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FLUORESCENCE SPECTRUM IS THE SUPERIOR TECHNIQUE FOR THE FUTURE REMOTE SENSING OF THE PLANT

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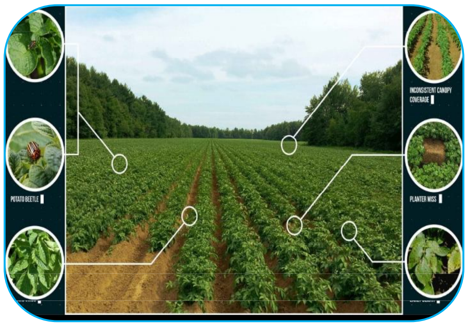
ABSTRACT:

Increasing agricultural productivity is all the more important in the coming decades. As the world's population grows rapidly and demands on the food supply increase, poor soil quality, droughts, floods, rising temperatures and new plant diseases are negatively affecting production worldwide. One method to increase yields is to monitor plant health and quickly detect disease, nutrient deficiencies or drought. Monitoring plant health will enable the correct use of agrochemicals, fertilizers and water to achieve maximum yield. In vivo plant sensors are an emerging technology with the potential to increase agricultural productivity. In this mini review, we discuss three major approaches to in vivo sensors for plant health monitoring, including genetic engineering, imaging and spectroscopy, and electrical.



KEY WORDS: *Increasing agricultural productivity , food supply increase, poor soil quality.*

INTRODUCTION:

There is a critical demand for more sustainable agricultural practices to increase crop production to meet the demands of a rapidly growing population. The UN estimates that the world population is expected to reach 10.3 billion people by 2055. However, farmers face a number of constraints, such as extreme temperatures, soil erosion, and drought that are expected to worsen under climate change. Increasingly sustainable agricultural practices are needed to ensure high yields that use minimal inputs and are minimally destructive to the land. Plant health monitoring is one such method to increase production and reduce environmental impact. Using low-cost, infield methods, water levels, soil quality, and the presence of pathogens and pests can be continuously monitored. Expensive agrochemicals and water can be used in a directed manner for better plant growth. Detecting the pathogen will allow immediate corrective action to prevent the spread of the disease. Farmers currently use many agricultural practices and technologies to maximize yields, such as crop rotation to improve soil health, using genetically modified seeds, or monitoring plants for the presence of pathogens and pests by planting non-native plants or sentinel plants. Many diagnostic technologies are also used to detect diseases. However, current laboratory-based techniques for plant diagnosis are not sufficient for plant monitoring. Several point-of-use technologies have been developed, such as lateral flow devices or portable devices for field use. However, this type of equipment requires the harvesting and processing of plant tissue, which is not conducive to continuous monitoring. Nanotechnology in plants is an emerging field in the last decade that has the potential to create more productive farming systems. The use of nanotechnology for applications in human health, medicine, pharmaceuticals and wearable devices has been extensively studied. Implantable sensors are also possible for continuous monitoring in humans. Nanotechnology has the potential to improve agriculture in many ways, including the creation of nano-fertilizers and agrochemicals, new delivery systems for agrochemicals, nanosensors for disease detection, nanodevices for genetic modification, and post-harvest crop management.

SPECTROSCOPIC APPROACHES:

Another method of rapid diagnosis is imaging and spectroscopy. Molecular methods using spectroscopy, such as real-time PCR and ELISA, are common methods for plant disease diagnosis but are highly invasive. They will not be covered in this mini review. Imaging includes techniques such as thermography, RGB imaging, fluorescent imaging, and hyperspectral imaging. Spectroscopy techniques included in this mini review are Raman spectroscopy, X-ray spectroscopy, and mass spectrometry.

Thermography imaging detects heat emitted by objects; It is used to survey a large area at once. Changes in plant temperature can be attributed to many factors including pathogen response, such as stomatal closure or abiotic stress. Although this method is ideal for monitoring large fields and is non-invasive, it is an indirect and non-specific detection method. RGB imaging uses a digital camera to measure any changes in transmittance. Simple digital images and videos are used to monitor different types of plants in the field. It can be used for single plants, such as with smartphone sensors, or with drones to monitor large fields. Interestingly, machine learning algorithms are being designed to detect patterns that indicate disease. Mahlen's comprehensive review shows many uses of RGB imaging. Since RGB imaging correlates changes in color with changes in plant health, it is an indirect method and may not always provide specific information on factors affecting plants. Fluorescent imaging is similar to RGB imaging; However, this involves a laser in addition to a camera for fluorescent excitation. The most common application of fluorescent imaging is chlorophyll fluorescence imaging, where the fluorescence of a leaf or plant is compared to the surrounding plant or a baseline value. Chlorophyll naturally fluoresces when stimulated by certain light. Several studies have used this phenomenon to correlate fluorescence with photosynthetic activity. Bolhar-Nordenkampf and colleagues used chlorophyll fluorescence to determine the photosynthetic activity of leaves collected from areas with different environmental air pollution and different agrochemical treatments. These different factors caused changes in chlorophyll fluorescence, indicating some disruption in photosynthetic activity. The study also outlined several possibilities for portable in-field devices. Since chlorophyll is fluorescent under strong sunlight, a simple fluorimeter can be used to take measurements in the field. Although this method is non-invasive, non-destructive and easily adaptable for field use, it is non-specific and unable to diagnose specific abiotic or biotic strains. Leaf fluorescence often fluctuates in response to many biotic and abiotic factors. Hyperspectral imaging is a technique that analyzes light across the electromagnetic spectrum to assess changes not always visible in RGB images. Although it can detect more subtle changes than visual or fluorescence images, it can only be used to detect general changes in plant surfaces. With further study, hyperspectral patterns can be attributed to specific conditions.

