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IMPACT OF CLIMATE CHANGE ON PLANT DISEASE MANAGEMENT

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Abstract

Climate change has become the burning issue in the present situation, as it changes the properties of the atmosphere like precipitation, humidity, temperature, etc. Climate affects the interaction between crops and pathogens in various ways. There is no doubt that this change will also affect the timing, efficiency, preference of chemical, physical, biological measures of disease management. Recently, developed experimental and modeling techniques improve the capability for climate change impact assessment and mitigation. Compared with other significant agriculture products like technical and social-economic changes, climatic change seems to be of little importance. But it will definitely add an invisible layer to the complexity and uncertainty of the system, which is already difficult to manage on a sustainable basis. Intense studies on climate change and other related issues could help to understand and manage plant diseases.

Keywords : climate variability, impact models, global warming, host-pathogen interactions.

Introduction

Even though advances in agricultural technologies like high yielding, resistant varieties, and pest management, etc. Climate still is the main issue causing the fluctuations in the crop yield. Climate also indirectly affects the plant by influencing pathogens, insects, vectors, and weeds that decrease the crop yields. Variations in the climate over the past few decades resulted in the growth of climate research to know if and why the world climate is changing. New research started to determine the impact of climate on crop production. The rise in interest is due to recognizing the fact that variability in climate might have impacted the epidemiology.

Weather is the current and predictable meteorological state of the atmosphere. Temperature, precipitation, relative humidity, radiation, wind speed, wind direction, cloud cover, and atmospheric pressure, etc., fall under the weather. Traditionally, the word “climate” is used for the average of weather conditions at a particular location. To describe the climate of a given area, average temperature and precipitation of 30 years were frequently used. But averages give no idea about a year-to-year variation. In 1970, the definition of climate changed from "average of weather" to "dynamic physical system that produces the weather." Climate change means "the average conditions that are changing over time and never return to those previously experienced. Stephen (1975) described the climate theory, theories of climate changes and classified natural and manmade causes. In 1980, climate variability was accepted as expected. Still, at present, global warming would occur due to the rise in the emissions of atmospheric carbon dioxide produced by burning fossil fuels.

Shreds of evidence for climate change

Solar radiation is the chief source of energy on earth, anything that changes the incoming solar radiation alters the planet's climate. Atmospheric temperature is increasing, which leads to global warming due to greenhouse gases. Among them, CO_2 becomes the main culprit of the scenario. Earth's climate responds to changes in greenhouse gas levels. The planet's average temperature has risen about 1.62 degrees Fahrenheit since the late 19th century. Human induced warming reached approximately 1 degree Celsius above pre-industrial levels in 2017, increasing at 0.2 degree

Celsius per decade. It is ten times faster than the average rate of ice age recovery warming. Most of the regions are undergoing greater temperatures than the global average. In the past 35 years, there were five warmest years on record taking place since 2010. Not only was 2016 the warmest year on paper, but eight of the twelve months that make up the year from Jan. to Sept. except for June, were the warmest on record.

Impacts on disease management

Without knowing the effect of climate change on patho-systems, it is impossible to make necessary changes in plant disease management. However, the changes may be through disease resistance, chemical, biological control agents. Identifying the cases where the efficiency of disease management is reduced under climatic changes is necessary.

Impact on host resistance

With the change in climate, host resistance became more effective against a pathogen, as increased defense mechanisms have been identified, which produces a change in physiology, nutrition status, and water availability. However, in contrary, host resistance is broken down by the emergence of the new race of the pathogen. Within a growing season, the number of infections is increased due to the rise in fecundity, more generations per season, and a more favorable microclimate for disease development. All these factors may lead to the evolution of aggressive pathogen races. Chakraborty et.al (1999) conducted experiment on *Colletotrichum gleosporoides* on *Stylosanthes* s*cabra* under high CO_2 concentration. In this experiment, susceptible variety was raised under controlled environmental conditions of high CO_2 concentration and inoculated repeatedly for eight infection cycles with conidia isolated from the previously infected same susceptible variety. They found that in high CO_2 conditions, there is increasing fecundity after eight infection cycles. Increase in fecundity increases the possibility of increasing more aggressive races that can overcome the host-resistance.

