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Climate Change and Emerging Plant Diseases: A Growing Threat to Global Food Security

*Dr. Ch. Yamuna and Dr. K. Eden Georgia
Department of Plant Pathology, VIAT, Vignan University, Vadlamudi, Guntur, Andhra Pradesh – 522213, India
*Corresponding Author's email: yamunachukka123@gmail.com

Climate change is one of the most significant challenges facing agriculture in the 21st century. Rising global temperatures, irregular rainfall patterns, increased atmospheric carbon dioxide (CO_2), prolonged droughts, floods, and extreme weather events are altering agricultural ecosystems worldwide. These environmental changes not only affect crop productivity but also influence the occurrence, distribution, severity, and evolution of plant diseases. As climatic conditions become more favorable for many pathogens and their vectors, the frequency of disease outbreaks is increasing, posing a serious threat to global food security and sustainable agriculture (Garrett *et al.*, 2006; IPCC, 2023).

Plant diseases caused by fungi, bacteria, viruses, nematodes, and phytoplasmas are highly influenced by environmental conditions. Temperature, moisture, humidity, and wind determine pathogen survival, reproduction, dispersal, and infection. Climate change is disrupting these interactions, allowing several pathogens to expand into new geographical regions and infect crops previously considered less susceptible. Consequently, emerging and re-emerging plant diseases are becoming major constraints to agricultural production worldwide (Bebber *et al.*, 2013).

Recent advances in climate science, digital agriculture, remote sensing, artificial intelligence (AI), and disease forecasting models are helping researchers and farmers anticipate disease outbreaks and implement timely management strategies. Integrating climate-resilient crop production with sustainable disease management has become essential for ensuring food security under changing climatic conditions.

How Climate Change Influences Plant Diseases

Climate change affects plant diseases through several interconnected mechanisms.

1. Rising Temperature

Increasing temperatures accelerate the growth and reproduction of many fungal and bacterial pathogens. Warmer climates also shorten pathogen life cycles, allowing multiple disease cycles during a single cropping season. Higher temperatures can also weaken plant defense mechanisms, making crops more vulnerable to infection (Chakraborty and Newton, 2011).

For example:

- Wheat rusts have expanded into cooler regions.
- Fusarium wilt has become more severe under elevated temperatures.
- Charcoal rot caused by *Macrophomina phaseolina* is increasing in drought-prone regions.

2. Changes in Rainfall and Humidity

Many plant pathogens require free moisture for spore germination and infection. Increased rainfall, prolonged leaf wetness, and high humidity create favorable conditions for diseases such as:

- Late blight of potato
- Rice blast

- Downy mildews
- Anthracnose
- Bacterial leaf blight

Conversely, drought conditions may favor soil-borne pathogens and root diseases.

3. Elevated Carbon Dioxide (CO_2)

Increased atmospheric CO_2 alters plant physiology by increasing canopy density and leaf area, creating humid microclimates that favor disease development. Elevated CO_2 may also modify host-pathogen interactions by changing leaf chemistry, nutrient composition, and plant defense responses.

4. Extreme Weather Events

Floods, cyclones, heatwaves, and storms facilitate rapid spread of plant pathogens.

Examples include:

- Floodwater dispersing soil-borne pathogens
- Strong winds transporting fungal spores over long distances
- Hurricanes introducing new pathogens into disease-free regions

Emerging Plant Diseases Under Climate Change

Several diseases are becoming more important because of changing climatic conditions.

1. Wheat Rusts

Stem rust (*Puccinia graminis* f. sp. *tritici*), stripe rust (*Puccinia striiformis*), and leaf rust (*Puccinia triticina*) have expanded their geographical distribution due to changing temperatures.

2. Rice Blast

Rice blast caused by *Magnaporthe oryzae* remains one of the most devastating diseases of rice. Increased humidity and fluctuating temperatures enhance disease severity.

3. Coffee Leaf Rust

Coffee leaf rust (*Hemileia vastatrix*) has spread into higher altitudes that were previously unsuitable because of rising temperatures.

4. Banana Fusarium Wilt (TR4)

Tropical Race 4 of *Fusarium oxysporum* f. sp. *cubense* continues to spread globally, threatening banana production.

5. Maize Diseases

Changing weather conditions have increased the incidence of:

- Turcicum leaf blight (*Exserohilum turcicum*)
- Maydis leaf blight (*Bipolaris maydis*)
- Banded leaf and sheath blight

Erratic rainfall and prolonged humidity promote disease epidemics.

6. Cotton Diseases

Climate variability is influencing the incidence of:

- Alternaria leaf spot
- Grey mildew
- Bacterial blight
- Cotton rust

Warmer temperatures also encourage insect vectors that transmit viral diseases.

Climate Change and Insect Vectors

Climate change not only affects pathogens but also insect vectors responsible for transmitting plant viruses and phytoplasmas.

