Int.J.Curr.Microbiol.App.Sci (2018) *7*(6): 250-256

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 06 (2018)**
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2018.706.030

Effect of Climate Change on Plant Diseases

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A B S T R A C T

Climate change has become a burning issue in the present century by changing the properties of atmosphere like rainfall, humidity, temperature etc. Green House Gases are having a major share in the climate change, Co_2 being an important culprit in the scenario. Due to the increased Co_2 concentration, there is an increase in atmospheric temperature, leading to Global Warming. Climate change is nowadays a trending issue in all sectors of agriculture. Researches have been done showing the influence of climate change on host-patho system. Some of the studies also showed the change in disease management strategies due to climate change. Climate change has also led to some of the severe epidemics in all over the world. It has not only increased the biotic stresses of plants, but also increased the cost of their management. Climate change has both positive and negative effect on crop diseases. One of the basic limitations in the study of climate change with respect to crop disease is that most of the studies are not able to answer the root mechanism behind the effects of climate change on crop diseases. So, it is a need of an hour to integrate all the mitigating strategies to tackle this global problem.

Keywords

Climate, Green House Gases, Global warming, Carbon dioxide

Article Info

Accepted:
06 May 2018
Available Online:
10 June 2018

Introduction

Diseases are one of the most important components that are having a major share in affecting agriculture. Plant diseases are the result of interaction between susceptible host, virulent pathogen and favorable environmental conditions (Garrett, 2008; Klopfenstein *et al.*, 2009; Grulke, 2011). As environment is one of the important components in disease development, changes in it can be strongly correlated with the changes in disease severity and losses due to it (Elad and Pertot, 2014). Strange and Scott (2005) estimated loss of at least 10% in global food production due to diseases. Agrios (2004) estimated that annual losses by disease cost US$220 billion. Disease control methods like chemical methods not only result in huge costs, but also increase environmental contamination threats and health issues. Thus there is a need of modification in disease control strategies in the current scenario. In context with plant diseases, CO_2, Ozone and high temperature are mostly responsible for altering development of pathogen, host and their interaction (Harvell *et al.*, 2002). They also can alter the geographical distribution of host and pathogen. Rising atmospheric CO_2 has been seen influencing the physiology, morphology and biomass of plants (Kimball, 1985). Some of the studies suggest that due to the elevated CO_2, higher carbohydrate concentration within host tissue trigger the development of some diseases like rusts (Manning and Tiedemann, 1995). Research in the effect of climate change on plant diseases continues to be limited, but some progress has been made (Garret *et al.,* 2006).

Green House Gases are the major drivers of climate change. According to Mahato (2014), GHG viz., CO_2, CH_4, N_2O, HFC, Ozone and water vapours trap reflected radiations and warm the earth's surface.

Depletion of stratospheric ozone (good ozone) has led to increase in the amount of UV-B radiations on earth surface. Second is the increase in tropospheric ozone (bad ozone), which is toxic towards plants and enhances biotic stresses in plants.

Effect of climate change on geographical distribution of host and pathogen

As temperature increases, there will be a pole ward shift of agroclimatic zones due to which many pathogens will spread into new geographic areas, where they will come into contact with new potential hosts (Baker *et al.*, 2000; Etterson and Shaw, 2001). Facultative parasites with broad host ranges would mostly fall in this category (Eshed *et al.,* 1981; Savile *et al.,* 1982). Chakraborty *et al.,* (2000) concluded that more aggressive strains of pathogen with broad host range, such as *Rhizoctonia, Sclerotinia, Sclerotium* and other necrotrophic pathogens can migrate from agricultural crops to natural vegetation.

Boag *et al.,* (1991) gave the results for the plant-parasitic nematodes *Xiphinema* and *Longidorus*. According to his results the distribution of these nematodes is directly related to July temperature of soil surface.

Another conclusion of climate change in Finland, Carter (1996) concluded that cropping area for cereals will expand by 2050 due to global warming. He also suggested that increased CO_2 concentration will lead to higher crop yields.

Robinet *et al.*, (2011) suggested that warmer temperature increases the transmission rate of the invasive pathogens.

Coakley (1999) suggested that climate change influences the geographical distribution and growth of plant species.

By these studies we can assume how climate change can have an effect on geographical distribution of host and pathogens.

Effect of climate change on crops and pathogens due to diseases

Elevated CO_2 could increase the leaf canopy which triggers crop losses due to foliar pathogens by modifying microclimate (Chakraborty *et al.*, 2003). Manning and von Tiedemann (1995) suggested that elevated CO_2 would increase canopy size and density, resulting in a greater biomass of high nutritional quality. Under elevated CO_2, there is an increase in C: N ratio of plants (Ball, 1997). Evidence from studies indicates that decomposition of high CO_2 litter occurs at a slower rate and also increased plant biomass, slower decomposition of litter and higher winter temperature could increase pathogen survival on overwintering crop residues and increase the amount of initial inoculum available to infect subsequent crops (Coakley, 1999).