Impact on chemical applications

Chemical control efficiency is affected by climate change. The fate of fungicide residue on crop foliage is affected by two factors. One of them is temperature and precipitation, the increasing frequency of rainfall wash- off the fungicide and results in reduced control. Fungicide dynamics are complex, and they depend on the interactions of precipitation frequency and intensity. For few fungicides, the increased efficiency is seen if they are applied after precipitation. Neuhaus et al. (1974) applied stimulated rain at two intensities on the potato crop. They observed that there is reduced fungicide residue on the leaf with high intense rainfall, but there is no difference in the disease intensity.

The second factor is a morphological and physiological change in crops grown under elevated CO_2 conditions that affect the uptake, translocation, metabolism of systemic fungicides. For example, increased cuticle wax thickness and crop canopy size are negatively correlated with chemical uptake and spray coverage, respectively, which leads to dilution of the chemical in host tissue. Research shows that the rise in temperature results in the degradation of pesticides alters the morphology and physiology of plants and increases the uptake of fungicide, high metabolic rates, and toxicity to the target organism.

Impact on Microbial interactions

Climate change can change the makeup and dynamics of microbial communities in aerial and soil ecosystems, influencing plant organ health. Changes in the phyllosphere and rhizosphere microbial populations may have an impact on plant disease through natural and augmented biological control agents. In a soil environment, a direct influence of elevated CO_2 is impossible since the microflora is routinely exposed to levels 10 to 15 times greater than ambient CO_2. Trees grown in nutrient-depleted soils, especially nitrogen-depleted soils, encourage arbuscular mycorrhizal fungi to colonise their roots. The association between elevated CO_2 and mycorrhizae is unclear, and there are conflicting studies about how it could be affected by plant and soil nutrient status. If a lower nitrogen status of plant tissue under increased CO_2 results in further mycorrhizal colonisation, this could boost plant health by increasing nutrient uptake. Temperature changes have a non-linear relationship with interactions of host pathogen and biological control agent.

Geographical impact on disease

Some diseases of economic concern don't occur in few regions like wart disease of potato, karnal bunt of wheat, Golden nematode, etc because the climatic conditions inhibit the causal agents from being established in certain regions. However, if the pathogen comes in contact with a conducive environment, there are high possibilities of an outbreak of these diseases. Exclusion, a plant disease control strategy, and quarantine agencies bear the pressure in managing these diseases. So, this strategy will play important role in managing the diseases due to climate change. Geographical information systems and climate matching tools guide quarantine agencies in deciding the threat caused by pathogens under current and future climates. Sansforth and Baker et al. (1998) used this approach to know the risk of establishing karnal bunt pathogens in the cereal-growing regions of the European Union.

Impact Models

Much has been said about plant disease and climate change relies on qualitative, rule-based logic. This impact model seems to be attractive because of the already available information regarding the environmental requirements of plants and their pathogen. For example, It is reasonable that raising temperature results in directional expansion of the geographical range of pathogens and more generations per year. The rise in winter temperature would increase the chance of survival and inoculum. Greater continental dryness in summer leads to reduce infections by the pathogen, which requires the wetness of the foliage or soil moisture for infection. But the process of infection depends on the interaction of atmospheric, climatic, biological factors with technical and social-economic interventions that are difficult to predict. These interactions are not amenable to qualitative analysis hence impact models comes into picture which is quantitative and allows to investigate multiple scenario and interactions simultaneously. Biological impact evaluation is a method that routinely evaluates the potential or current impact, including risks and advantages, of the occurrence, arrival, or entry of particular endemic or exotic species into a biological environment. Surtherst et al. (1996) and Teng and Yang et al.(1993) have given a framework on impact models. The analytical tools are needed for quantitative impact assessment in plant pathology.

Conclusions

Climate change has both positive, negative, and neutral impacts on the specific nature of the interaction of host and pathogen interactions. This limits the research on the effects of climate change on plant diseases. In this changing climate scenario, modified chemical, biological practices have to be adopted. Breeders have to begin gene expression analysis for developing varieties against biotic and abiotic stress. Climate prediction models have been developed for plant disease management. Climate change is at a global level from a plant disease management point of view, and it requires disease specific information at the field scale level. To mitigate the problem of climate change, a collaboration of all the disciplines is necessary. More rational approaches have to be taken to know the actual mechanism for plant disease management.

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