STEWARDS OF THE FUTURE

Abstract Title	Author(s)	Presenting Author	Organizational Affiliation	Background, Motivation and Objectives:	Statement of Contribution/Methods:	Results, Discussion and Conclusions:
Plant Stress Monitoring in Plants using Nanocellulose Electrodes	James Reynolds, Mike Wilkins, Michael Daniele, and Alper Bozkurt	James Reynolds (James.Reynolds@ncsu.edu)	North Carolina State University	Scientists have known for quite some time that plants respond to stress with bioelectrical signals. The difficulty has been recording these signals in a manner that does not interfere with normal functions and over a long period of time. Our goal has been to observe the plant responses to stress in real-time using cutting edge technology.	Our nanocellulose electrodes allow for plant transpiration while measuring the electrical activity and characteristics of the plant tissue. We use a variety of electronics and techniques to actively record and analyze the plant's activity, which enables us to have near instantaneous feedback about a plant's current state over a long period of time.	We have observed bioelectrical stress responses to physical wounding, gaseous pollutants, and environmental changes. In addition, our electrodes have had no negative effects on plant growth or functionality after weeks to months of attachment. When combined with other sensors, this technique could provide valuable information about plant physiology, phenotyping, and health—benefiting both researchers and farmers alike. While this field is far from mature, we believe that studying electrical signaling in plants will be critical for understanding plant behavior.
Noninvasive Diagnosis of Tomato Late blight via Smartphone Fingerprinting of Leaf Volatiles	Zheng Li, Rajesh Paul, Taleb Ba Tis, Amanda Saville, Jeana Hansel, Jean B. Ristaino, and Qingshan Wei	Zheng Li (zli47@ncsu.edu)	North Carolina State University	Emerging and re-emerging plant diseases such as late blight disease caused by Phytophthora infestans is one of the most severe agricultural diseases, which accounts for an annual financial loss of nearly five billion dollars. Plant disease diagnosis conventionally relies on molecular technology that is complicated, time consuming, and constrained to centralized laboratories.	We developed a cost-effective smartphone-based volatile organic compound (VOC) fingerprinting platform that allows for noninvasive diagnosis of late blight by monitoring characteristic leaf volatile emissions in the headspace. This handheld device integrates a disposable colorimetric sensor array consisted of plasmonic nanocolorants and chemo-responsive organic dyes to detect key plant volatiles at ppm level detection limit within one minute of gas exposure.	We demonstrate the multiplexed detection and classification of 10 individual plant volatiles with this field-portable VOC sensing platform, which permits early determination of tomato late blight only 2 days after inoculation, and differentiation from other fungal infections that lead to similar symptoms of tomato foliage. Furthermore, we demonstrate 95% detection accuracy in diagnosis of P. infestans among lab-inoculated or field-collected tomato leaves in a blind pilot test. Considering the flexibility of sensor array design, multiplexability, and cost-effectiveness, this integrated optical sensor platform can be promisingly applied to detect a variety of common pathogenic infections at very early stages, as well as monitor numerous abiotic stresses of plants in the field.
A CMUT-Based Electronic Nose for Real-Time Monitoring of Volatiles Emitted by Plants: Preliminary Results	M. M. Mahmud, N. Constantino, C. Seok, F. Y. Yamaner, R. A. Dean, and Ö. Oralkan	M. M. Mahmud (mmahmud@ncsu.edu)	North Carolina State University	Plants give off a unique profile of volatile organic compounds (VOCs) in response to abiotic and biotic stresses. The ability to discern specific VOC profiles provides for the early detection and subsequent treatment of insect infestation and pathogen infection. This unique problem statement demands/requires the use of detectors to identify and distinguish plant emitted VOCs. The identification of individual volatiles being emitted may not be needed if the comparison and recognition of patterns in the volatile profile, much like a fingerprint, can be identified to discern what type of attack may be occurring.	This work presents an electronic nose (e-nose) system based on a capacitive micromachined ultrasonic transducer (CMUT) with real-time monitoring capability for detecting and discriminating VOCs. Previously, CMUTs have been used to demonstrate detection of environmental pollutants with parts per billion (ppb) resolution. CMUTs have inherent advantages of excellent mass resolution and high quality factor, due to small plate mass and vacuum-backed vibrating thin plates, making them a good choice for this application.	This preliminary work demonstrates the ability of the CMUT sensor system to detect VOCs released from plants in real time. CMUT sensors functionalized with generic polymers are used in this study which allows us to demonstrate the capability of the CMUT based e-nose to capture the release of plant volatiles upon stress. The sensor prototype also features an integrated pressure, temperature and humidity (PTH) sensor which provides information about changes in the ambient conditions.
