM associations, we showed that (1) oxidized Fe(III)-SOM interactions are lost and (2) reduced Fe(II) is preferentially stabilized under conditions that favor frequent dissolution and co-precipitation of Fe and SOM. Using short-term (14-d) incubation experiments, we showed that microbial SOM mineralization increased 3-fold after soils with frequent wet-dry cycles in the field were exposed to persistently dry conditions. Based on preliminary 16S sequencing results, this response co-occurred with a shift in the relative abundance of bacterial taxonomic families. This microbial community response was unique to historically variably saturated soils, pointing towards a tightly coupled relationship among Fe biogeochemical transformations, microbial community processes, and SOM cycling. In ongoing work, we are developing approaches for higher-throughput characterization of soil mineralogical characteristics using X-ray excitation-emission matrix spectroscopy (EEMS), enabling rapid tracking of temporally variable Fe-SOM transformations as described here. Collectively, these findings illustrate how synchrotron-based characterization can inform new perspectives on environmental processes critical for understanding ecosystem response to global change.

Primary author: POSSINGER, Angela (Virginia Tech)

Co-authors: BADGLEY, Brian (Virginia Tech); ARTHUR, Zachary (Canadian Light Source); DYNES, James (Canadian Light Source); LEHMANN, Johannes (Cornell University); REGIER, Tom (Canadian Light Source); SPOTSWOOD, Abby (Virginia Tech); SCOTT, Durelle (Virginia Tech); STRAHM, Brian (Virginia Tech)

Presenter: POSSINGER, Angela (Virginia Tech)

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **72** Type: **Poster**

Probing the Fate of Siderophores in Soils through Gallium X-ray Absorption Spectroscopy

Thursday, 13 July 2023 16:30 (1 hour)

Approximately one third of global land area is covered by high pH, alkaline soils that are deficient in one or more essential elemental nutrients, potentially limiting the productivity of agricultural crops. Nutrient deficiencies, especially iron (Fe), can stem from the insolubility of the metal, preventing their dissolution and limiting bioavailablity. Iron deficiency causes anemia in more than 2 million people worldwide, especially affecting woman and children. This health crisis has been exacerbated by the need to increase yield of crops, which has prioritized overall yield above micronutrient nutritional content. To combat Fe deficiencies, plants, bacteria, and fungi have developed specific uptake strategies, such as the production of siderophores, a structurally diverse class of strong Fe(III) complexing agents exuded to facilitate the solubilization and uptake of essential nutrients from soils. Historically, tracking the fate Fe-siderophore complexes in soils has proven difficult because of the abundant iron phases in soils. To solve this issue, we are using gallium (Ga) complexes with the model siderophore desferrioxamine-B (DFOB) to probe siderophore fate in soil environments. We conducted experiments to study the sorption of Ga-DFOB complexes to the surfaces of common soil minerals. Extended X-ray absorption near edge structure (EXAFS) spectroscopy analysis showed that Ga was separated from the siderophore by ferrihydrite and birnessite, but intercalated as a whole complex into montmorillonite clay. Spatially resolved X-ray fluorescence analysis of Ga-DFOB reacted with a Casville soil revealed hotspots where Ga or Ga-DFOB complexes associated with specific minerals. This work is improving our understanding of siderophore function to determine factors limiting micronutrient uptake in crops to aid in the development of better management strategies to improve crop yields and nutritional content. Future work will focus on expanding to other siderophores to see how different structures affect sorption and fate in soils.

Primary author: EVERS, Anna (North Carolina State University)

Co-author: Dr DUCKWORTH, Owen (North Carolina State University)

Presenter: EVERS, Anna (North Carolina State University)

Session Classification: Poster Session 2

Track Classification: Focus on Food: Security, Toxicity, and Sustainability

Contribution ID: **74** Type: **Oral Presentation**

Small-Angle X-ray Scattering Fundamentals

Tuesday, 11 July 2023 10:00 (30 minutes)

Presenter: BYER, Amanda (Cornell University)

Session Classification: X-ray Methods & Resources for Agricultural Science

Contribution ID: **75** Type: **Oral Presentation**

Modern X-ray Methods: X-ray spectroscopy

Tuesday, 11 July 2023 09:30 (30 minutes)

Chris Pollock

Presenter: POLLOCK, Chris (CHESS)

