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From President's Desk

Advancements in Plant Disease Diagnostic Tools: Bridging Traditional Methods and Cutting-Edge Innovations in Agriculture

The growing demand for sustainable agriculture necessitates innovative approaches to manage plant diseases, which significantly threaten global food security by impacting crop yield and quality. Early and accurate detection is crucial for effective disease management and sustainable agricultural practices. Recent advancements in diagnostics have transformed the ability to detect, quantify, and address pathogens with precision. This article briefly explores a wide range of diagnostic tools, from traditional biological assays to cutting-edge technologies like CRISPR-Cas systems and IoT-based detection methods. It also highlights the key challenges in diagnostics, practical applications, solutions to barriers, future prospects, and provides a concluding synthesis.

Accurately assessing disease severity is vital for informed decision-making in agriculture, guiding interventions, resource allocation, and crop management. Biological indexing such as lesions, discoloration, wilting, or necrosis on plant tissues assessments often rely on morphological symptoms like lesions or discoloration. However, these methods are subjective, prone to human error, and influenced by environmental factors like light and angles, leading to inconsistent results and inefficiencies in disease control.

To address these limitations, modern high-throughput tools have been developed that offer greater accuracy, objectivity, and scalability. Traditional diagnostic techniques such as microscopy, culture-based assays, and enzyme-linked immunosorbent assays (ELISA) have been widely used in plant pathology. These methods, while highly effective in identifying a broad range of pathogens, are often limited by time consumption, labour intensity, and sensitivity issues. The rise of molecular techniques - including polymerase chain reaction (PCR), quantitative PCR (qPCR), Loop mediated isothermal amplification (LAMP), Recombinase Polymerase Amplification (RPA) and Next-Generation Sequencing (NGS)-has revolutionized diagnostics, offering specificity and accuracy in pathogen identification and disease diagnostics in agriculture.

Emerging techniques like CRISPR-Cas12 integrated with Lateral Flow Assay (LFA) have further enhanced detection precision. These tools rely on nucleic acid targeting, enabling real-time identification of plant pathogens at the molecular level with unmatched sensitivity. Furthermore, advancements in Internet of Things (IoT) technologies have integrated sensor systems, cloud-based analytics, and machine learning for real-time, large-scale monitoring of plant health, offering predictive capabilities to farmers.

Meanwhile, remote sensing-derived hyperspectral imaging has emerged as a more advanced approach to disease severity assessment. Unlike traditional RGB or multispectral imaging, hyperspectral imaging captures hundreds of narrow spectral bands across the electromagnetic spectrum. This fine spectral resolution allows for the detection of subtle biochemical and physiological changes in plants, such as alterations in water content, pigment concentrations, or cellular structure-often before visible symptoms manifest. Coupled with machine learning algorithms, these tools can analyse vast datasets, identifying patterns and correlations that indicate disease severity with high precision.

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Implementing these advanced diagnostic tools comes with its own set of challenges. Significant issue is the variability and complexity of plant pathogens, particularly fungi and viruses, which exhibit high mutation rates and genetic diversity. This variability can render traditional diagnostic tools ineffective and necessitates constant updates to molecular assays. High costs, need for specialized equipment, and technical expertise can limit their accessibility to small-scale farmers. However, integrating these tools with mobile apps and remote sensing technologies can bridge this gap, making precision farming accessible to a broader audience. Tools like RT-qPCR and NGS provide quantitative data on pathogen load, aiding in the assessment of disease severity. This information is critical for decision-making regarding treatment options and resource allocation.