SPECTROSCOPY:

Raman spectroscopy detects the vibrational frequencies of molecules; This can be used to determine the chemical footprint of the structure to identify the molecule. Simply, a sample is illuminated with a monochromatic laser. Light interacts with the sample and the resulting change in energy provides information about the molecules in the sample. Raman spectroscopy is non-destructive and biochemically safe for detecting molecules in highly complex samples, a portable Raman spectroscopy instrument and used Coleus lime as their model organism. Two photosynthetic pigments, anthocyanins and carotenoids, were the target molecules for Raman studies. Carotenoids are the first line of defense against reactive oxygen species (ROS), and anthocyanins block harmful radiation. Both increase biosynthesis in response to many environmental factors. Four methods of abiotic stress were applied: light irradiation, cold, drought and salt stress. Using both a Raman microscope and a portable Raman instrument, the relative concentrations of carotenoids and anthocyanins, which are indicators of abiotic stress, were determined 2 days after application of light, cold, drought, and salt stress. The concentration of carotenoids and anthocyanins indicated the presence of stress in the plant before the appearance of physical symptoms. Both results were confirmed with chemical analytical findings. Changes in these pigments over time revealed that Raman spectroscopy was the method to accurately measure these molecules and suggested a functional link between the molecule and the response to excessive ROS during abiotic stress. Portable Raman instruments had limitations; They were unable to detect anthocyanins. However, further optimization can increase the efficiency. Gupta et al. developed a portable Raman leaf clip sensor that can distinguish between nitrogen-rich and nitrogen-deficient plants. Raman spectroscopy has also been shown to detect the presence of pathogens and insects living in host seeds and chemical pesticides. X-ray fluorescence (XRF) spectrometry is a nondestructive method used to determine the chemical composition of many samples. In XRF, X-ray beams interact with the sample and the fluorescent X-rays produced can be used to identify elements in the sample. Montana and others. used XRF with an infrared gas analyzer to quantify aqueous Zn and Mn in soybean leaves and stems for 48 h. The authors observed elemental distribution changes in plants to see the effect of localized X-ray exposure on living plant tissues. Typical XRF did not cause visible damage, dehydration, or elemental redistribution in living plants, although the long-term effects of low-dose X-ray exposure have not been studied.

Mass spectrometry is a method used to determine the massto-charge ratio of ions; There are several types depending on the sample for analysis. Ambient ion mass spectrometry allows mass spectrometry analysis without special sample handling, such as in a high vacuum environment. A low-temperature plasma (LTP) can be used to ionize samples in ambient air. LTP is a relatively mild method of ionization.

MICRONEEDLE ELECTRODES OF ELECTRICAL APPROACHES:

Real-time monitoring system for non-destructive detection of salinity in stems of tomato plants by electrical conductivity. They designed a self-contained unit with microneedle electrodes and electrode pads that could be inserted into the stem of a tomato plant. The device was tested under greenhouse conditions and field conditions. Under field conditions, signal noise decreased and electrical conductivity measurements decreased, although the authors believe that the decreased signal can be fixed by redesigning the electrical components to make them more practical for in-field use. A similar method using a thermal microneedle probe was used to measure xylem sap movement in tomato stems. Maize as a model system for developing similar microneedle leaf sensors. However, their device takes canopy temperature measurements that can be used to measure water stress. It can be calibrated for any plant, soil type and relative humidity. It is powered by solar energy and transmits data wirelessly through an antenna.

An organic electrochemical transistor sensor (OECT) has been invented for use in biosensing. Simply, a conductive polymer film or channel is placed in direct contact with the electrolyte and electrode. Connected to the channel are the source and drain electrodes and the gate electrode which establishes an electrical connection with the electrolyte. A typical OECT sensor is fabricated using the conductive polymer poly(3,4-ethylenedioxythiophene) (PEDOT) doped with various side groups.

CONCLUSION:

There are various requirements for good plant diagnostic technology. The best technology for a given farmer will depend on the size of the land they farm, the specific needs of their crops, and the natural, social, and economic environment they are in. Developing an array of sensors and innovative technologies is key. Agricultural demands of a large population. Current technology to measure plant health or diagnose disease is expensive, invasive, and often requires sending samples to central facilities for processing. Nanotechnology and advanced spectroscopy techniques are emerging technologies for plant disease diagnosis and detection of plant disturbances, all with the common goal of increasing production in a sustainable way.

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