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Editorial

Detection of phytopathogens, disease forecasting and management practices for sustainable agriculture

Plant pathogens are microorganisms that cause diseases when exposed to certain environmental variables. If a plant can survive only on its genetic makeup, it is said to be healthy. Due to the rapid rate of world growth, it is vital to guarantee maximum sustainable crop output. The first step in creating strategies for disease management that are necessary for maintaining the maximum yield of economically significant crops is the detection of phytopathogens and the diagnosis of plant illnesses. For an early detection of phytopathogens causing diverse root and foliar diseases, some quick serological approaches are being applied. These include different formats of enzyme linked immunosorbent assay (ELISA), dot immunobinding assay (DIBA), and indirect immunofluorescence (IIF).Due to speed, accuracy, sensitivity, and simplicity of use, ELISA is most frequently employed in diagnostic laboratories. The use of plate trapped antigen coated (PTA)-ELISA has had the biggest influence on the widespread detection of foliar and root diseases in a variety of economically significant crops, including perennial plantations and horticulture crops. IIF is also suitable for detection and localization of pathogen in plant tissue because the cells can be seen directly. Transmission electron microscopy, which uses immunogold labeling, is another immunological approach using PAbs produced against pathogen. Monitoring airborne particles and microbes in a variety of situations is made possible by the microtitre immunospore trapping (MTIST) device, a lightweight, reliable, and affordable instrument that may also be used to conduct several tests within a single sampling time.Additionally, DNA/RNA based molecular technologies are currently used for pathogen detection and identification, and they outperform immunological techniques for a variety of reasons. For the accurate and precise detection and identification of plant diseases at the species or race levels inside the affected tissues, specific DNA probes can be used. Modern molecular approaches, based on PCR amplification of conserved regions of the genome and sequencing of the resultant PCR products, are becoming more and more important for the identification, taxonomy, and epidemiological investigations of phytopathogens.The molecular techniques are predominantly PCR based and include different variations with increasing sensitivity such as nested PCR, multiplex PCR, reverse transcriptase PCR, real time PCR, loop-mediated isothermal amplification (LAMP) and nano-based PCR. Smartphone-based diagnostics are being used in remote field settings where it is challenging to detect diseases using laboratory techniques. Artificial intelligence has also lately been incorporated into plant pathology. Thus, by use of one or more sophisticated techniques it is possible to detect pathogens rapidly and specifically.

Crops suffer enormous economic losses as a result of the plant diseases. Due to the disease's virulence and environmental conditions, the disease's onset, rate of spread, and degree of devastation might vary. When applying the control measures, knowledge of the relationship between the weather and the disease is necessary. A management approach called plant disease forecasting is used to foresee the occurrence or alteration in the severity of plant diseases. Growers employ these systems at the field level to decide on the most cost-effective disease control measures. An established part of quantitative epidemiology is disease forecasting. A powerful and well-respected element of disease forecasting and management, disease development mathematics has reached a mature state. Many plant disease forecasting models, however, have fallen short of expectations that they would significantly contribute to improved disease management. The potential to feed weather predictions into disease models and generate "true disease forecasts" is an interesting breakthrough in this field. It will be possible to provide seasonal estimates of disease likelihood and anticipate outbreaks as weather forecasts advance along with more precise estimations of environmental factors relevant for plant disease models, such as precipitation and leaf wetness duration. Since superfluous sprays have a major influence on production costs and delayed applications may lead to insufficient control, this is particularly intriguing for crop management. A technique for forecasting disease outbreaks using weather data has been made available using computer modeling. Traditional plant disease models forecast the infection process and pinpoint periods of high disease risk by combining the total number of hours of wetness duration with temperature requirements. These models track when a sufficient number of favorable illness hours have transpired to require management action. These models have been utilized as a component of integrated pest management strategies.

Advances have been made in the creation and use of decision support systems for growers and pest management specialists as a result of the revolution in web-based technology. SIS- ALERT is a multi-model platform that uses advanced disease risk assessment models to unlock the power of hourly weather station data and hour-by-hour weather forecasting information. These models use weather data to provide information on both expected disease risk and historical or present disease behavior. The versatility of the SISALERT format makes it special since it enables coupling of crop and disease models depending on which model is being used.

The green revolution was characterized by the active management of crops and the understanding of their genetics, the improvement of soil fertility by chemical fertilization and irrigation, and the control of pests with synthetic pesticides. To boost crop output while using fewer fertilizer and agrochemical inputs is one of the main difficulties faced globally by agricultural experts.In many areas, simplistic agro-ecosystems prone to pest infestations have replaced diverse ecosystems. The crops primarily need protection from the pests and diseases to preserve the high level of output required to assure food security. Since it is obvious that in nature, plants have evolved in the setting of complex microbial communities that play essential roles in fulfilling plant functions linked to plant growth, vigor, and defense, the involvement of the root microbiome cannot be ignored in this context. It is crucial to use the knowledge of root microbiome processes to increase crop yield, stress resistance, and sustainability by using fewer agrochemicals while increasing crop productivity. The rhizosphere is home to a diverse community of commensal and mutualistic microbes that support plant growth directly through processes like nitrogen fixation, phosphate solubilization, feeding, and mineral uptake. They can also defend plants from infections. The relationship between various microbial communities and various plant species suggests that plants exert selective pressure on the rhizosphere's microbial community, most likely as a result of compounds released by the plants there. Numerous rhizosphere bacteria known as PGPR such as *Actinobacter, Arthrobacter, Bacillus*, *Burkholderia, Enerobacter, Ochrobactrum, Paenibacillus* and *Pseudomonas* have the capacity to solubilize soil phosphate, making it accessible to plants. They are also directly engaged in promoting plant development and induced systemic resistance (ISR), a type of plant resistance. *Trichoderma*, formerly categorized as a biocontrol agent (BCA) with mycoparasitic activity, is now seen as a microorganism with a variety of advantageous features, including promoting plant development, competing with other organisms for resources, causing ISR, and alleviating abiotic stress. Numerous *Trichoderma* species, including *T. asperellum*, *T. aureoviride*, *T. harzianum*, *T. virens*, and *T. viride*, induce immunity in plants, which results in the development of disease resistance. The fact that the defense responses are not limited to the roots alone but are also noticeable in the shoots has also been shown to be a sign of systemic induction of resistance by arbuscular mycorrhizal fungi (AMF) such as *Glomus mosseae* and *Gigaspora gigantea.* The development of sustainable future crops that are better able to maximize the beneficial and protective functions from beneficial microbes in their root microbiome will be made possible by the continuous advancement of our knowledge on the molecular and genetic basis of plant-beneficial microbe communication in the context of its evolutionary and ecological relevance.

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