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Impact of Climate Change on Plant Disease Dynamics

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Abstract

Global climate change affects plant diseases in such a way that it affects the occurrence, distribution and virulence of diseases that affect agricultural output and biological diversity. Global climate change causes changes in infection rates and the results of their effects on plants, furthermore changes in temperature, precipitation, atmospheric CO _{2} concentration, and humidity lead to unsteadiness in the relations basic of plant pathogens and inevitably lead to new opportunities in the control of plant diseases in agriculture. Rising temperatures have increased pathogen potency and replication and have modified the duration or lengthened diseases cycles or geographical distribution ranges. For instance, diseases that result from the attacks of fungi such as wheat rust or diseases affecting grapevine particularly the downy mildew disease are on the rise because of increasing temperatures. In addition, existing patterns of precipitation in terms of rain that causes flooding or lack of rain that extend periods during which susceptibility to diseases increase and transmission of water borne pathogen enhances. Humidity, especially high, enhances growth of fungal and bacterial pathogen leading to worsening effect of such diseases on crops. Although raised atmospheric levels of CO2 stimulate plant growth, they are at the same time changing the patterns of plant resistance and influencing plant-pathogen interactions. Sometimes for some species, they fall vulnerable to diseases by alterations in nutrient quality and defense reactions at high CO2. Besides, climate change is making new diseases affecting plant and spreading diseases that were previously known to other spread areas like soybean rust disease, citrus greening disease.

Introduction

Climate change is one of the world's biggest problems that can have a vast impact on the world's climate, species, crop growing, and food accessibility. Climate parameters inclusive of;

temperature, transpiration, precipitation, CO2 levels as well as, humidity have powerful effects that interfere with the effective plant-pathogen interactions hence changed plant disease dynamics. It is important to grasp how climate change affects plants diseases so that solutions to help reduce the effect can be determined. Diseases of plants due to fungi, bacteria viruses and other pathogens pose a serious threat to agriculture and food security around the globe. These diseases can greatly affect crops, lower yields and trigger poor quality food which is dangerous to food security. Dynamics of plant diseases depend on host-pathogen-environment interactions as well as management practices that can either effectively control the disease or increase its spread and impact. Climate change is changing these environmental factors in ways not seen before, and this has raised significant challenge for farmers and researcher to predict and control the diseases. For instance marketplace temperatures influence the development rate of the pathogen, the season of arrival of the diseases, and geographical spread of some diseases. Mild temperatures can allow pathogens to become established in new areas, and bring diseases into territories that were hitherto free of them. Similarly, change in precipitation frequency intensifies the transmission pattern of waterborne diseases while high relative humidity promotes fungal and bacterial diseases. An increase in CO2 concentration is good for the plant growth, however it affects the plants ability to defend itself against diseases affecting crops. Because climate change is only progressing, the ways in which climate influences plant diseases are important to understand. Climate change and its effects on plant diseases are the focus of this article, and the author considers ways to respond to and alter the effects on agriculture and food security.

Effects of different factors on disease severity and spread.

Diseases are one of the most critical challenges for agriculture and horticulture since they affect quality, quantity, and healthy ecosystem. These diseases can be attributable to any of the following pathogen agents; fungi, bacteria, virus, nematodes and parasitic plants. Plants diseases are dynamic processes, which are affected by factors such as environmental influence, pathogen factors, host, plant resistance, and human activities. Such dynamics are crucial for disease management, particularly as global climate change perturbs the conditions that favor diseases in plants. Pathogen behavior is one of the fundamentals upon which disease processes in plants are

