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A REVIEW

IMPACT OF CLIMATE CHANGE ON PLANT DISEASES : A REVIEW

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ABSTRACT

Climatic change globally affects the agriculture and their allied sectors. The impact of climate change on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends. Climate change is expected to have significant impact on distribution, phenology and abundance of many plant pathogenic species. Temperature is the major factor in global climate change that directly affects the development of different pathogens, their reproduction and survival. Change in rainfall pattern also has implications for different pathogen survival. Abiotic stress such as temperature and drought may contribute plant susceptibility to pathogens. An increase in atmospheric carbon dioxide level will have positively affected the growth and productivity of crops by increasing the photosynthesis. An intermittent rain from flowering to fruiting stage of the crop favours the infection and development of foliar diseases. Protected cultivation technology can be adopted to combat climate change. The application of biotechnological approaches in crop improvement can contribute significantly in minimizing the problem of stress. The greater relevance in new emerging research area such as climate change impacts on diseases and crop yield, pest risk analysis and disease forewarning.

Key Words **: Climate change, Mitigation, Plant diseases**

Agriculture typically plays a major role in developing countries like India. In India, Agriculture make up approximately 20% of GDP and provides nearly 52% of employment when compared to the developed countries like United States, where the GDP rate and employment is 1 and 2 per cent, respectively. Climate change is one of the main determinants affecting plants in natural and agricultural ecosystem. Studies have shown that climate change in India will affect in highest agricultural productivity losses throughout the 21st Century (up to 2100). The impact of climate change on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends. Agriculture is highly

depended on variation in weather and therefore, any change in climate will have major effect on crop yields and productivity. Researches in the effects of climate change on plant disease are limited. The farming community is facing substantial and economic losses due to sudden changes in weather factors like droughts, change in the behavior of mansoon, change in the pattern of rains, frost, hailstorm etc. The sudden change in weather favours the disease development. Climatic change globally affects the agriculture and their allied sectors. An increase in atmospheric carbon dioxide level will have positively affected the growth and productivity of crops. The increase in temperature can reduce the duration of crops, due to increase in respiration and alteration in photosynthesis resulting negative effect on the growth and productivity of crops. It also affect the survival and distribution of plant pathogens and insect-pests. The increase in soil temperature has increase nitrogen mineralization, which affect its availability due to increased gaseous losses through process such as volatilization and denitrification.

India is large country with diverse climate and two third area of total agriculture is dependent on rain. The variation in season, crops and farming system are the main features of Indian agriculture. Climate change can affect crop yields as well as the types of crops that can be grown in certain areas by impacting agricultural inputs such as water for irrigation, amounts of solar radiation that affect plant growth as well as the prevalence of pests. Agriculture is one of the most vulnerable sectors to anticipated climate change and most of the crops are sensitive to their growing condition. Crop losses due to diseases and pest not only affect national and world food supplies and economics but also affect individual farmers ever more, whether they grow the crop for direct consumption or for sale. Sudden change in the climatic condition may drastically influence the development of diseases and infestations of different insect-pests. Climatic factors play a major role in agricultural production by inducing severe plant disease epidemics (Coakley *et al*., 1999). Worldwide losses from diseases due to climate change range from 9–16 per cent in wheat, rice, barley, maize, potato, soybean, cotton and coffee (Oerke *et al*., 1994). Plant diseases are one of the important factors which have a direct impact on global agricultural productivity. The impact of climate change may be positive or negative on diseases, much discussion on the impact is needed to obtain base-line information on different disease system. There is significant concern about the climate change throughout the world. The total crop loss from disease and pests are estimated at about one third of the potential production of the world and 6–12 per cent post harvest losses to pest. Totally for the entire world to about 45 per cent of all food crops (Agrios, 2005). Crop production plays an important role in mitigating the green house gas emissions. It brings 32 per cent reduction in carbon dioxide emissions, 42 per cent of the carbon affects from bio-fuel production, 16 per cent from reduced methane emissions and 10 per cent from reduced emissions of nitrous oxide (Uprety, 2015). Therefore, agriculture can contribute to mitigate the climate change by combining appropriate land with better management practices to increase crop production.

