Commentary Article

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Description

Plant pathogens are the primary yield-limiting factors that significantly decrease crop productivity worldwide, posing serious threats to food security and remaining the world's most pressing agricultural issue. Chemical treatment is still the most effective method for reducing plant disease incidence, but repeated application can make pathogens less susceptible. Overspray can also harm the soil microbiota and pollute the environment. As a result, effective diagnostic methods for rapidly identifying plant pathogens in the early stages of infection become essential for ensuring agricultural sustainability and food security. In order to achieve this objective, numerous molecular methods have been developed for the rapid detection of plant pathogens. However, they are generally unsuitable for in-situ analysis, take a long time to complete, are expensive, and require skilled operators. Any of the nanotechnology tools for diagnosing plant pathogens, such as micro needle patches, nanopore sequencing, nano barcoding, nano biosensors, quantum dots, equipment for nano diagnostic kits, metal nanoparticles, miRNA-based nano diagnosis, and array-based nano sensors, can be used to protect plants. In light of their potential to facilitate high-throughput analysis and enhance plant pathogen identification sensitivity, accuracy, and speed. The use of nanotechnology for faster, cheaper, and more accurate diagnosis of plant pathogens is the focus of this review.

Prevalence and Severity of Plant

In order to meet the needs of every growing population, agricultural ecosystems have expanded to cover approximately 40% of the planet's surface over the past 300 years. One of the main constraints on food resources worldwide is the deterioration of plant products, which is estimated to result in a loss of between 10 and 30 percent overall. Food safety is something to think about because pathogens and the toxins they produce are one of the main causes of this deterioration. Plant diseases are primarily brought on by infections caused by bacteria, fungi, and viruses. Through the disease-causing agents being introduced into the field or through the infected plants, these infections spread widely throughout plantations. Making an early assessment of the prevalence and severity of plant diseases on field crops is essential for both basic and applied plant research. Since assessments form the basis for field plant protection actions, they must be carried out accurately and promptly. From the most basic detection of symptoms appearing on leaves to nucleic acid detection methods, various sensing techniques have been used to create sensitive and selective detection systems over the years. Conventional analytical techniques for the detection of plant diseases have been divided into two main categories: direct and indirect methods of detection. One of the direct methods is polymerase chain reaction. Thermography, gas chromatography, hyper spectral imaging, and fluorescence imaging are examples of non-invasive indirect methods. These common methods take a long time, cost a lot of money, and require a lot of work. While direct methods offer high throughput analysis and high sensitivity, they are not widely used in laboratories. The procedure necessitates time-consuming sample preparation and skilled personnel for measurements and analysis. For the early detection of plant infections, indirect methods have been beneficial, but their applicability to monitoring in larger canopies has been limited by the need for an expensive camera system and extensive data analysis. This paper examines a number of recently developed sensors for plant pathogen detection. Using the search terms "plant diseases, biosensors, advances in agriculture, miniaturized devices for plant pathogens" in databases like PubMed, Web of Sciences, and Scopus, this study conducted a systematic search. We shed light on various bio sensing system transduction mechanisms, plant pathogens being detected, and techniques. Table 1 contains a table containing the most recent developed methods, target details, and detection limits. In-field direct diagnosis, which has the potential to simplify the way farmers and pathologists diagnose plant diseases now and in the future, is the focus of this paper, which examines recent technological advancements that are being used or have the potential to be used. Finally, the difficulties that plant sensors face and the prospects for the future are discussed.

Detection of Pathogen

Endophytes are essential to the health of plants because they can form intricate co-associations with them. In addition to promoting plant growth, they may enhance plant nutrient acquisition, stress tolerance, and defense against pathogen attack. However, there are pathogenic endophytes that pose a threat to human health by entering the food chain and becoming ingested by humans. In the endosphere of some fresh-cut vegetables, such as lettuces, cucumbers, and tomatoes, opportunistic pathogens have been found. Although the composition and variety of plant endophytes have been characterized in a number of studies, little is known about the abundance of risky endophytes and how they respond to human activities. The public has been very concerned about outbreaks of food-borne diseases all over the world. World Health Organization statistics show that contaminated food causes approximately 600,000,000 illnesses and 420,000 deaths annually. Plants can be reservoirs for some human pathogens and are an important source of food-borne illnesses, as demonstrated by recent outbreaks linked to contaminated fruits and vegetables. We should pay more attention to pathogens in the endosphere, which are difficult to eradicate, given that pathogens attached to plants can typically be eradicated through surface washing. The majority of endophytic pathogens originate in soils contaminated by irrigation water and animal feces. Because of its abundance of nutrients, protection from UV rays, and prevention of desiccation through water films, the rhizosphere is regarded as a hotspot for pathogens. It has been demonstrated that root uptake allows pathogens in rhizosphere soils to enter plant tissues. Additionally, some pathogens can remain viable in soils for more than 200 days; therefore, the probability of pathogen-contaminated plants in the environment will not decrease in a short period of time. The majority of studies only focused on the detection of one kind of pathogen, like E. coli O157: H7 or Salmonella enterica in a single compartment, such as the phyllosphere or soil, for instance However, we still lack a comprehensive quantification of a wide range of human-pathogenic bacteria in the plant-soil system and investigation into how these bacteria respond to human activities like fertilization.