Session Classification: X-ray Methods & Resources for Agricultural Science

Contribution ID: **76** Type: **Oral Presentation**

Synchrotron x-ray imaging methods

Tuesday, 11 July 2023 11:00 (30 minutes)

Presenter: POLO, Carla Cristina (The Brazilian Synchrotron Light Laboratory (LNLS-Brazil))

Session Classification: X-ray Methods & Resources for Agricultural Science

Contribution ID: **77** Type: **Oral Presentation**

Full-Field and Scanning Probe X-ray Microscopy as Tools for Elemental and Chemical Imaging

Tuesday, 11 July 2023 11:30 (30 minutes)

Presenter: PÉREZ, Carlos (Brazilian Synchrotron Light Laboratory (LNLS-CNPEM))

Session Classification: X-ray Methods & Resources for Agricultural Science

Contribution ID: **78** Type: **Oral Presentation**

Sponsored Talk: Decentralization of Synchrotron X-ray Fluorescence Microscopy: Recent Advances in Lab Based µXRF

Tuesday, 11 July 2023 13:00 (45 minutes)

Synchrotrons accelerate and bend electron beams in order to create tangential, high flux photons across a wide energy range. While synchrotrons are quite difficult to access with very expensive beamtime, there are several powerful analytical modalities accessible through this approach including X-ray crystallography, infrared microscopy, powder diffraction, X-ray absorption spectroscopy, and others. Here we discuss X-ray fluorescence microscopy (XFM), another powerful application associated with Synchrotrons, and how recent advances in lab based µXRF (micro X-ray fluorescence) spectroscopy can be used to inform proper synchrotron design of experiment and substitute for difficult to access synchrotron beamtime. Lab based µXRF instruments now allow decentralized access to high spatial resolution elemental mapping of samples down to 5 µm spot excitation diameter. Data will be presented comparing synchrotron-generated elemental maps to lab based µXRF for several different sample types including cofactor migration tracking within biological tissue sections, element accumulation and distribution in plants, and minerology mapping.

Presenter: HELLESTED, Mandi (IXRF Systems, Austin, TX)

Session Classification: X-ray Methods & Resources for Agricultural Science

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **79** Type: **Oral Presentation**

Micron-Scale Confocal X-ray Fluorescence Imaging

Tuesday, 11 July 2023 15:10 (20 minutes)

We describe and present examples of synchrotron-based confocal x-ray fluorescence microscopy (CXRF) employing custom-fabricated collimating channel array optics (CCAs), developed at the Cornell High Energy Synchrotron Source, which permit CXRF to be performed with micron-scale, achromatic resolution. Subsequent to their development, CHESS-fabricated CCAs have been employed as part of the APS general user program since approximately 2016, and were implemented at NSLS-II in 2019 specifically to study micronutrient transport, signaling, and homeostasis in plants. Compared to CXRF with polycapillair optics, CCA-based CXRF permits colocalization of elements with very different fluorescence energies, such as potassium, calcium, iron and zinc, as well as permitting visualization of individual cells, permitting evaluation of elemental concentration differences among different tissue types. Compared to micro-XRF computer tomography, CCA-based CXRF overcomes some of the sample-size constraints associated with CT, particularly at low XRF energies. Apart from new imagery, we present novel characterization of CXRF performance, including quantitative evaluation of the elemental yield and solid angle of collection as a function of energy.

Presenter: WOLL, Arthur (CLASSE)

Session Classification: X-ray Methods & Resources for Agricultural Science

Contribution ID: **80** Type: **Oral Presentation**

Chemical Imaging of Plant-Soil-Microbe Systems at SSRL: Resources and Capabilities

Tuesday, 11 July 2023 14:50 (20 minutes)

Presenter: RICHARDSON, Jocelyn (SLAC National Accelerator Laboratory)

Session Classification: X-ray Methods & Resources for Agricultural Science

Contribution ID: **81** Type: **not specified**

Extended Q&A and Informal Discussion

Tuesday, 11 July 2023 15:30 (1 hour)

Contribution ID: **82** Type: **Poster**

Design and Performance of High Frame Rate sCMOS Cameras for Direct and Indirect X-Ray Detection

Wednesday, 12 July 2023 16:30 (1 hour)

The development of higher brilliance and faster repetition rate X-Ray sources offer higher throughput analysis opportunities for applications based on Tomography, Coherent Diffraction Imaging (CDI) or Ptychography. These benefits can be exploited with the recent advances in sCMOS (scientific Complementary Metal-Oxide Semiconductor) image sensors, which offer a unique combination of fast frame rates, high sensitivity thanks to ultra low-noise floor (<2e-) and high Quantum Efficiency (QE up to 95%), high dynamic range to yield highest contrast data and large area/small pixels options.

