



Effect of Weather and Climate Change on Crop Diseases

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Agriculture is a fundamental pillar of the Indian economy, sustaining the livelihoods of nearly 60% of the population and contributing significantly to the country's GDP (FAO, 2020). This sector is not only the primary source of food and raw materials but also a significant means of employment for millions of rural households. However, the agricultural landscape in India is fraught with challenges, one of the most pressing being the impact of weather and climate change on crop health and productivity.

Weather and climate are crucial determinants of agricultural success. They influence every aspect of farming, from sowing and growing to harvesting and storage. With the advent of climate change, the predictability of weather patterns has diminished, leading to increased uncertainty and vulnerability for farmers. Extreme weather events, such as droughts, floods and heatwaves, are becoming more frequent and severe, exacerbating the risk of crop diseases (Kumar *et al.*, 2020).

Crop diseases caused by various pathogens including fungi, bacteria, viruses and nematodes, can devastate yields and quality, leading to significant economic losses. The relationship between weather, climate change and crop diseases is intricate and multifaceted. Changes in temperature, humidity and precipitation patterns can directly affect the life cycles of pathogens and the susceptibility of crops to diseases. For instance, warmer temperatures can accelerate the growth and reproduction of many fungal pathogens, while altered rainfall patterns can create favorable conditions for the spread of diseases (Das *et al.*, 2021).

In India, where agriculture is predominantly rain-fed and dependent on the monsoon, the impact of climate variability is particularly pronounced. The Indian subcontinent has witnessed shifts in monsoon patterns with some regions experiencing excess rainfall leading to floods, while others face prolonged dry spells and droughts (Choudhary *et al.*, 2020). These fluctuations not only affect water availability and soil moisture but also influence the emergence and spread of crop diseases.

Impact of Weather on Crop Diseases

Weather plays a crucial role in the development and spread of crop diseases. Various meteorological factors such as temperature, humidity, and rainfall can significantly influence the incidence and severity of plant diseases. In India, where agriculture is predominantly rain-fed and dependent on the monsoon, the impact of weather on crop diseases is particularly pronounced.

Temperature: Temperature fluctuations can profoundly affect the incidence and severity of crop diseases. High temperatures often create favorable conditions for various pathogens, enabling them to thrive and proliferate. For instance, the proliferation of fungi such as *Fusarium oxysporum* and *Aspergillus flavus* is enhanced by warmer temperatures (Singh *et al.*, 2018). These fungi can cause diseases like Fusarium wilt and Aspergillus ear rot, which severely impact crops like wheat, rice and maize.

Conversely, cooler temperatures can slow down the growth of certain pathogens but may also stress plants, making them more susceptible to infections (Mehta *et al.*, 2018). Cold stress can weaken plants' immune systems, making them more prone to infections by bacterial and fungal pathogens. In regions with fluctuating temperatures, this can lead to a complex interplay of disease dynamics.

Humidity: Humidity is another critical factor influencing the development and spread of crop diseases. Many fungal and bacterial pathogens require high humidity for spore germination, infection and disease progression. In India, the interplay between humidity and crop diseases is particularly significant due to the varying climatic conditions across different regions.

High humidity levels create an ideal environment for the proliferation of various plant pathogens. For instance, diseases such as downy mildew (*Plasmopara viticola*) in grapes and powdery mildew (*Podosphaera xanthii*) in cucurbits are more prevalent in humid conditions. These pathogens thrive in moist environments, where the humidity facilitates the germination and spread of their spores (Kumar *et al.*, 2020).

Conversely, low humidity can also impact plant health by causing physiological stress, which can make crops more vulnerable to disease. In arid and semi-arid regions of India, such as Rajasthan and Gujarat, the low humidity levels can lead to water stress in plants. This stress can weaken plant defenses and create openings for opportunistic pathogens to invade (Sharma *et al.*, 2020).

Rainfall: Rainfall is a pivotal factor in the development and spread of crop diseases. In India, the erratic monsoon patterns, characterized by both excessive rainfall and prolonged dry spells, have significant implications for agricultural health and productivity.

Excessive Rainfall: Excessive rainfall can create waterlogged conditions in the soil, which are highly conducive to the growth and spread of soil-borne pathogens. For example, the fungi *Phytophthora infestans* and *Pythium ultimum* thrive in wet conditions and can cause devastating diseases such as late blight in potatoes and damping-off in seedlings (Bhattacharya *et al.*, 2020).

Insufficient Rainfall: Conversely, insufficient rainfall can lead to drought conditions, which stress plants and make them more susceptible to diseases. Drought-stressed plants are more vulnerable to diseases like wilt caused by *Fusarium oxysporum* and various bacterial infections (Sharma *et al.*, 2020).

Erratic Rainfall Patterns: The changing rainfall patterns due to climate change have made it difficult for farmers to predict and manage crop diseases effectively. Unpredictable monsoon rains with periods of heavy downpours followed by dry spells, create fluctuating conditions that can exacerbate the spread of plant pathogens. These erratic patterns disrupt traditional farming schedules and complicate disease management strategies (Choudhary *et al.*, 2020).

