SMART researchers develop method for early detection of bacterial infection in crops

Novel Raman Spectroscopy-based method enables early detection and quantification of pathogens in plants, which can impact plant disease management and agricultural industry

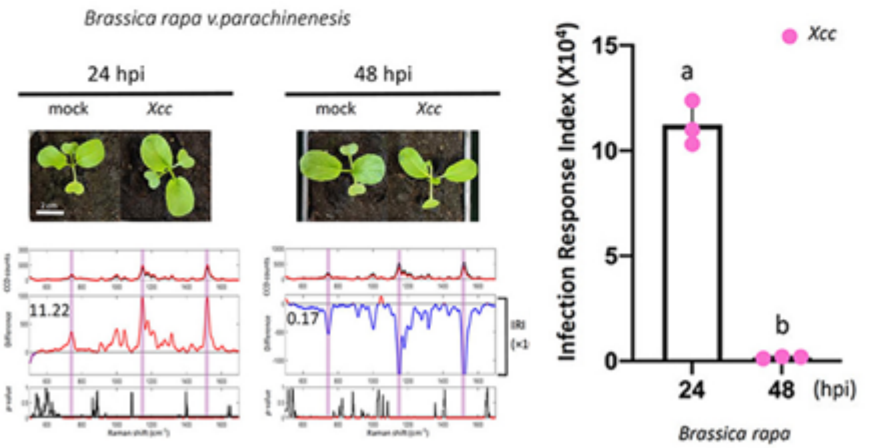
- Climate change and global warming are accelerating crop loss and also the spread of plant diseases
- Bacterial pathogens infections in crop plants are one of the main causes of agricultural yield loss and early detection is crucial to improve plant diseases management
- Using quantitative Raman spectroscopy, an algorithm has been developed to detect and quantify bacterial infection much quicker and earlier than other existing methods
- New method is non-invasive and can be implemented in a portable Raman system to be used on crops in commercial agricultural farms

Singapore, 18 November 2021 - Researchers from the Disruptive & Sustainable Technologies for Agricultural Precision (DiSTAP) Interdisciplinary Research Group (IRG) of Singapore-MIT Alliance for Research and Technology (SMART), MIT's research enterprise in Singapore and their local collaborators from Temasek Life Sciences Laboratory (TLL), have developed a rapid Raman spectroscopy-based method for the detection and quantification of early bacterial infection in crops. The Raman spectral biomarkers and diagnostic algorithm enable the non-invasive and early diagnosis of bacterial infections in crop plants, which can be critical for the progress of plant disease management and agricultural productivity.

Facing an increasing demand for global food supply and security, there is a growing need to improve agricultural production systems and increase crop productivity to overcome this challenge. Globally, bacterial pathogen infection in crop plants is one of the major contributors to agricultural yield losses. Climate change also adds to the problem by accelerating the spread of plant diseases. Hence, developing methods for rapid and early detection of pathogen-infected crops is important to improve plant disease management and reduce crop loss.

The breakthrough by SMART and TLL researchers offers a faster and more accurate method to detect bacterial infection in crop plants at an earlier stage, as compared to existing techniques. The team explained their research in a paper titled "Rapid detection and quantification of plant innate immunity response using Raman spectroscopy" published in the prestigious journal *Frontiers in Plant Science*.

SMART
Singapore-MIT Alliance for Research and Technology



Rapid detection of bacterial infection (Xanthomonas campestris pv. Campestris (Xcc)) in leafy vegetable Choy Sum using quantitative Raman spectroscopy-based algorithm. On the right, the Infection Response Index is shown, which can aid farmers to identify infections and take action.
Photo Credit: Singapore-MIT Alliance for Research and Technology (SMART)

“The early detection of pathogen-infected crop plants is a significant step to improve plant disease management,” says DiSTAP co-lead Principal Investigator Professor, TLL Deputy Chairman, and co-corresponding author, Chua Nam Hai. “It will allow the fast and selective removal of pathogen load and curb the further spread of disease to other neighbouring crops.”

Traditionally, plant diseases diagnosis involves a simple visual inspection of plants for disease symptoms and severity. “Visual inspection methods are often ineffective as disease symptoms usually manifest only at relatively later stages of infection when the pathogen load is already high, and reparative measures are limited. Hence, new methods are required for rapid and early detection of bacterial infection. The idea would be akin to having medical tests to identify human diseases at an early stage, instead of waiting for visual symptoms to show so that early intervention or treatment can be applied,” says DiSTAP Principal Investigator, MIT Professor, and co-corresponding author, Rajeev Ram.