Level of symptom expression and susceptibility of host towards infection can increase due to moisture and temperature (McElrone *et al.,* 2001). Water stress causes stomata closure and reduces photosynthesis, leaf growth is inhibited and changes in shoot architecture and the root/shoot ratio are commonly observed (Elad and pertot, 2014). There are indications of increased aggressiveness at higher temperatures of stripe rust isolates (*Puccinia striiformis*), suggesting that rust fungi can adapt to and benefit from higher temperatures (Mboup *et al.,* 2012). Bearchell *et al.,* (2005) conducted an experiment using PCR to study the presence of two plant pathogens in archived wheat samples from a long-term experiment started in 1843. The data were used to construct a unique 160-yr time-series of the abundance of *Phaeosphaeria nodorum* and *Mycosphaerella graminicola*, two important pathogens of wheat. Factor taken into consideration was Sulphur dioxide and it was seen that the increase in ratio of DNA of these 2 pathogens strongly correlated with atmospheric sulphur dioxide emission. This finding suggests that long-term, economically important, changes in pathogen populations can be influenced by anthropogenic induced environmental changes.

Kido *et al.,* (2008) in their studies on melon necrotic spot virus concluded that expression of systemic symptoms increase as temperature falls from 25 to 20°C and decrease as temperature increases from 20 to 25°C. Hence, they concluded that low temperature leads to expression of symptoms while as high temperature leads to latent infection or "Heat Masking"

Effect of climate change on host resistance

Increased temperature decreases the durability of resistance genes due to the evolution of pathogen races (Garrette, 2006). Garret *et al.,* (2006) have mentioned various researches regarding impact of climate change on host resistance in their publication. One of the works mentioned in their publication is of Browder and Eversmeyer (1986), reporting that, for the wheat- *Puccinia recondita* system, host-pathogen gene pairs related to resistance responded differently to different temperature ranges. Another research included is of Newton and Young (1996) suggesting that resistance mechanisms in barley may be disrupted following drought stress as cells undergo expansion once an adequate water supply is restored. Increase in temperature can modify host physiology and resistance. Temperature variation influences the host resistance, by affecting heat induced susceptibility and temperature sensitive genes (Dyck, 1983).

Lignification of cell walls increased in forage species at high temperatures to enhance resistance to fungal pathogens (Strange, 1993). Agricultural crops and plants in natural communities may harbour pathogens as symptomless carriers (Dinoor, 1974) and disease may develop if plants are stressed in a warmer climate. Drought have additive effect on disease stress, this has been reported in *Xylella fastidiosa*, *Beet yellows and Maize dwarf mosaic virus* (Olson *et al.,* 1990; Clover *et al.,* 1999; McElrone *et al.,* 2003).

Climate change and disease management

Climate change can have an effect on fungicide efficiency. The efficiency of fungicides can get altered due to change in duration, onset and intensity of precipitation. Higher level of precipitations can lead to the wash-off of fungicides. The temperature influences the degradation of pesticides, and alters the morphology and physiology of plants affecting their penetration, translocation and mode of action (Elad and Pertot, 2014).

Few of the epidemics that have already occurred

Plant Diseases	Climate Change	Author
Downy mildew epidemics on grape vines under climate change in north-west of Italy (*Plasmopara viticola*)	**Increase in temperatures and precipitation**	**Salinari *et al.*, 2006**
Alternaria epidemic of Apple in Kashmir (*Alternaria mali*)	**Prolonged rains followed by high temperatures.**	**Bhat*et al.*, 2015**
A severe epidemic of Swiss needle cast (*Phaeocryptopus gaeumannii*) disease in the Oregon coasts	**Increase in temperature during winter and duration of leaf wetness during spring and autumn**	**Stone *et al.*, 2008**

Increased thickness of epicuticular wax layer on leaves could result in slower or lower uptake of fungicide by the host (Bowes, 1993). According to Ghini (2008) increased canopy due to elevated CO2 can affect the penetration, translocation and mode of action of systemic fungicides. Hunsche (2006) showed the influence of leaf surface characteristics on retention of mancozeb on apple seedlings, bean seedlings and knol-khol plants. He also showed that fungicide retention has strong negative correlation with surface roughness and total cuticle wax. He concluded that increased canopy size could have a negative impact on spray coverage and can lead to dilution of active ingredients.

As far as biological control is concerned less information is available. Some of the researchers suggest that increased CO_2 concentration can lead to decrease in nitrogen levels in soil, which favour VAM. This mychorhizal association proves beneficial for plants. Some studies suggested increased efficiency of *Trichoderma harzianum* T39 in soil when there is increased temperature and less relative humidity (Elad *et al.*, 1993).

Davelos (2004) suggested that due to variation in interaction among microbial species, it is difficult to simulate effect of climate change on disease suppressive soils.

Climate change can have positive or negative effect on crops and their diseases. There has been however limited research on impact of climate change on plant diseases. Modified chemical and biological control need to be implemented against diseases in the changing climate scenario. It is a responsibility of a breeder too to begin gene expression analysis towards various biotic and abiotic stresses. Climate prediction models have been however also developed against plant diseases. Climate change is burning issue in today's century. There is a need of collaboration of all the disciplines together to mitigate this global problem. More rational approaches need to be taken to know the actual mechanism of impact of climate change on plant diseases.

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How to cite this article:

Nargis Nazir, Sheikh Bilal, K.A. Bhat, T.A. Shah, Z.A. Badri, F.A. Bhat, T.A. Wani, M.N. Mugal, Shugufta Parveen and Stanzin Dorjey. 2018. Effect of Climate Change on Plant Diseases. *Int.J.Curr.Microbiol.App.Sci.* 7(06): 250-256.
doi: https://doi.org/10.20546/ijcmas.2018.706.030