The recent introduction of direct detection sCMOS sensor versions now also offer high spatial and energy resolution options in the EUV range.

An overview of sCMOS architecture and performance is presented, with comparison to slower CCD (charge-coupled device) image sensors. Recently-developed back-illuminated sCMOS sensors are compared with previous generations of front-illuminated designs. Performance of direct versus indirect x-ray detection is compared, and an overview of scintillator types and optical coupling strategies is reviewed.

Finally, we give a brief overview of several applications that benefit from faster measurement throughput and other advances enabled by these technological improvements, including phase contrast X-ray tomography of soft tissue samples and high-harmonic generation spectroscopy.

Primary authors: WISE, Adam (Andor Technology); Dr VARAGNAT, Antoine (Andor Technology)

Presenter: WISE, Adam (Andor Technology)

Session Classification: Poster Session 1

Track Classification: Poster Session

Contribution ID: **83** Type: **Oral Presentation**

XRF Imaging as a Tool for the Study of Regulation of Metal Homeostasis in Plants: Implications to Food Security and Nutritional Quality.

Wednesday, 12 July 2023 15:30 (30 minutes)

Presenter: VATAMANIUK, Olena K (Plant Biology, School of Integrative Plant Science, Cornell University)

Session Classification: Fundamental research and in vivo studies

Contribution ID: **86** Type: **not specified**

Facility Update - CHESS: Progress and Opportunities

Wednesday, 12 July 2023 13:30 (30 minutes)

Louisa Smieska

Presenters: SMIESKA, Louisa; WOLL, Arthur (CLASSE)

Session Classification: Facility Updates

Contribution ID: **87** Type: **not specified**

Facility Update - LNLS

Thursday, 13 July 2023 09:00 (30 minutes)

Presenter: HESTERBERG, Dean (LNLS-CNPEM)

Session Classification: Facility Updates

Contribution ID: **88** Type: **Oral Presentation**

The Periodic Table of Food: Metadata Harmonization from Point-of-Production to Plate

Thursday, 13 July 2023 11:00 (30 minutes)

The Periodic Table of Food Initiative (PTFI) is a global initiative to create an open, publicly accessible database, not only to catalog the world's edible biodiversity but to understand the association between food composition, human health, and planetary health. Yet food composition data are rarely interoperable, making it difficult to aggregate, analyze, and draw conclusions from data drawn from disparate sources. The successful implementation of the PTF initiative, which relies on decentralized collection and analysis of food, hinges on ensuring a standardized description of all food items and associated metadata. Thus, we have adopted in-house and two widely recognized, community-maintained ontologies: the Food Ontology (FoodOn) and the NCBI Taxonomy. The PTFI Core metadata encompasses 35 metadata elements, each serving to describe the collection event (i.e., when the food was collected), the collected food specimen itself (e.g., Food Product Internationalized Resource Identifier or IRI), and the derived sample(s). The elements are organized in 3 modules: collection event, specimen and sample. Fields contain either single-select or multi-select values. The PTFI Core metadata are captured at the point-of-production through a simple user interface, and then stored in the PTFI sample management system. By leveraging FoodOn, the PTFI can establish a standardized framework for data representation, enabling effective data sharing and interoperability across food systems from point-of-production to plate. Reflecting on the reciprocal nature between the PTFI and FoodOn, we envision a positive feedback loop shaping the evolution of FoodOn toward the betterment of food systems research. For future extension metadata, to include regenerative agricultural practices, we again consulting existing ontologies combined with our own framing to capture agricultural practices that may be influencing food composition and health.

