Plant Disease Response to Climate Change in NE Region- A Review

B.C. Nath[1*], L.C. Bora[1], K.C. Puzari[1], Kushal Sarmah[2]

[1]Department of Plant Pathology, College of Agriculture, Assam Agricultural University, Jorhat-785013, Assam, India

[2]Department of Agrometeorology, Assam Agricultural University, Biswanath Chariali-784 176, Assam, India

ABSTRACT

Occurrence of plant disease is a result of interaction among susceptible host, aggressive or virulent pathogen and conducive environment over time. Parameters like elevated temperatures, carbon dioxide concentration, and rainfall pattern can influence the development of both hosts, pathogen which ultimately, impact disease development. The purpose of this review is to summarize the pathogens response to environmental change and its ultimate effect on crop growth, development and production. From disease management or protection point of view we have to prepare ourselves and have to take diverse of measures in collaborations with epidemiologist, climatologist, sociologist, economist, Geological Information system (GIS) specialist and management practitioners to have a better understanding of plant pathogen interactions under climate change conditions.

Keywords: Plant disease, climate change, environment, epidemiology, plant health.

1. INTRODUCTION

Due to different diseases, insects and weeds a total of 36.5% loss was estimated and 14.1% of crop losses are attributed due to the occurrence of diseases, which represents an annual loss of $220 billion dollars (Agrios, 2005). Plant health is the ability of a plant to 'carry out its physiological functions to the best of its genetic potential'– is an example of a positive plant health definition. It does not refer to disease or injury and does not carry any elements of negation. Whether diseased plants are unable to show its best genetic potential may be due to the pathogenic organisms or environmental factors.

Amongst the environmental factors like temperature, relative humidity etc., altogether change of climate is playing a very great role in plant health concept and lead to new disease and epidemic condition. It has been reported that over the past century Earth's average temperature has risen by 1.4°F, and is projected to rise another 2 to 11.5°F over the next hundred years. A large and potentially dangerous shift in climate and weather can be seen with a Small change in the average temperature of the planet. Human activities have released large amounts of carbon dioxide and

other greenhouse gases into the atmosphere over the last century and the majority of greenhouse gases come from burning fossil fuels to produce energy, although deforestation, industrial processes, and some agricultural practices also emit gases into the atmosphere and leading a great impact on development of plant disease epidemic. Changing climatic conditions playing a great role in disease development and it is found that disease which were of least important are gaining economic importance and threatening crop production.

2. THE DISEASE TRIANGLE AND DISEASE DEVELOPMENT

Development of plant disease epidemics are generally driven by three factors as a susceptible host, the presence of the competent pathogen and conducive environment (Fig 1) along with time and human factor. Here we can consider 'disease triangle' is a fundamental concept of plant pathology. So by manipulating or modify any one or all three factors of this cycle, then disease will not occur and we can successfully manage plant diseases (Van Der Plank, 1963 and Agrios, 2005). For disease development, synchronous interaction between host, pathogen and environment is very important and these interactions can be conceptualized as a continuous sequence of cycles of biological events including dormancy, reproduction, dispersal and pathogenesis. The quantification of this cycle or synchronous process was developed during 1950s (Campbell and Madden, 1990).

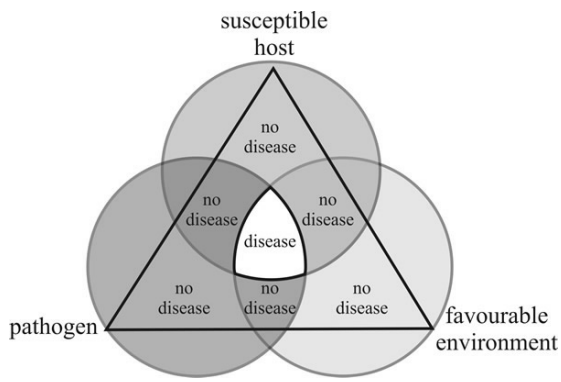

Fig 1: The disease triangle (David Moore, Geoffrey D. Robson and Anthony P. J. Trinci, 2001)

The plant itself is host and must be susceptible to that particular pathogen to cause disease. High bacterial or fungi populations present in the natural environment are responsible for cause disease incidence. But pathogens cannot do any harm without the right host and environmental factors. Here Pathogens can be very specific and infect only one host, or they can be very broad spectrum, capable of infect a large number of crop plants. **The environment** includes the weather conditions needed for a pathogen to thrive best with optimum level for growth, reproduction and spread of diseases. This environment is long been an important criterion for plant pathologist as it is very important for disease to occur and its development to takes place with other factors (Garrett, 2008

and Grulke, 2011). In this regard elevated temperature, CO_2 concentration with other changed climatic factors which favouring plant pathogens to grow well and also outbreak of various sleeper pathogens to cause heavy damage to our crop plants.

