Sentries in the garden shed: Plants that can detect environmental contaminants, explosives

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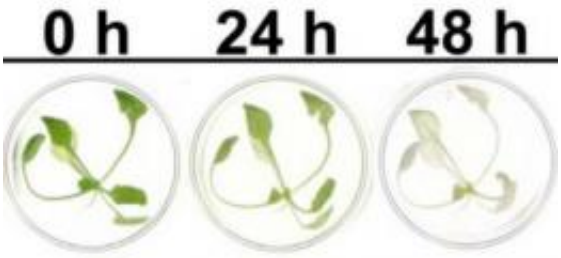


This graphic shows de-greening in plants over a 48-hour period. Credit: Colorado State

Someday, that potted palm in your living room might go from green to white, alerting you to a variety of nasty contaminants in the air, perhaps even explosives.

The stuff of science fiction you say? Not so, says a Colorado State University biologist whose research is funded in part by Homeland Security's Science and Technology Directorate (DHS S&T), as well as by the Defense Advanced Research Projects Agency (DARPA), the Office of Naval Research (ONR), and others.

Dr. June Medford and her team in the Department of Biology at Colorado State have shown that plants can serve as highly specific

sentries for environmental pollutants and explosives. She's enabled a computer-designed detection trait to work in plants. How? By rewiring the plant's natural signaling process so that a detection of the bad stuff results in the loss of green color.

Based on research so far, Medford says the detection abilities of some plants (tobacco is an example) are similar to, or even better, than those of a dog's snout, long the hallmark of a good detector. Best of all, the training time is nothing compared to that of a dog.

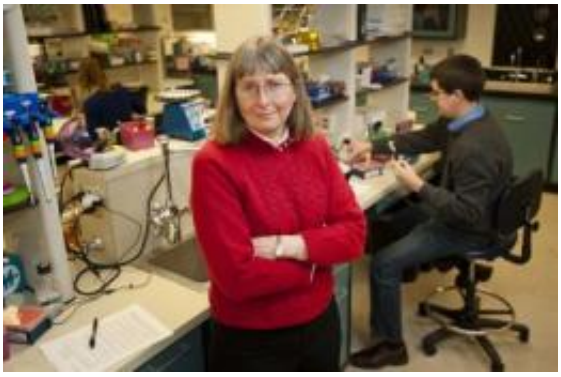
"The idea comes directly from nature," Medford said. "Plants can't run or hide from threats, so they've developed sophisticated systems to detect and respond to their environment. We've 'taught' plants how to detect things we're interested in and respond in a way anyone can see, to tell us there is something nasty around, by modifying the way the plant's proteins process chlorophyll. Our system, with improvements, may allow plants to serve as a simple and inexpensive means to monitor human surroundings for substances such as pollutants, explosives, or chemical agents."

The detection traits could be used in any plant and could detect multiple pollutants at once – changes that can also be detected by satellite. While visible change in the plant is apparent after a day, the reaction can be remotely sensed within a couple of hours. A spectral imaging system designed specifically for the detection of de-greening biosensors would provide the fastest indication of a threat detected by the plants.

Computational design of the detection trait was initially done in collaboration with Professor Homme Hellinga at Duke University, and more recently with Professor David Baker at the University of Washington. The Baker and Hellinga laboratories used a computer program to redesign naturally-occurring proteins called receptors. These redesigned receptors specifically recognize a pollutant or explosive.

Medford's lab then modifies these computer redesigned receptors to function in plants, and targets them to the plant cell wall where they can recognize pollutants or explosives in the air or soil near the plant. Once the substance is detected, an internal signal causes the plant to turn white.

Medford and her team want to speed up detection time. The initial or first-generation plants respond to an explosive in hours, but improvements are underway to reduce the response time to just a few minutes. A faster response time increases the likelihood of identifying the threat and preventing an attack.



This is Dr. June Medford in her lab at Colorado State University. Credit: Colorado State

"At this point in the research, it takes hours to achieve a visible change in the foliage," says Doug Bauer, DHS S&T's program manager on the research. "Ideally, we'd want the reaction to be considerably faster." In addition to faster response times, Bauer says, in the next generation of the research, the indicators may take place in a non-visible spectrum, such as infrared, by using color-changing methods other than the suppression of chlorophyll. That way, law enforcement equipped with

the appropriate sensors would be alerted, but a terrorist would not be tipped off.

A decentralized, ubiquitous detection capability could allow the early detection of bomb-manufacturing sites, instead of waiting for a potential bomber to show up at a transportation hub or other target zone.

There are still many, many years of research to go before any possible deployment of plant sentinels. Once the research achieves a point where it may be possible to deploy, there are other considerations that will have to be taken into account and additional studies to be conducted. For example, USDA regulations stipulate that genetically-altered plants must go through a rigorous study on their impact to and interaction with the environment before they can be cultivated or planted in the United States.

This work could eventually be used for a wide range of applications such as security in airports or monitoring for pollutants such as radon, a carcinogenic gas that can be found in basements. Harnessing plants as bio-sensors allows for distributed sensing without the need for a power supply. "One day, plants may assist law enforcement officers in detecting meth labs or help emergency responders determine where hazardous chemicals are leaking," Bauer says. "The fact that DoD, DHS and a variety of other agencies contributed to funding this research is an indicator of the breadth of possibilities."

More information: The research from Medford's team appeared in the peer-reviewed journal *PLoS ONE*.

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