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RESEARCH NEWS STORY

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Optical Properties of Plants Reflect Ozone-Induced Damage

A portable optical scanner non-invasively measures environmental-stress-induced changes in plants' internal structures

Environmental pollutants such as ozone can damage the internal structure of plants and impair their growth and productivity. Conventional assessments requiring sample processing may not accurately reflect internal damage. A new study highlights the application of a novel 'optical coherence tomography' scanner for the non-invasive temporal assessment of live plants exposed to ozone. The technique can aid the timely detection of deficiencies and stress-induced damage, thereby supporting better plant management and improving crop productivity.

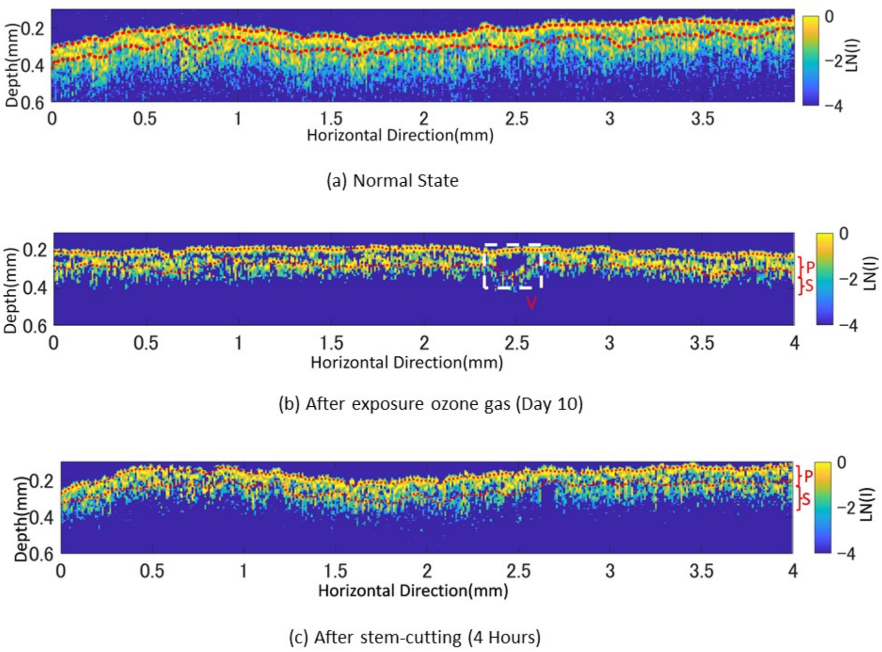

Image title: Effect of ozone exposure as an environmental stress on the internal structure of white clover leaves
Image caption: Researchers develop a novel optical coherence tomography scanner that can non-invasively measure changes in the optical properties of leaves exposed to environmental pollutants and reflect stress-induced internal damage
Image credit & source link: Dr. Tatsuo Shiina, Chiba University, Japan
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Escalating pollution and contamination of water and soil are emerging as serious threats to plant growth and its overall health. Plants are exposed to environmental pollutants for extended periods and exhibit changes in their color, texture, and internal structure in response. Among environmental pollutants, ozone concentrations are particularly high in urban and industrial regions and have been reported to inhibit plant growth and reduce crop yields. Conventional assessments rely on visual inspections, microscopic examinations, and remote sensing. However, these methods require invasive analysis and may not provide accurate quantitative measurements or facilitate long-term monitoring of internal changes.

To overcome these challenges, an international team of researchers developed a portable optical coherence tomography (OCT) scanner device that enables non-invasive, non-destructive, non-contact, and quantitative evaluation of internal plant structures. The pioneering work was conducted by Associate Professor Tatsuo Shiina and Dr. Hayate Goto from the Graduate School of Science and Engineering, Chiba University, Japan; Assistant Professor Jumar Cadondon from the University of the Philippines Visayas, Philippines; and Professor Maria Cecilia Galvez and Professor Edgar Vallar from De La Salle University Manila, Philippines.

Their work was published in Volume 15 of the journal *Scientific Reports* on October 31, 2025. Giving further insights, Dr. Shiina says, *"By using OCT, the internal structure can be non-destructively quantified layer by layer to identify areas affected by the external environment. Since stress responses in plants appear first in the interior of the plant, OCT has the potential to elucidate environmental stresses that cause internal changes in plants."*

The researchers performed OCT measurements on the leaves of white clover (*Trifolium repens*), an indicator plant that is highly sensitive to environmental pollutants. At high concentrations, ozone enters leaves through their stomata (pores on the leaf surface) and destroys the palisade tissue (internal cell layer), thereby changing its optical properties. To quantify these optical changes, the researchers first exposed potted indicator plants to high ozone concentrations and monitored temporal changes in the same leaves over 14 days. Further, they measured changes in water lost by transpiration in leaves with cut stems to differentiate between changes caused by water/transpiration stress and ozone stress.

The experiments revealed that ozone exposure attenuated light scattering within the palisade layer, indicating structural disruption and damage to the cell walls and intercellular boundaries. The researchers also noted a gradual increase in palisade tissue thickness, consistent with the observed decrease in OCT signal intensity and ozone-induced structural damage.

Having established a baseline of ozone exposure, the researchers then sampled indicator plants from four different regions in the Chiba Prefecture, Japan, with varying ozone concentrations ranging from 0.04 to 0.16 ppm. They noted a similar trend in the OCT parameters of the sampled leaves, suggesting that the internal structural characteristics of leaves reflect the level of ozone exposure. Going further, on-site OCT measurements can rule out stress caused by stem cutting and transportation, providing a more accurate measure of the effects of ozone exposure.

Overall, these findings demonstrate the feasibility of OCT in the evaluation of environmental stress in plants, especially at the cellular level prior to the onset of symptoms. Moreover, OCT scanning offers a non-invasive, faster, and simpler alternative to conventional methods that require chemical fixation and staining, thus allowing the evaluation of the same living leaves over a longer period. Timely assessments with portable OCT scanning can improve disease monitoring and facilitate the early detection of deficiencies or stress-induced changes, thereby allowing early intervention to minimize losses. Additional studies can help validate its effectiveness in different environmental conditions like varying humidity, temperature, and light intensities.

Dr. Shiina concludes by saying, *"Continued research in this direction could expand OCT's utility in optimizing crop environments and improving agricultural productivity. The ability to estimate atmospheric and soil conditions on-site from a single OCT measurement provides a promising approach to advancing crop management and environmental monitoring."*

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About Associate Professor Tatsuo Shiina from Chiba University, Japan
Dr. Tatsuo Shiina is an Associate Professor at the Graduate School of Science and Engineering, Chiba University, Japan. His research interests include photoelectric measurement, scattering optics, and atmospheric physics. His work focuses on developing a short-range mini-lidar for monitoring the lower atmosphere and gases, inventing a portable OCT scanner for industrial applications, enabling internal measurements of living organisms, plants, and industrial materials, and enhancing the efficiency and internal sensing of laser light in highly scattering materials.

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Reference:
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