Adaptation Strategies for Farmers

Scientists in India are suggesting various strategies to adapt to the challenges posed by climate change. These strategies aim to enhance resilience, improve productivity and ensure sustainable agricultural practices. Here are some key adaptation strategies:

1. Drought-Resistant Crops: Farmers are increasingly turning to drought-resistant crop varieties to cope with changing rainfall patterns. These crops are genetically engineered or selectively bred to withstand prolonged dry periods, ensuring better yields even in drought conditions. For example, in India, drought-resistant varieties of crops like pearl millet and chickpea have been developed and adopted by farmers (Kumar *et al.*, 2020). These crops have deeper root systems that allow them to access water from deeper soil layers, making them more resilient to dry conditions. By choosing these crops, farmers can better secure their harvests even in the face of erratic rainfall.

2. Improved Water Management: Efficient water management practices, such as rainwater harvesting, drip irrigation and mulching are being adopted to make the most of available water resources. These techniques help conserve water, reduce evaporation and ensure that

crops receive adequate moisture even during dry spells. In Rajasthan, farmers have implemented traditional rainwater harvesting methods like johads to improve water availability. Drip irrigation systems deliver water directly to the plant roots, minimizing water wastage and ensuring efficient use of water resources. Such practices are critical for sustaining agriculture in water-scarce regions.

3. Soil Health Management: Maintaining soil health is crucial for sustainable agriculture. Farmers are adopting practices such as crop rotation, cover cropping and organic farming to enhance soil fertility and structure. Healthy soils can better retain moisture and nutrients, making crops more resilient to climate stressors. Studies have shown that organic farming practices improve soil health and crop resilience in India (Sharma *et al.*, 2020). Crop rotation helps in breaking pest and disease cycles, while cover crops prevent soil erosion and add organic matter to the soil. These practices contribute to long-term agricultural sustainability.

4. Climate-Smart Agriculture (CSA): CSA integrates climate change considerations into agricultural planning and practices. This includes using climate-resilient crop varieties, adopting conservation agriculture practices and implementing agroforestry systems. CSA aims to increase productivity, enhance resilience and reduce greenhouse gas emissions. The implementation of CSA practices has shown positive results in increasing resilience in farming communities in India (Aggarwal *et al.*, 2018). Conservation agriculture practices, such as minimum tillage and crop residue retention, help improve soil health and water retention. By adopting CSA, farmers contribute to mitigating climate change while improving their livelihoods.

5. Precision Farming: Advancements in technology, such as drones, satellites and GPS are enabling precision farming. These tools help farmers monitor crop health, optimize resource use and make informed decisions. Precision farming can improve efficiency and reduce waste, making agriculture more sustainable. Drones equipped with multispectral cameras can capture detailed images of crop fields, allowing farmers to detect early signs of stress or disease. This timely information helps farmers take proactive measures to protect their crops.

6. Insurance and Financial Support: Access to crop insurance and financial support is crucial for farmers facing climate-related risks. Insurance schemes can provide compensation for crop losses due to extreme weather events, helping farmers recover and continue their operations. Financial support can also be used to invest in climate-resilient infrastructure and technologies. The Pradhan Mantri Fasal Bima Yojana (PMFBY) is an example of a crop insurance scheme in India that provides financial support to farmers (GoI, 2021).

7. Community-Based Adaptation: Farmers are increasingly working together in community-based adaptation initiatives. These initiatives involve sharing knowledge, resources and best practices to collectively address climate challenges. Community-based approaches can enhance resilience and foster innovation at the local level. In India, community-based water management projects have successfully improved water availability and crop productivity. Farmers' groups and cooperatives play a vital role in promoting collective action and knowledge sharing. Such collaboration strengthens the farming community's ability to respond to climate impacts.

8. Capacity Building and Education: Training and educating farmers about climate change and adaptive practices are crucial for successful implementation. Extension services, workshops and farmer field schools can help disseminate knowledge and skills. Programs like the National Initiative on Climate Resilient Agriculture (NICRA) focus on building the capacity of farmers to adapt to climate variability (ICAR, 2020). By enhancing their understanding and providing technical support, farmers can make informed decisions and adopt effective adaptation strategies.

9. Policy Support and Government Initiatives: Supportive policies and government initiatives play a vital role in promoting climate adaptation in agriculture. Governments can provide subsidies for climate-resilient technologies create awareness campaigns and facilitate access to credit and insurance. Initiatives like the National Mission for Sustainable

Agriculture (NMSA) and the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) aim to promote sustainable agricultural practices and improve water use efficiency (GoI, 2018).

10. Market Access and Value Addition: Improving market access and adding value to agricultural products can enhance farmers' income and resilience. By connecting farmers to markets and providing opportunities for value addition, such as processing and packaging, farmers can diversify their income sources and reduce vulnerability to climate shocks. In India, initiatives like the e-National Agriculture Market (e-NAM) platform facilitate better market linkages and fair prices for farmers' produce (Government of India, 2017).

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