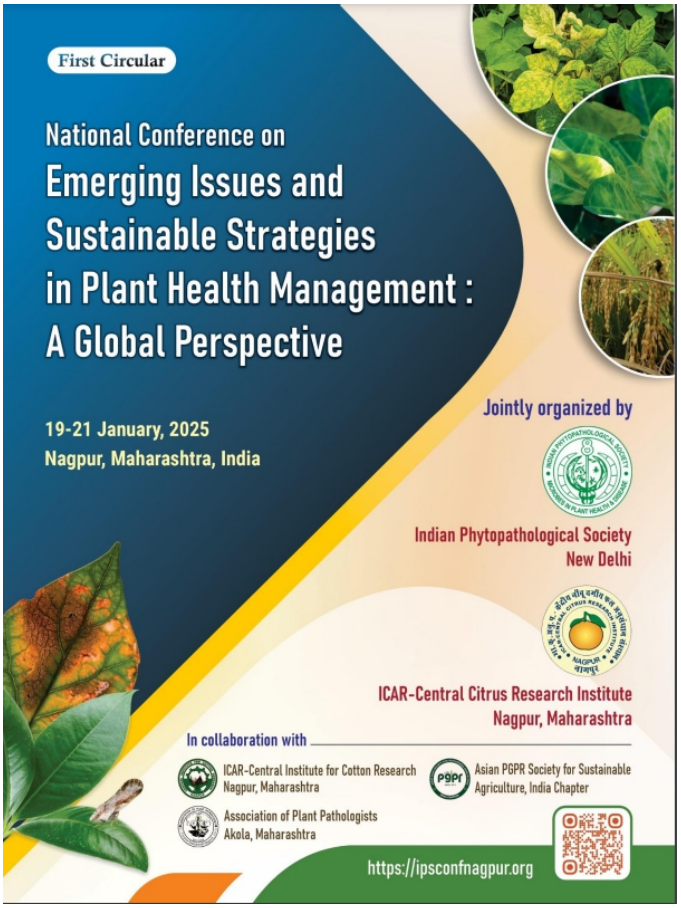
Additionally, detecting pathogens during their latent stages-before symptoms are visible-is critical for early intervention but remains difficult for most existing methods. Furthermore, the integration and analysis of data from diverse diagnostic platforms, such as IoT devices, imaging systems, and molecular assays, demand robust computational infrastructure and expertise in data analytics, which can be lacking in many agricultural systems. These barriers highlight the need for more affordable, scalable, and user-friendly diagnostic solutions to ensure equitable access and effective disease management globally. Integrated platforms that combine molecular diagnostic tools with geospatial and imaging technologies offer a comprehensive view of plant health. By integrating data from qPCR assays, hyperspectral imaging, and remote sensing, these platforms allow precise mapping of disease prevalence and severity across large agricultural fields. Such tools reduce reliance on chemical treatments by targeting interventions to specific areas of need, thereby optimizing resource use and minimizing environmental impact. These practical applications exemplify how molecular diagnostics and technological integration can address existing challenges and pave the way for more efficient, sustainable disease management in agriculture.

To overcome the challenges of high costs and technical barriers, researchers are working on developing low-cost, user-friendly diagnostic kits. Training programs for farmers and agricultural extension workers can enhance their capacity to use these tools effectively. Additionally, public-private partnerships can play a crucial role in subsidizing the cost of advanced diagnostics for small-scale farmers.

The future of plant disease diagnostics lies in scalability, affordability, and ease of use. Innovations such as nanotechnology-based biosensors offer the promise of ultra-sensitive, low-cost detection. Advances in CRISPR-based multiplexing could enable simultaneous detection of multiple pathogens. The development of robotics and autonomous drones for large-scale field monitoring further complements IoT solutions.

The advancements in plant disease diagnostics, from traditional assays to high-precision tools like CRISPR-Cas12 and IoT-based detection, are revolutionizing sustainable agriculture. These tools provide accurate, rapid, and actionable insights into plant health, empowering farmers to manage diseases effectively and sustainably. While challenges remain, ongoing innovations and collaborative efforts promise a future where precision agriculture is accessible to all, ensuring food security and environmental sustainability.

D.K. Ghosh
President
Indian Phytopathological Society



Research Highlights

Diversity, pathogenic characteristics and molecular identification of *Fusarium* spp. isolates causing post-flowering stalk rot in maize

Harish J.[1], Prashant P. Jambhulkar[1]*, Ruchira Bajpai[1], Meenakshi Arya[1], Piyoosh K. Babele[1], Sushil K. Chaturvedi[1], Anil Kumar[1] and Dilip K. Lakshman[2]*

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Seventy-one isolates were collected from 40 locations in five agro-climatic zones of India to assess the diversity of *Fusarium* spp. associated with maize crops showing symptoms of post-flowering stalk rot in the field (Fig. 1). *Fusarium* isolates were divided into 9 distinct clusters based on pigmentation, colony colour, mycelium pattern, mycelium type, conidial size, and shape. The ten most virulent Fusarium isolates, based on the highest observed disease index, were identified by homology and phylogenetic analyses of partial sequences of the translation elongation factor 1 α (Tef 1-α) as *Fusarium acutatum* (2/10), *Fusarium verticillioides* (Syn. *Gibberella fujikuroi* var. *moniliformis*) (7/10), and *Fusarium andiyazi* (1/10). All these species are part of the *Fusarium fujikuroi* Species Complex (FFSC). Due to the pronounced intraspecies morphological variabilities and the presence of multiple species within the FFSC, sequencing of Tef 1-α is recommended to reliably identify Fusarium pathogens. (Frontiers in Microbiology, 14 https://doi.org/10.3389/fmicb.2023.1121781)