built. Various microorganisms are characterised by different ways of invasion, toxic substances, and multiplication. For instance while fungal pathogens can spread about through spores through the medium of wind or water, bacterial pathogens infect plants through injuries or naturally provided apertures. Viruses, on the other hand, can only move to another plant through some vector, often an insect. These pathogens have different affinities with their host plants during disease development. Susceptible plants offer suitable environment for pathogen to colonize, while, resistant plants are genetically armored to prevent disease invasion. There is significant evidence to indicate that the environment is an important determinant of plant disease. Climate variables, such as temperature, humidity, moisture and light influence pathogen population dynamics, growth, reproduction and pathogenic potential. For instance, some of the fungal diseases are most suitable in warm and moist conditions whereas others are suitable in cool conditions. For water borne diseases, pathogen dissemination is affected by rainfall as well as irrigation regimes. The vector breeding rate and distribution are likely to be impacted by changes the climate, for example temperature or amount of rainfall due to climate change therefore disease occurrences, severity and distribution are also affected. The susceptibility of plants to diseases caused by pathogens greatly depends on their ability to protect themselves. In order to protect themselves from pests, plants have developed number of defense strategies such as mechanical and constitutive defenses and induced defenses and resistance. However, these defenses can be suppressed by environmental stress factors including those induced by climate change diminishing plant ability to withstand diseases. Workers using this information base will understand these interdependencies in ways that help in predicting and managing the effects of plant diseases within this climate variability.

Important factors that affect plant disease

Temperature is among the most significant biotic factors that determine the pattern of plant diseases in an environment. It influences directly pathogen growth, reproduction, pathogenicity, and host plant infection. Global warming is altering the distribution, prevalence, and intensity of plant diseases through effects on the pathogens, habitat range and disease cycles. All fungi pathogens especially wilt causing ones have temperature preference at which the pathogen grows

and reproduces. For instance, wheat rust, and the late blight causing by Phytophthora are fast growing fungi at high temperatures, therefore, disease progression is speedy. Potentially, these pathogens might not only form more quickly during warmer months, but may also possibly have a longer span of duration than the host's cells, likely leading to more regular and serious infection epidemics. Also, because of global warming, diseases that were once unable to penetrate some specific latitudes because of cold weather are definitely able to penetrate those areas hence bringing new diseases. The other factor is that fluctuations in temperature chow40130 alters the susceptibility of the host plant to the particular pathogens. An adverse effect of heat stress and elevated growth temperatures is reduced immune competence, which in turn increases the plants' vulnerability to diseases. For instance, heat stress may decrease the capacity of a plant to produce antipathogenic compounds or to trigger an immune reaction and make it prone to diseases. On the other hand, it is low temperatures would slow down the growth of pathogens in the environment but the pathogens regain active growth once the temperatures start rising again. Temperature also has an effect of time in relation to the outbreak of plant diseases. Mild winters allow pathogens to mature and spread earlier in the spring; Pathogen active seasons can be affected by warm or cold snaps that come earlier than expected or later than normal. SDs can thus be problematic when devising disease management plans because farmers may be unable to determine the appropriate timing for the outbreak of diseases on their crops.

Weather and Climate

Precipitation especially humidity is another factor that determines the disease status of plants which has a major impacts on agriculture. Changes in the rainfall frequency, its intensity and rarefaction, the changing patterns of precipitation, and fluctuations of relative humidity affect the conditions that pathogens have been encountered with. These changes are primary due to climate change meaning that diseases to plants appear and manifest in new forms. More rainfall and longer duration of wet conditions promotes many water and soil pathogens and parasites. For instance, Phytophthora that affects root and blight of different crops prefers an area with way too much of moisture. The first factor which could be interpreted as an advantage of the biotrophic

pathogens is that, the water on the surface of the plants or in the soil can remain for relatively long periods to enable the spores to germinate and infect the host plants. Likewise, there are certain types of bacteria for instance Xanthomonas, which gets easily transported from one plant to the other and at a faster pace during the time of heavy rainfall because water droplets act a pathogen carriers. In the same way, low rainfall and drought stress also have an impact on plant disease process P = Plant Disease & Populations = Plant Pathogens = Biotic factors = P P = Biotic factors = Microbial populations = Rainfall & Drought stress = Reduced precipitation Drought, for instance, can trigger vulnerability within the various plant defense mechanisms to attack. Explants under water stress may synthesize inadequate metabolites for defense and general plant health may deteriorate as a potential prey for pathogen attacks. However, it stresses that for the pathogens, the concentrations of numbers could be seen in the little water available hence there could be a risk of aggressive infections once the conditions improve. Higher humidity also contributes to the continued spread of many fungal and bacterial disease agents since the majority of those types of pathogen need moisture to survive and multiply. High relative humidity sustains the fungus spores including the pathogenic ones such as Alternaria and Botrytis which make diseases on crops including tomatoes, grapes, and strawberries. On the same note, the high humidity prolongs the time needed to dry plants after rain a factor that exposes plant tissues to pathogens for extended periods.