Examples include:

- Whiteflies transmitting Tomato leaf curl virus
- Aphids spreading Barley yellow dwarf virus
- Thrips transmitting Groundnut bud necrosis virus
- Leafhoppers transmitting phytoplasmas

Warmer winters increase vector survival, while longer growing seasons allow additional generations each year, resulting in higher disease pressure (Bebber *et al*., 2013).

Technological Innovations for Climate-Smart Disease Management

Modern technologies are revolutionizing plant disease surveillance and management.

Artificial Intelligence (AI)

AI-powered mobile applications can identify diseases from leaf images within seconds, enabling early diagnosis and timely management.

Remote Sensing and Drones

Satellite imagery and drones monitor crop health over large areas and detect disease hotspots before symptoms become visible.

Weather-Based Disease Forecasting

Disease forecasting models combine weather data with pathogen biology to predict outbreaks.

Examples include forecasting systems for:

- Potato late blight
- Wheat rust
- Rice blast
- Apple scab

These models help farmers optimize fungicide applications and reduce unnecessary pesticide use.

Molecular Diagnostics

Rapid molecular tools such as PCR, quantitative PCR (qPCR), Loop-mediated Isothermal Amplification (LAMP), and Next-Generation Sequencing (NGS) enable early and accurate pathogen detection.

Climate-Smart Disease Management Strategies

Managing plant diseases under changing climates requires an integrated approach.

Major strategies include:

- Development of climate-resilient and disease-resistant crop varieties
- Adoption of Integrated Disease Management (IDM)
- Crop diversification and rotation
- Biological control using beneficial microorganisms such as *Trichoderma*, *Pseudomonas*, and *Bacillus*
- Weather-based disease advisory services
- Precision agriculture technologies
- Conservation agriculture and improved soil health
- Regular disease surveillance and early warning systems

These practices enhance crop resilience while minimizing environmental impacts.

Challenges and Future Prospects

Despite technological progress, several challenges remain.

The response of pathogens to climate change varies among regions, making disease prediction difficult. Many developing countries lack comprehensive disease surveillance networks, regional pathogen databases, and reliable weather monitoring systems. In addition, the emergence of new pathogen races and fungicide resistance complicates disease management.

Future research should focus on integrating climate science, genomics, artificial intelligence, remote sensing, and predictive epidemiology to improve disease forecasting and preparedness. International collaboration, data sharing, and farmer awareness programs will be crucial for building climate-resilient agricultural systems. Investments in digital agriculture, precision disease management, and breeding climate-resilient cultivars will play a central role in safeguarding global food production (Savary *et al.*, 2019; IPCC, 2023).

Conclusion

Climate change is reshaping the landscape of plant diseases by influencing pathogen biology, host susceptibility, and environmental conditions. Rising temperatures, altered rainfall patterns, elevated atmospheric CO_2, and extreme weather events are driving the emergence and spread of many economically important diseases across the globe. These changes threaten agricultural productivity, food security, and farmers' livelihoods.

Fortunately, advances in artificial intelligence, remote sensing, molecular diagnostics, weather-based disease forecasting, and climate-smart agriculture are providing powerful tools for early disease detection and sustainable management. Strengthening research, improving surveillance systems, and promoting integrated disease management will be essential to reduce the impact of climate change on crop health. By combining scientific innovation with sustainable agricultural practices, we can enhance the resilience of cropping systems and ensure food security for future generations.

References

1. Bebber, D.P., Ramotowski, M.A.T. and Gurr, S.J. (2013). Crop pests and pathogens move polewards in a warming world. *Nature Climate Change*, **3**: 985–988.
2. Chakraborty, S. and Newton, A.C. (2011). Climate change, plant diseases and food security: An overview. *Plant Pathology*, **60**(1): 2–14.
3. Garrett, K.A., Dendy, S.P., Frank, E.E., Rouse, M.N. and Travers, S.E. (2006). Climate change effects on plant disease: Genomes to ecosystems. *Annual Review of Phytopathology*, **44**: 489–509.
4. IPCC. (2023). *Climate Change 2023: Synthesis Report*. Intergovernmental Panel on Climate Change, Geneva, Switzerland.
5. Savary, S., Willocquet, L., Pethybridge, S.J., Esker, P., McRoberts, N. and Nelson, A. (2019). The global burden of pathogens and pests on major food crops. *Nature Ecology & Evolution*, **3**: 430–439.
6. Velásquez, A.C., Castroverde, C.D.M. and He, S.Y. (2018). Plant–pathogen warfare under changing climate conditions. *Current Biology*, **28**(10): R619–R634.
7. Eastburn, D.M., McElrone, A.J. and Bilgin, D.D. (2011). Influence of atmospheric and climatic change on plant–pathogen interactions. *Plant Pathology*, **60**(1): 54–69.
8. Chaloner, T.M., Gurr, S.J. and Bebber, D.P. (2021). Plant pathogen infection risk tracks global crop yields under climate change. *Nature Climate Change*, **11**: 710–715.