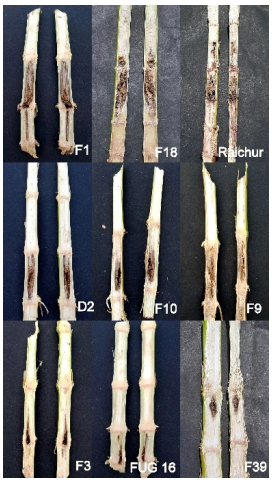


Fig. 1. Comparative lesion sizes of virulent (F1, F18, Raichur), Moderately virulent (D2, F10, FUG49), and less virulent (F3, FUG 16, F39) isolates of FFSC. Virulent isolates caused lesions covering 2-3 nodes, moderately virulent isolates covered entire pith between nodes, and less virulent isolates caused lesions restricted to the inoculated area

Awards/Honours/Promotions

- **Dr. Charudatta D. Mayee**, Former Chairman, ASRB awarded with Rashtrasant Tukdoji Maharaj Jeevan Sadhana Puraskar given by Rashtrasant Tukdoji Maharaj Nagpur University for his life long contribution to Agriculture on August 4, 2024 at the hand of Dr. Raghunath Mashelkar in a glittering function at Nagpur. He has also been awarded with Sardar Vallabhbhai Patel National Krishi Jeevan Puraskar-2024 by Association of National Agricultural Journalists on September 22, 2025 at Ahmedabad at the hand of H.E. Acharya Devvrat, Governor of Gujarat.
- **Dr. A. Ramesh Sundar**, took over as Head, Division of Crop Protection, ICAR-Sugarcane Breeding Institute, Coimbatore since June 2023 and also awarded with NAAS Fellowship.
- **Dr. Krishna Kumar**, former Dean, Pandit Deendayal Upadhyay College of Horticulture and Forestry, under RPCAU, Bihar joined as Principal Scientist (Plant Pathology), Division of Crop Protection, ICAR-IIPR, Kanpur, Uttar Pradesh.
- **Dr. Efath Shahnaz**, Associate Professor, DARS, Rangreth, SKUAST-Kashmir, Srinagar, Jammu & Kashmir has been awarded Women Scientist Award-2024 during the National Symposium on Multidisciplinary Perspectives for Pest and Disease Management in Sustainable Production of Crops organized by Division of Plant pathology, Faculty of Agriculture, Wadura, SKUAST-Kashmir along with Society of Plant Protection Sciences, New Delhi and Association of Plant Pathologists, Dr. PDKV, Akola, Maharashtra, India on 28th-30th August, 2024.
- **Dr. Satish Kumar Verma**, Assistant Professor, Department of Botany, Institute of Science, Banaras Hindu University has been awarded "Excellent Young Research Award" and "Best Presentation Award" in the 8th International Conference on Plant Growth-Promoting Rhizobacteria (PGPR) for Sustainable Agriculture, held at World Vegetable Center in Tainan, Taiwan during September 24-27, 2024.
- **Dr. Jagmohan Singh**, Scientist, Department of Plant Pathology, CCS HAU, Hisar was honored with the SERB-ITS (Travel Grant) Award by the Science and

Engineering Research Board (SERB), Department of Science and Technology (DST), Government of India, to attend the "Plant Health-2024" conference.

Symposia/Workshop: Organized

Dr. Jagmohan Singh, Scientist, Department of Plant Pathology, CCS HAU, Hisar organized special session on 'Applications of Nanotechnology, Biosensor, and Microfluidics in Plant Pathogen Detection' as co-Chairperson at the international conference "Plant Health-2024" of American Phytopathological Society at Memphis, USA from 27th July to 30th July, 2024.

Symposia/Workshop: Attended

Dr. Dilip Ghosh, Director, ICAR-Central Citrus Research Institute (CCRI), Nagpur, and President of Indian Phytopathological Society, New Delhi, attended the 7th International Research Conference on Huanglongbing (IRCHLB), held at the Riverside, California, USA, from March 26-29, 2024. The conference, organized by the Citrus Research Board (CRB), focused on the theme "Transitioning Research to Field Reality" and brought together over 500 citrus researchers, regulators, and industry professionals from around the world. Dr. Ghosh presented his research paper titled "Present status of developing diagnostics, molecular characterization, and novel management strategies for Huanglongbing (HLB) in India" as an oral presentation.