Development of A Field-Compatible Abiotic Stress Biosensor	Donna Liebelt Colleen Doherty	Donna Liebelt	North Carolina State University	Abiotic stress induced intra-field spatial yield variability has led to inefficient and overuse of fertilizer and water; contributing to groundwater and air pollution as well as freshwater scarcity. Irreversible plant damage can occur by the time symptoms to the environmental stress are detectable. However, plants go through many levels of regulation before visible physiological changes occur. We aim to develop a field-compatible reporter under the control of endogenous stress responsive promoter candidates to create an agriculturally optimized biosensor.	We are developing field-functional biosensors using fluorescent proteins with emission spectra within Fraunhofer lines. We are simultaneously identifying and characterizing candidate stress-responsive promoters in both Arabidopsis thaliana and monocot C4 plant Setaria viridis.	

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Plant Sciences Initiative: Looking for Collaborators	Rebecca S. Boston, Stephen P. Briggs, Geoffrey R. Bock	Rebecca S. Boston (boston@ncsu.edu)	North Carolina State University	A growing population, reduction in farm acreage, shifts in climates and water sources, and emergence of diseases, pests and herbicide-resistant weeds are just some of the grand challenges facing the world today. The NC Plant Science Initiative (PSI) is envisioned to be a world-class transdisciplinary convergence for research and development of innovative discovery tools across a wide spectrum of disciplines. The PSI will be anchored by a new 185,000 sq. ft. building scheduled to open fall of 2021 on Centennial Campus. The building will house wet labs, think tanks, conference and collaboration spaces, core instrumentation and plant growth facilities to support research and technology that will deliver sustainable food and agricultural systems. Because the building will accommodate projects rather than units or departments, we are working to build transdisciplinary teams for the inaugural PSI projects in advance of the building and is actively looking to engage with motivated, energetic subject matter experts across campus and beyond.	The Office of Research and Innovation in collaboration with CALS and a growing list of partners will soon launch a new Game-Changing Research Incentive Program (GRIP4PSI). The goal is to encourage interdisciplinary collaborations that challenge conventions, explore new ideas and open-up new avenues for sustainable research funding focused on one or more of the Research Platforms that comprise the PSI: 1) Plant Data Sciences 2) Plant Improvement (including areas of feed and nutrition) 3) Food Systems, Environmental Sustainability and Resilience	The GRIP4PSI will provide up to three awards ($600,000 over three years). Our PSI team is available to discuss your research, help identify potential partners in CALS or facilitate ideation/networking opportunities. For more information see go.ncsu.edu/ncpsi or email spbriggs@ncsu.edu.
Digital Phenotyping	Stijn Dhondt	Stijn Dhondt (stdho@psb.vib-ugent.be)	VIB	While digital phenotyping claimed his central role in many plant research projects, phenotypic data is being produced at high speed and at high quantity. High throughput phenotyping platforms continuously generate plant images with several modalities. Nowadays, the same system can acquire RGB, thermal infrared, fluorescence and hyperspectral images and stores both environmental and weighing and irrigation data. The next hurdle is to be able to properly manage the high amount of raw and derived data.	At VIB we developed PIPPA as a central database and web interface with image and data visualization and analysis functionality. Several automated WIWAM phenotyping platforms, ranging from an XY table for controlled irrigation and imaging of Arabidopsis to more crop-oriented systems, have been integrated with PIPPA. The interface allows scientists to setup and analyse their own experiments, while keeping all data together in a structured database.	The database takes care of the data management and integration, linking images, metadata, environmental data, and image analysis and measurement results. As the software package is developed as a web interface, the tool is available on every computer within the department. Preprocessing of images, such as cropping, can be automated and image analysis is performed by starting a task on the server or computer cluster, for fast processing. The analysis framework is designed to support the integration of external image analysis scripts. Furthermore, environmental measurements, weighing and irrigation output, the experimental design, and image analysis results can all be graphically visualized within PIPPA, bringing the plant phenotyping results to your fingertips. Current and future developments focus on the interoperability of image processing tools and the public accessibility of raw phenotypic data to enable community based 'big data' analysis initiatives.
Real Time Crop Analytics	Raju Vatsavai	Raju Vatsavai	North Carolina State University			