While existing techniques, such as current molecular detection methods, can detect bacterial infection in plants, they are often limited in their use. Molecular detection methods largely depend on the availability of pathogen-specific gene sequences or antibodies to identify bacterial infection in crops; the implementation is also time-consuming and non-adaptable for on-site field application due to its high cost and bulky equipment required, making it impractical for use in agricultural farms.

“At DiSTAP, we have developed a quantitative Raman spectroscopy-based algorithm that can help farmers to identify bacterial infection rapidly. The developed diagnostic algorithm makes use of Raman spectral biomarkers and can be easily implemented in cloud-based computing and prediction platforms. It is more effective than existing techniques as it enables accurate identification and early detection of bacterial infection, both of which are crucial to saving crop plants that would otherwise be destroyed," explained Dr Gajendra Pratap Singh, Scientific Director and Principal Investigator at DiSTAP, and co-lead author.

A portable Raman system can be used in agricultural farms and provides farmers with an accurate and simple yes or no response when used to test for the presence of bacterial infections in crop plants. The development of this rapid and non-invasive method will improve plant disease management and have a transformative impact on agricultural farms by efficiently reducing agricultural yield loss and increasing productivity.

"Using the diagnostic algorithm method, we experimented on several edible plants such as Choy Sum," says DiSTAP and TLL Principal Investigator and co-corresponding author Dr Rajani Sarojam. "The results showed that the Raman spectroscopy-based method can swiftly detect and quantify innate immunity response in plants infected with bacterial pathogens. We believe that this technology will be beneficial for agricultural farms to increase their productivity by reducing their yield loss due to plant diseases."

The researchers are currently working on the development of high-throughput, custom-made portable or hand-held Raman spectrometers that will allow Raman spectral analysis to be quickly and easily performed on field-grown crops.

The development and discovery of the diagnostic algorithm and Raman spectral biomarkers were done by SMART and TLL. TLL also confirmed and validated the detection method through mutant plants. The research is carried out by SMART and supported by the National Research Foundation of Singapore under its Campus for Research Excellence And Technological Enterprise (CREATE) programme.

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About SMART Disruptive & Sustainable Technologies for Agricultural Precision (DiSTAP) [精准农业技术研究中心]

DiSTAP is one of the five Interdisciplinary Research Groups (IRGs) of the Singapore-MIT Alliance for Research and Technology (SMART). The DiSTAP programme addresses deep problems in food production in Singapore and the world by developing a suite of impactful and novel analytical, genetic and biomaterial technologies. The goal is to fundamentally change how plant biosynthetic pathways are discovered, monitored, engineered and ultimately translated to meet the global demand for food and nutrients. Scientists from Massachusetts Institute of Technology (MIT), Temasek Life Sciences Laboratory (TLL), Nanyang Technological University (NTU) and National University of Singapore (NUS) are collaboratively: developing new tools for the continuous measurement of important plant metabolites and hormones for novel discovery, deeper understanding and control of plant biosynthetic pathways in ways not yet possible, especially in the context of green leafy vegetables; leveraging these new techniques to engineer plants with highly desirable properties for global food security, including high yield density production, and drought and pathogen resistance, and applying these technologies to improve urban farming.

The DiSTAP IRG at SMART is led by MIT co-lead Principal Investigator Professor Michael Strano and Singapore co-lead Principal Investigator Professor Chua Nam Hai.

For more information, please log on to: http://distap.mit.edu/

About Singapore-MIT Alliance for Research and Technology (SMART) [新加坡-麻省理工学院科研中心]

Singapore-MIT Alliance for Research and Technology (SMART) is MIT's Research Enterprise in Singapore, established by the Massachusetts Institute of Technology (MIT) in partnership with the National Research Foundation of Singapore (NRF) since 2007. SMART is the first entity in the Campus for Research Excellence and Technological Enterprise (CREATE) developed by NRF. SMART serves as an intellectual and innovation hub for research interactions between MIT and Singapore. Cutting-edge research projects in areas of interest to both Singapore and MIT are undertaken at SMART. SMART currently comprises an Innovation Centre and five Interdisciplinary Research Groups (IRGs): Antimicrobial Resistance (AMR), Critical Analytics for Manufacturing Personalized-Medicine (CAMP), Disruptive & Sustainable Technologies for Agricultural Precision (DiSTAP), Future Urban Mobility (FM) and Low Energy Electronic Systems (LEES).

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