Primary author: BRINKLEY, Sarah (Alliance of Bioversity International and CIAT)

Co-authors: GALLO FRANCO, Jenny Johana (Alliance of Bioversity International and CIAT); LAPORTE, Marie Angelique (Alliance of Bioversity International and CIAT); RAJESEKHARAN, Maya (Alliance of Bioversity International and CIAT); CHIEN, Chi-Ming (Verso Biosciences); DE LA PARRA, John (The Rockefeller Foundation); AHMED, Selena (The American Heart Association); PRENNI, Jessica (Colorado State University); ARNAUD, Elizabeth (Alliance of Bioversity International and CIAT)

Presenter: BRINKLEY, Sarah (Alliance of Bioversity International and CIAT)

Session Classification: Focus on Food: Security, Toxicity, Sustainability

Contribution ID: **89** Type: **not specified**

Facility Update - CLS

Friday, 14 July 2023 09:00 (30 minutes)

Presenter: Prof. BOTTON, Gianluigi (CLS)

Session Classification: Facility Updates

Contribution ID: **90** Type: **not specified**

Inorganic nanomaterials: their applications and implications in agriculture and food safety

Presenter: PARKASH DHANKHER, Om (UMass Amherst)

Session Classification: Agricultural Engineering & Systems Modeling

Contribution ID: **92** Type: **not specified**

Welcome, Acknowledgements, Announcements

Wednesday, 12 July 2023 09:20 (10 minutes)

PALSA Organizers

Presenters: WOLL, Arthur (CLASSE); SMIESKA, Louisa

Session Classification: PALSA & Workshop Check in: Coffee and light breakfast fare provided.

Contribution ID: **94** Type: **Oral Presentation**

Inorganic Nanomaterials: Their Applications and Implications in Agriculture and Food Safety

Friday, 14 July 2023 11:30 (15 minutes)

The widespread use of metal-based nanoparticles (MNPs) can have significant applications and implications in agriculture and the environment. Several MNPs have positively influenced plant growth and have been used as nano-fertilizers and nano-pesticides. However, their extensive use in agriculture and the environment may result in the increased accumulation of metals in agricultural soil that poses a threat to human health from food chain contamination.

We studied the effect of several MNPs such as nanoparticles of silver (AgNPs), Cu oxide (CuO NPs), and nanosulfur (NS), etc., in various crop species at physiological, biochemical, and molecular levels. In one study, we investigated the effect of silver nanoparticles (AgNPs) on soybean growth and nodule formation. Exposure to 32 and 64 ppm of AgNPs significantly affected growth and yield, reducing nodule weight by 40%, fresh shoot weight by 66%, and seed yield by 68% when compared to controls. However, equivalent doses of Ag+ ions and bulk Ag had no impact on the plants. Further, nanosulfur (NS) application in soil alleviated AgNPs toxicity, and importantly. Plants treated with NS with AgNP co-exposure accumulated significantly less Ag in the shoots, roots, and seeds. In another study, we studied the effect of nanoscale sulfur (NS) on counteracting the toxicity and accumulation of arsenic in rice. NS application showed fertilization effect and caused a 40% increase in seedling biomass and a 26% increase in seed yield, compared to untreated control plants. Arsenite (AsIII) exposure caused severe toxicity to rice; however, co-exposure of plants to AsIII and NS alleviated As toxicity. Further, NS application significantly decreased arsenic accumulation (50-75%) in rice shoots, roots, and grains. These findings demonstrate the potential of NS as a sustainable soil amendment to reduce the accumulation and toxicity of AgNPs and arsenic and as a valuable nano-enabled strategy to promote food safety and security.

Primary authors: DHANKHER, Om Parkash (Stockbridge School of Agriculture, University of Massachusetts Amherst MA 01003); Mr SHARMA, Sudhir (Stockbridge School of Agriculture, University of Massachusetts Amherst MA 01003); Dr WHITE, Jason (The Connecticut Agricultural Experiment Station, New Haven CT); Prof. XING, Baoshan (Stockbridge School of Agriculture, University of Massachusetts Amherst MA 01003)

Presenter: DHANKHER, Om Parkash (Stockbridge School of Agriculture, University of Massachusetts Amherst MA 01003)

Session Classification: Agricultural Engineering & Systems Modeling

Track Classification: Agricultural Engineering and Systems Modeling

Contribution ID: **95** Type: **not specified**

Outlook and Opportunities – The School of Integrative Plant Science at Cornell

Wednesday, 12 July 2023 09:30 (30 minutes)

Presenter: NELSON, Rebecca (Associate Director of Research, SIPS, Cornell University)

Session Classification: Grand Challenges in Agricultural Science

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **96** Type: **Poster**

Mogno, A Versatile Micro and Nano X-ray Imaging Beamline: Applications in Agrigultural Sciences

Thursday, 13 July 2023 16:30 (1 hour)