3. ENVIRONMENTAL FACTORS AND DISEASE DEVELOPMENT

Environment has a very important role to cause disease such as some pathogens are unable to infect its host without sufficient surface moisture (i.e. rain, dew or high humidity) as seen in oomycetes and other fungi, bacteria, nematodes or vectors inability to overwinter when temperatures go below a critical level and reduces amount of inoculum. Again high temperature reduces the inoculums of viruses and mollicutes (Agrios, 2005). So, climate change leads to weather events that are more favourable for disease and there will be increased disease pressure. But the relationship between climate change and associated weather events, and resulting changes in disease development will generally not be a simple one-to-one relationship. Parameters like elevated temperatures, carbon dioxide concentration, and rainfall pattern, altogether climate change influence the development of both hosts, pathogen which ultimate impact can be seen in disease development. With increasing atmosphere concentrations of ozone, SO_2 and CO_2 disease development may increase, decrease or remain stable depending on the particular pollutant and host-pathogen interaction (Coakley, 1995). Chakraborty *et al*., 2008 also revealed that elevated CO_2 on plant disease has been evaluated in the context of several free-air CO_2 enrichment (FACE) experiments. It is found that FACE experiments allow more realistic evaluations of the effects of elevated CO_2 levels in agricultural fields or natural systems such as forests. Higher CO_2 levels may favour disease through denser more humid plant canopies and increased pathogen reproduction, but may reduce disease risk by enhancing host disease resistance. Current CO_2 concentration in the atmosphere remind exceed 400 ppm in a few years which is higher than the range of concentrations (180–300 ppm) measured from ice cores going back 650, 000 years. The main causes of this global increase of CO_2 are fossil fuel burning and deforestation (Paterson and Lima, 2010). This increase in CO_2 concentration along with other green house gases contributing in increase in the global average temperature of 0.6–0.7°C over the last century (Walther *et al*., 2002). Lake and Wade (2009) reported that elevated CO_2 concentrations may accelerate plant pathogen evolution, which can affect virulence of the pathogen and cause better development of diseases. Kobayashi *et al*., 2006 also reported that Rice plants grown in an elevated CO_2 concentration were more susceptible to leaf blast than those in ambient CO_2 concentration. It have been observed for the concentration of methane (CH_4), nitrous oxide (N_2O) and other greenhouse gases (Spahni *et al*., 2005; IPCC, 2007) and found increasing day by day.

In India report of Singh *et al*., 1988 in red rot of sugarcane (*Colletotrichum falcatum*), reaction of cultivars shift towards resistance under low temperature of January conditions and cultivars shift to susceptibility under higher temperature of August. Again report of Williamson, 1998 in his root

knot disease found that root knot resistance gene Mi (Mi-1) derived from *Lycopersicum peruvianum* is not effective at temperatures above 30^0C, but some other genes may express at other temperature conditions like 32^0C, 25^0C. Moisture also plays very important role in disease development. It is generally seen that in most of the foliar diseases temperature and moisture together plays very important role in disease occurrence and development. Schnathorst, 1965 placed different species into 3 broad categories based on their requirement of humidity for conidial germination as 70-100%, 20-100% and some up to 70% relative humidity. Report of Chavan *et al*., 1995 emphasized that humidity plays very important role in sporulation also and stated that relative humidity above 57.4% at temperatures of 12-30^0C which is not found at relative humidity 7.4% and temperatures below 8.4^0C and above 34^0C for sporulation. Occurrence of bacterial diseases such as *Ralstonia solanacearum, Acidovorax avenae* and *Burkholderia glumea* are greatly affected by temperature and proliferate in areas where temperature-dependent diseases have not been previously observed (Kudela, 2009). Likewise wind also plays very important role in dispersal of pathogen and making injuries in leaf and other parts of the plant and enhances infection process. So with elevated temperature and CO_2 concentrations various diseases like wilt diseases caused by *Ralstonia solanacearum,* blast, sheath blight of rice etc. are gaining more economic importance in various parts of the world.