Effects of Raised Levels of Atmospheric CO2 on Plant Pathogens

Climate change, which is characterised by high level CO2 in the atmosphere negatively impacts plants and plant-pathogen interactions. With an ever-increasing CO2 concentration, added effect on plant diseases is an area of interest. Even though elevated CO2 levels promotes plant growth by increasing photosynthesis, the effect of raised levels of CO2 in determining the defense systems of plants and with regards to the change in the plant pathosystem is still under debate. The first impact of raised CO2 level to plants is the increase in biomass. This increased growth can render the plants more vulnerably to some diseases since diseases causing agents find their feed more amplified. For example, increased size of wheat, rice and soybeans grown under higher concentrations of CO2 is witnessed and since the fungal pathogens like Puccinia (wheat

rust) or Hemileia (coffee rust) attack on a enlarged surface area of the affected crop, then crop yields shall reduce under higher concentrations of CO2. Also, while growth could be enhanced, tissues of plants exhibit decline in nutritive value a factor that lowers their resistance to certain diseases like a reduction in nitrogen content. Plant defense mechanisms also become affected by high amounts of CO2, being another effect of this compound. There are chemical weapons in plants basal on phenolic and phytoalexin to forestall pathogenic attack. But the elevated levels of CO2 consequence the production of these compounds in some cases even the weaken the defence mechanism of the plant. Instead of investing in more defense mechanisms they may invest in growth and end up being extremely vulnerable to infections. However, clearer effect of elevated CO2 on plants is that it can stimulate increased resistance responses in some species, making the plant prepare itself to fight against diseases more effectively but this effect also varies depending on the type of plant species and the main environmental conditions. Furthermore, CO2 can also affects the behavior of the pathogens at higher concentrations. There are some researches that claim that higher levels of CO2 can stimulate pathogens, therefore aggravate diseases. Of all these factors, fungal pathogens, for instance, may grow and reproduce more rapidly under high levels of CO2 and hence enhance the susceptibility of crops to damage by infections.

New and Shifts in Disease Trends

Climate change is affecting disease dynamics in plants to a great extent in relation to some existing diseases and the appearance of new diseases. Fluctuations in temperature, humidity, rainfall and other micro-climatic factors are giving disease the opportunity to expand its frontiers and move to new territories or get worse in the zones where it had been effectively combatted. This temporality of the disease geometry on plants renders agriculture the world and biodiversity unstable. Probably the most evident manifestation of climate change on plant diseases is through range expansion of pathogens into new regions. They include the following, Availability of warmer temperatures for instance leads to pathogens that were earlier confined to some areas to spread to other regions. For instance, soybean and wheat diseases such as rust have been known for a long time to occur in the tropic or subtopic climatic conditions but today they occur in

temperate climate. These pathogens can now survive in places where it used to be too hot, and therefore cause breakout in areas it was rare before. In addition, climate change can transform the season and time of disease occurrence. The disease pathogen may persist in the environment due to warmer temperatures and a long-growing season, which means that disease cycles are longer, and the outbreak occurs several times a year. For instance, the long growing season in some regions because of high temperature can allow the more frequent infection of crops by fungal pathogens such as Botrytis (grey mould) whereas changes in rainfall can allow the spread of water borne pathogens such as Phytophthora. These changes in the time of occurrence of these diseases prove to be a challenge in disease prediction and working out management plans for farmers. This development has also been compounded by the fact that the climate is changing and this bring about new pathogens. As the environment changes however, new pathogens can develop and colonize a new area, often bringing with them totally different diseases never seen before. For instance, the bacterial pathogen; Xylella fastidiosa has been invading areas like Europe and has seen new emerging plant diseases like olive tree decline. Often these new pathogens cause problems as they might be novel to the host plants and often have no effective management measures, or cultivars with resistance to the pathogen.