MOGNO beamline, from the 4th generation Light Source in Brazil, Sirius, will be focused on high throughput, time resolved experiments and multi-scale analysis. This beamline will work in high energies (22, 39 keV, and 67.5 keV), with a cone beam geometry that enables continuous magnification of the image, from ~55 μm to ~120 nm, known as zoom-tomography. In addition, MOGNO will be equipped with a high-Z direct area-detector that provides a maximum field of view of ~85x85 mm2. In the agricultural sciences, this means it is possible to measure a soil monolith in a large field of view, aiming to detect for instance macropores and primary roots, and zooming into inter- and intra-aggregate pore zones, where most of the micropores are found, often near root hairs, defining the rhizosphere region. In addition, the high photon flux and the direct area-detector will allow fast data acquisition, in which experiments are resolved both in space and time (4D). This will benefit studies of soil functions such as storage and distribution of water. The other relevant aspect to be considered for innovative soil studies relies on the possibility to scan samples in contact and phase contrast image regimes. The phase contrast regime arises as the sample to detector distance increases, due to the free propagation of the X-ray wave refraction caused when it crosses any material interface, thus greatly benefiting biological samples. This configuration, allied with robust phase retrieval algorithms which are under development by the Scientific Computing Group (GCC/LNLS), are hoped to allow the identification of organic matter inside soil samples without the need of staining procedures. Therefore, the goal of this work is to present the new opportunities that are becoming available with this cutting-edge technique applied in agricultural studies. MOGNO is currently open to scientific commissioning with external users.

Primary author: ROSAS FERREIRA, Talita (CNPEM)

Co-author: LOPES ARCHILHA, Nathaly (Brazilian Synchrotron Light Laboratory (LNLS), Brazilian Center for Research in Energy and Materials (CNPEM))

Presenter: ROSAS FERREIRA, Talita (CNPEM)

Session Classification: Poster Session 2

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **97** Type: **Oral Presentation**

Edible synchtrotron science: cheese, chocolate and meat

Thursday, 13 July 2023 09:30 (30 minutes)

Climate change and lack of sustainable lifestyles are some of the most critical challenges of our civilization today. It is imperative to change our manufacturing systems and lifestyles to be in-tune with the carrying capacity of our planet. One of the largest contributors to greenhouse gas emissions, excessive water consumption and pollution is agriculture. By changing how we eat, we can have a large positive impact on sustainability. Many non-animal based foods have recently appeared in the market, promising similar eating experience to that of animal based foods, in particular cheese, meat and milk. Even though plant-based milks have progressed well and are accepted as a viable substitute, meat and cheese have not. The main barrier to the acceptance of meat analogues is texture, which is directly related to structure at different length-scales. High moisture extrusion, electrospun scaffolds, 3D printing, laminar shear processing, and other techniques are some of the ways of achieving similar functionalities tothose of muscle tissue (beef, pork, fish), or a piece of cheese. This talk will present a general overview of the synchrotron-based techniques used in our laboratory to help us guide our attempts to reverse engineer a food material's functionality. In particular, here we will show the development of plant-based cheese and meat using micro-CT, as well as mid-IR spectromicroscopy, as well as adipose tissue analogues using micro-CT. To top it off, we will also present a novel way to temper chocolate using self-assembled phospholipids. Here we show by micro-CT and small-angle X-ray scattering how the tempering process in chocolate is truly a multi-scale problem and how tempering at one length-scale, does not guarantee tempering at the next one, which is critical in the manufacture of good chocolate. The key role of synchrotron science in solving applied problems will be highlighted.

Primary authors: Prof. MARANGONI, Alejandro (University of Guelph); Mr STOBBS, Jarvis (Canadian Light Source Synchrotron); Ms DOBSON, Stacie (University of Guelph)

Presenter: Mr STOBBS, Jarvis (Canadian Light Source Synchrotron)

Session Classification: Focus on Food: Security, Toxicity, Sustainability

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **98** Type: **Poster**

Synchrotron X-ray Fluorescence (SXRF) Microscopy signifies the role of the micronutrient copper in the reproduction of Cu-deficient Arabidopsis thaliana mutants (spl7, citf1, and spl7 citf1) and wild type.