Dr. Jagmohan Singh, Scientist, Department of Plant Pathology, CCS HAU, Hisar attended the "Plant Health-2024" conference in Memphis, USA, from July 27th to 30th, 2024.

Announcement of IPS Award Applications 2025

The online award application portal for the various awards of the Society is open from June 01, 2024 (https://ipsdis.org/awards). The last date for submission of the online application is July 31, 2024. Interested members are requested to apply for an award of their choice. Please go through the instructions available on the website before the online application (https://ipsdis.org/award-guidelines).

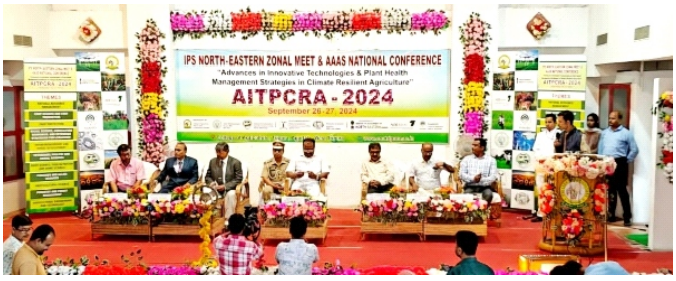
IPS Conferences 2024-25

IPS one day seminar at Raiganj, WB

The One-Day National Seminar on "Current Trends in Plant and Microbial Research for Crop and Crop Health Management" was held on 6th September 2024 at Raiganj University. The seminar was a grand success, with active participation of more than 70 delegates. This seminar was organized by Dr. Parimal Mandal, Raiganj University, Raiganj, West Bengal.

IPS North-Eastern Zone Symposium

The College of Agriculture, Tripura along with Indian Phytopathological Society (IPS), New Delhi and Academy for Advancement of Agricultural Sciences (AAAS), Kalyani organized "IPS North-Eastern Zonal Meet & AAAS National Conference on "Advances in Innovative Technologies & Plant Health Management Strategies in Climate Resilient Agriculture (AITPCRA - 2024)" in collaboration with Society for Advancement of Agricultural Innovation (SAAI), Agartala, Tripura and Directorate of Extension Education (DEE), CAU, Imphal during September 26-27, 2024 at College of Agriculture, Tripura. Hon'ble Governor of Tripura has inaugurated the Conference and was attended by more than 200 numbers of dignitaries from different regions of India.



IPS forth-coming conferences

IPS National Conference: January 19-21, 2025, Nagpur, MS (Title: Emerging Issues and Sustainable Strategies in Plant Health Management: A Global Perspective)

IPS Zonal Conferences

Northern Zone: November 7-8, 2024, CSK HPKV, Palampur (Title: New Vistas in Plant Pathological Research)

Eastern Zone: November 28-29, 2024, ICAR-NRRI-CRURRS, Hazaribag, Jharkhand (Title: Holistic Approaches for Biotic and Abiotic Stress Management in Crops for Sustainable Agriculture)

Southern Zone: December 11-12, 2024, UAS, Dharwad, Karnataka (Title: Plant Health Management: A Sustainable Tool in Addressing Crop Diseases Under Climate Resilient Agriculture)

Central Zone: December 12-13, 2024, PJTSAU, Hyderabad, Telangana (Title: Recent Advances in Plant Pathology and Innovative Approaches in Plant Disease Management (RAPPID)

Mid-Eastern Zone: January 3-4, 2025, Rani Lakshmi Bai CAU, Jhansi, Uttar Pradesh (Title: Plant Microbes Interaction for Sustainable Agriculture and Food Security)

Western Zone (Online): January 9, 2025, AAU, Anand, Gujarat (Title: Climate change, Plant, Pests and Human health: A triple challenge)

Delhi Zone: January 15-16, 2025, ICAR-IARI, New Delhi (Title: Integrating Genomics in Plant Pathology: New Frontiers in Disease Management)

Obituary

- **Dr. Uma Shankar Singh** left for his heavenly abode on 9th May 2024. He had been serving as South Asia Advisor for Research & Partnerships at IRRI. He was the President of IPS in 2013.
- **Prof. C.L. Jandaik**, Professor & Head (Retd.), Department of Mycology and Plant Pathology, UHF, Nauni, Solan, Himachal Pradesh, left to his heavenly abode on 17th August, 2024.
- **Dr. Srikant Kulkarni**, Former Professor & University Head (Plant Pathology), UAS, Dharwad, Karnataka left to his heavenly abode on 8th September, 2024.

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