4. ENVIRONMENTAL CHANGES AND HOST PHENOLOGY

Change in the host distribution and phenology with changing environment is one of the main key to disease development and change in pattern of diseases. So here we have to summarize all the pathogen and disease response due to environmental change and its ultimate effect on crop growth, development and production. It is reported that *Botrytis cinerea*, which causes gray mold of strawberry and other fruits, infects only at the time of flowering. In case of bacterial disease of apple and pears, called fire blight, also utilises flowers as a major entry point which ultimately help in development of the disease.

Floods can help in ease spread of water-borne pathogens, droughts and heat waves can predispose plants to infection, storms is found to enhance wind-borne dispersal of spores. So, all these plays important role in plant health and ultimate disease incidence (Boland *et al*., 2004; Hegerl *et al*., 2011). Report of Cerri *et al*., 2007 describe that current temperatures are already close to the maximum physiological limit which contribute many tropical crops to show yield reductions. Kobayashi *et al*., 2006 reported that elevated CO_2 concentrations increase the severity of sheath blight and rice blast and also pointed that higher incidence of sheath blight disease due to increased chance of sclerotia of *Rhizoctonia solani* coming contact with leaf sheath having higher number of tillering and rice blast due to reduced silicon content of leaves. Thus host phenology, environment and plant pathogens carrying importance with respect to disease development and management point of view.

5. COLLABORATIVE STRATEGY AND PLANT HEALTH

From disease management or protection point of view we have to prepare ourselves and have to take diverse of measures in collaborations with epidemiologist, climatologist, sociologist, economist, Geological Information system (GIS) specialist and management practitioners to have a better understanding of plant pathogen interactions under climate change. Along with the increasing food production for the increasing human population we have to be very cautious about use of different chemicals in agricultural field and also other relevant fields to maintain a healthy environment. Also various steps have to be taken to reduce green house gases and global warming. In this context a little attention has been paid to how this issue will be influenced by the effects of climate change on plant health, or some strategy have to be find out (Jones, 2009).

6. PLANT DISEASE SITUATION TO NORTH EAST INDIA

The North East region of India has a temperature range varies from 23-31^0 C and rainfall of 1000-2000 mm during kharif season. Again during rabi season the temperature range varies from 9-24^0 C and about 200 mm of rainfall. By 2030, during kharif season projected increase of temperature is about 2^0 C and in southern parts of north east it is projected as 1.5^0 C. It has been also assumed that seasonal rainfall may reduced by about 10 per cent in most of its part. But during kharif temperature of 2.5^0 C and rainfall of about 10 per cent increase is projected (Klima- NE, E-News Letter, Zonal Project Directorate, Zone-III, Meghalaya, No. 1, Vol. 1, 2012). So changes in the temperature and rainfall patter of this region over time changed the profile of pathogen, activate sleeper pathogens and ultimately causing economic damage to our crop plants. Prevalent hot and humid climatic conditions playing a great role in disease development and it is found that disease which were of least important to this region are gaining economic importance now a days. Amongst rice diseases incidence of some diseases like false smut of rice, blast, sheath blight, brown spot, bacterial leaf blight, rice tungro are becoming more and more over time, some of which are new and were found with very low incidence.

As Kobayashi *et al*., 2006 reported that rice last and sheath blight incidence become more with high elevated CO_2 concentration. Again powdery mildew of pea and some other crops are also increasing in this region. Both rhizome rot of ginger and bacterial wilt of *bhooot jalakia* (king chilli) caused by *Ralstonia solanacearum* are also new to this region threatening the production. In this regard study of Kudela, 2009 revealed that bacterial diseases such as *Ralstonia solanacearum, Acidovorax avenae* and *Burkholderia glumea* are greatly affected by temperature and proliferate in areas where temperature-dependent diseases have not been previously observed. Outbreak of different insect pest like swarming caterpillar in some parts of the region and vectors like aphid along with various vector borne viral diseases like papaya ring spot disease, viral necrosis disease of chilli are also gaining economic importance to this region.

7. CONCLUSION

Along with increased food production we should care for our environment as climate change is becoming a very important issue of concern. Some proper strategy should be made with collaboration from different fields to protect our environment and maintain health of the plant. So, judicious use of chemicals, use of natural resources and adoption of climate resilient technology will help to cope up to some extent with the changing climatic conditions for sustainable production.

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