Wednesday, 12 July 2023 16:30 (1 hour)

It has been known for decades that the micronutrient copper is essential for plant growth, development, fertility, and seed/grain yield. However, which plant reproductive organs require copper, how copper is delivered to these structures, and how it acts to ensure fertility is not entirely understood. I will report our recent studies deriving from the use of synchrotron x-ray fluorescence microscopy (2D-SXRF) at the nanoscale, 3D and 2D confocal synchrotron x-ray fluorescence microscopy (2D and 3D C-SXRF) and 3D-SXRF-Computed Tomography that allowed us to establish the spatial distribution of copper in floral organs of a model plant Arabidopsis thaliana at different resolution scales. I will also discuss the role of two transcription factors in controlling copper uptake, internal transport, and delivery to the specific sites in flowers and the impact of these transcription factors on the development of the male and female gametophytes. Importantly, we show that the role of copper and these transcription factors in reproductive processes is conserved in other plant species. Our new data not only significantly increase our understanding of the role of copper in plant reproduction but also invoke the possibility of its signaling role in reproductive organ development.

Primary author: SHATOKHINA, H. (Cornell University)

Co-authors: CHIA, J.C. (Cornell University); RAHMATI ISHKA, M. (Cornell University); YAN, J. (Cornell University); YANG, Y. (Cornell University); SMIESKA, L. (Cornell University); FEI, Z. (Cornell University); VATAMANIUK, O.K. (Cornell University)

Presenter: SHATOKHINA, H. (Cornell University)

Session Classification: Poster Session 1

Track Classification: Fundamental Research and In Vivo Studies

Contribution ID: **99** Type: **not specified**

Cornell High Energy Synchrotron Source - Tour #1

Thursday, 13 July 2023 13:15 (1 hour)

Wilson Synchrotron Laboratory is home to one of the most powerful accelerators in the world, allowing scientists to harness the power of light to answer questions about the world around us. Take a tour of Wilson Lab to explore Cornell's historic synchrotron (including a tour of the underground tunnel), electron/positron storage ring (CESR), our x-ray experimental floor (CHESS), and peek into the future of synchrotron radiation research.

Session Classification: Facility Tours

Contribution ID: **100** Type: **not specified**

Cornell High Energy Synchrotron Source - Tour #2

Thursday, 13 July 2023 14:30 (1 hour)

Wilson Synchrotron Laboratory is home to one of the most powerful accelerators in the world, allowing scientists to harness the power of light to answer questions about the world around us. Take a tour of Wilson Lab to explore Cornell's historic synchrotron (including a tour of the underground tunnel), electron/positron storage ring (CESR), our x-ray experimental floor (CHESS), and peek into the future of synchrotron radiation research.

Session Classification: Facility Tours

Contribution ID: **101** Type: **not specified**

Liberty Hyde Bailey Conservatory

Thursday, 13 July 2023 14:30 (1 hour)

Passionate about plants? Or at least curious? Come visit the Liberty Hyde Bailey Conservatory, home to more than 600 species from around the planet. Our collection includes the world's smallest water lily and a pair of massive Titan arums, which produce the largest (and stinkiest) inflorescences in the plant kingdom. Many rare and endangered species, succulents, carnivorous plants, orchids (including one that you can eat) and more.

Session Classification: Facility Tours

Contribution ID: **102** Type: **not specified**

Weil Hall Plant Growth Facilities

Thursday, 13 July 2023 14:30 (1 hour)

Visitors will view the growth chambers at Weill Hall, which are designed to be highly energy efficient while carefully maintaining enviornmental conditions.

Session Classification: Facility Tours

Contribution ID: **103** Type: **not specified**

Stocking Hall Tour (Home of the Cornell Dairy Bar)

Thursday, 13 July 2023 14:30 (1 hour)

Session Classification: Facility Tours

Contribution ID: **104** Type: **Poster**

Formalin-fixed paraffin embedded animal tissue spatial elementomics using synchrotron X-ray fluorescence

Thursday, 13 July 2023 15:30 (1 hour)