Recommendation on Agricultural Management

Plant diseases caused by climate change pose threats to agricultural management due to the dynamism in the disease cycle. With changes in temperature, precipitation and humidity patterns, the farmers are presented with new disease risks, new disease progression and new locations of pathogens respectively. Management strategies for pests and diseases on crops in a changing climate will therefore need to combine climate aspects with most of the existing pest and disease management practices. Based on climate changes, plant disease management will require more adaptable systems of early warning and post rainfall disease monitoring. conventional models of disease forecasts, which literally rely on previous knowledge, are not longer reliable under new climatic conditions. This will require agricultural management to take into consideration real time climate data as well as complex predictive modeling and monitoring of disease emergence and progression on a frequent basis. This will help to contain disease spreading early enough to

reduce crop losses and will also reduce the use of pesticides on crops. Growing crop resistance to diseases of new or emerging pathogens would require application of adaptive disease-resistant crop breeding in the future. With climate change extending the habitats of many plant diseases, there will be greater importation of crop varieties with resistance to a wider variety of diseases. One of them will be, the breeding of resistant cultivars with duration resistance to diseases that are on the increase due to environmental changes. Moreover, incorporating disease 'rebuff' genes into elements like crop, rotation/ agro ecological measures are effective preventive measures against diseases and conservation of bio diversity. In addition, this entry will show how future integrated pest management (IPM) programs will have to reflect new patterns of pathogen behavior. In the light of this, it will be seen that the integrated pest management IPM that includes biological control, cultural practices and chemical treatments will need some updating as new strains of pathogen surface and the method is tested under different circumstances. Farmers may also have to also adapt watering regimes, land health and planting calendar in view of the impact of climate change on plant diseases.

Consequences to the Agricultural Management

This paper aims to investigate the effect of climate change on plant diseases and its implications towards production in agriculture by emphasizing on the strengths, weakness' opportunities and threats that farmers are likely encounter in combating this problem. As the climate changes consistently through increase in temperature, rains and fluctuations in humidity new diseases will crop up and existing diseases will spread requiring a dynamic and more strategic and coordinated disease control system. One is the expansion of a prognosticative and early alert systems of such diseases. Such trends may no longer be an effective way to identify the likelihood of a plant disease outbreak given climate change. Accommodation of climate models, real-time data about weather conditions and remote sensing tools will have to become part of the agricultural managers' work, as these are helpful in disease prediction and control. Each of these elements makes timely detection possible and prevent huge loses in crops, therefore reducing the use of broad-spectrum pesticides. Breeding for resistance against disease will also become more important as climate change transposes the diseases to new areas and increases their time of

activity. Having crops with innate protection from diseases, which are currently being produced by scientists to solve the climate problem, will mean protection from the new and complex diseases as well. Moreover, diversified cropping with plant types that grow in warmer and drier conditions will help the farmers to avoid risky production dependence on one type of disease-resistant crop. Additionally, integrated pest management features will also have to be revised from time to time in response to the dynamic plant disease environment. Biological control, host plant resistance, cultural management practices, IPM and the pesticide clause if in any required, must shift to the new challenges which climate change is posing. This may range from changing the planting calendar, changing in the practices of use of irrigation, integrating new disease control technologies among others.

Conclusion

The effects of climate change on plant diseases processes are extensive and complicated, which pose both risks and opportunities for plant diseases management. Due to the changes in temperature, rainfall and humidity the pathogens distribution and the intensity of plant diseases occurrence are changing; new pathogens appear and the existing ones move to new geographical areas. These shifts threaten the security of food and agriculture systems, crop yields and production, as well as plant and animal genetic resources, and hence, farmers and agribusiness personnel need to adopt flexibility. One of the messages of global warming therefore is the importance of improving tools in disease prediction and surveillance that factor in the climate. The conventional approaches, which rely on historical trends, are not sufficient for the early warning of an outbreak under conditions of prevailing climate change. Therefore, the operationalisation of true time climatic information, modelling, and enhanced warning systems will make great sense for disease control. Furthermore, improved varieties that can bear the new climate dynamics including; ascending temperatures, changing precipitation patterns and increased numbers of climatic events that promote disease advent will also be effective in averting the effects of plant diseases. Hoping for the generation of disease resistant crops in the field of biotechnology, crop diversification and multiple crop management methods will decrease the chances of disease transmission to a large extent that affects agriculture. Further effective

implementation and innovation of Integrated Pest Management (IPM) measures will also have profound importance in controlling the diseases affecting plants. The strategy of IPM is therefore more sustainable and incorporates the biological, cultural, as well as the chemical control of organisms causing diseases in plants.

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