Spatial evaluations are powerful tools in understanding function of structures within complex tissues. Distribution of elements within animal tissues are not commonly performed using X-ray fluorescence and represents an opportunity for expansion. Animal tissues are commonly preserved in formalin-fixed paraffin embedded (FFPE) blocks and large libraries of normal and diseases tissues are available. The FMB beamline at the Cornell High Energy Synchrotron Source measured XRF spatial maps of FFPE bovine ovaries using a 10 keV microbeam (3 x 13 μm2) to evaluate distribution of micronutrients such as calcium, zinc, and iron in different ovarian structures. We found that calcium is enriched in the cortical region of the bovine ovary. The cortex is the layer closest to the ovarian surface typically between 1 and 2 mm in thickness and is also the area where the ovarian oocyte reserves are located. Since the bovine ovary was previously fixed in formalin before being embedded in paraffin, it is possible that there was some interaction between the cortex and the formalin that occurred during the fixation process. To rule out formalin fixation as a cause for the calcium enrichment in the cortex, fresh bovine ovary sections (unfixed) was imaged using the same setup and a similar distribution of calcium enrichment at the cortex layer was observed. Enrichment of calcium in the cortex region of the ovary has not been described and further validation is required. FFPE specimen libraries could be good candidates for confocal XRF mapping to improve the lateral spatial resolution and reduce noise from surface contamination. Other possible use of synchrotron X-ray fluorescence in FFPE sections for agriculture includes studying the distribution of toxic metals in brain and placental tissues of agricultural animals.

Primary authors: CHEONG, Soon Hon (Cornell University); SMIESKA, Louisa

Presenter: CHEONG, Soon Hon (Cornell University)

Session Classification: Poster Session 2

Track Classification: Poster Session

Contribution ID: **106** Type: **Oral Presentation**

Delivering Cassava modified with RNAi technology for Resistance to Cassava Brown Streak Disease to Benefit East African Smallholder Farmers

Wednesday, 12 July 2023 10:00 (30 minutes)

Food and economic security for smallholder cassava farmers in sub-Saharan Africa is threatened by Cassava brown streak disease (CBSD). CBSD causes brown necrotic lesions within the storage roots, rendering them inedible and unmarketable. RNAi technology was applied to develop cassava with durable, high-level, resistance to CBSD. Sequences from the coat proteins (CP) of CBSV and UCBSV were fused to produce an inverted repeat construct and transgenic plants regenerated. Resistance to CBSD in the greenhouse and under field conditions in East Africa was correlated with the level of CP-specific siRNAs accumulated, with the best performing lines remaining disease free across multiple years in multiple locations in Kenya and Uganda. Best performing RNAi events underwent breeding programs, with the resulting F1 progeny lines inheriting the T-DNA and expressing CP-specific siRNAs in the predicted 1:1 ratio. F1 lines were cultivated over five 12-month growing cycles across six locations in Kenya and Uganda and selected for resistance to CBSD, Cassava mosaic disease and plus other farmer-required traits. A regulatory application was submitted to, and approved by the Kenyan National Regulatory Authority, to establish elite F1 lines within National Performance Trials. Parallel work has been initiated to develop the seed systems required to multiply and distribute CBSD resistant RNAi cassava to smallholder farmers in East Africa. Additional work has successfully stacked RNAi-mediated CBSD resistance with technology to elevate levels of iron and zinc in cassava storage roots to levels that would beneficially impact the nutritional status and health of cassava consumers. The presentation will illustrate the steps, processes and hurdles encountered in developing and delivering a modified orphan crop to smallholder farmers in Africa.

Primary author: TAYLOR, Nigel (Donald Danforth Center Plant Science Center)

Co-authors: KURIA, P. (Kenyan Agricultural and Livestock Research Organization, Nairobi, Kenya); WAGABA, H. (National Agricultural Research Organisation, Kampala, Uganda); WILLIAMS, E. (National Agricultural Research Organisation, Kampala, Uganda); OBIERO, H. (Kenyan Agricultural and Livestock Research Organization, Nairobi, Kenya); NARAYANAN, N. (Donald Danforth Plant Science Center, St Louis, MO); KAREMBU, M. (International Service for the Acquisition of Agri-biotech Applications, Nairobi, Kenya); IRAKI, B. (International Service for the Acquisition of Agri-biotech Applications, Nairobi, Kenya); KARIUKI, J. (Mennonite Economic Development Associates, Nairobi, Kenya); NDUWUMUREMYI, A. (Rwanda Agriculture and Animal Resources Development Board, Kigali, Rwanda); TARACHA, C. (Kenyan Agricultural and Livestock Research Organization, Nairobi, Kenya); NARAYANAN, N. (Kenyan Agricultural and Livestock Research Organization, Nairobi, Kenya); ALICAI, T. (Kenyan Agricultural and Livestock Research Organization, Nairobi, Kenya); MIANO, D. (Kenyan Agricultural and Livestock Research Organization, Nairobi, Kenya)

Presenter: TAYLOR, Nigel (Donald Danforth Center Plant Science Center)

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