Climate change is expected to have significant impact on distribution, phenology and abundance of many plant pathogenic species. Temperature is the major factor in global climate change that directly affects the development of different pathogens, their reproduction and survival. Change in rainfall pattern also has implications for different pathogen survival. Late blight of solaneceous crops (*Phythophthora infestance*), leaf spot disease of groundnut (*Cercospora spp.*), alternaria blight of different crops etc. have been found to be adversely affected by rainfall and atmospheric temperature. Disease forewarning model is an important to take precautionary measure for timely management of different diseases. A change in any environmental factor may favour the host, pathogen, or both. The possible change in precipitation, temperature pollution (concentration of CO_2, CH_4, and N_2O) are expected to have significant impact on disease thus affecting the agricultural crop production. Abiotic stress includes any environmental conditions or combination of them negatively affects the expression of genetic potential for

growth, development and reproduction of crops. Drought stress frequently occurs simultaneously, exacerbating one another. Under drought stress, the plants stomata close, reducing transpiration consequently raising plant temperature resulting loss in crop productivity. Flowering, pollination and grain filling of mostly crops are especially sensitive to water stress. The crop yield may be suffer if the adverse weather condition, especially height temperature and excess or deficit precipitation during critical development stages such as the early stage of plant reproduction (Ram Niwas and Khichar, 2015).

Effect of temperature :

Abiotic factors such as humidity precipitation and temperature are likely to affect fungal pathogen virulence and transmission (Dorrance *et al*., 2003). A single factor like temperature can have a catastrophic effect on crop yield. India is projected to experience warming (2-4°C) above the global mean (Kavikumar, 2010). According to Aggarwal *et al*., 2009, the grain yield of rice would reduce 5.4, 7.4 and 25.1 per cent with the increase in temperature 1, 2 and 3°C, respectively. There is probability of 10-40 per cent loss in crop production in India by 2080 to 2100 due to global warming (Rosenweig *et al*., 2001; IPCC 2014) despite beneficial aspects of increased carbon di oxide According to some researchers there is a possibility of loss of 4-5 million tones in wheat production with every rise of 1°C temperature throughout the growing period. In India, both temperature stress and moisture stress are important and affect the wheat and other cereals productivity. Terminal stress (temperature and moisture) badly affects wheat productivity especially in late sown wheat, which is a common practice in cotton-wheat cropping system due to delayed maturity of cotton crop (Ram Niwas and Khichar, 2015). The changes in average daily maximum temperature during flowering and grain filling stages had a negative effect on grain yield in different food grain crops. A significant negative impact of heat stress on wheat grain yield was reported recently from South Australia. Flowering, formation of pollen and fertilization are very much sensitive to the heat stress. Heat stress during anthesis increases floret abortion. Abiotic stress such as temperature and drought may contribute plant susceptibility to pathogens. Increased temperature may increase the metabolic rates of fungal pathogen and increase infection (Thompson *et al*., 2010). Anthropogenic activities have been found to contribute to the spread of sudden death of oak tree due to *Phytophthora ramorum* (Prospero *et al*., 2009). The negative effects on plant growth and mortality imposed by fungal pathogens are varying with climate change (Swinfield *et al*., 2012). Change in temperature and humidity may change the population dynamics of pathogens. Temperature and rainfall affect not only the development of the pathogen but also the resistance response of the host (Huang *et al*., 2005 and 2006).

Effect of carbon dioxide :

Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon di oxide, methane and nitrous oxide. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and likely to have been the dominant cause of the observed warming since the mid-20th century (IPCC, 2014). Human activities are now increasingly influencing changes in global climate (Panchauri and Reisinger, 2007). The measurements of atmospheric carbon di oxide concentration began at South Pole of Antarctica during 1957 by the analysis of air which was tapped in bubbles in polar ice cores. Later on the similar study was carried out at Maunaloa (Hawaii) during March, 1958. These studies showed that carbon dioxide was 205 ppm 20,000 years ago. Whereas the study of Maunaloa showed that the increase of 1.0 ppm carbon di oxide per year from 1958-1982. The increase in carbon di oxide concentration in the atmosphere causes global warming by absorbing long wave heat radiation from earth surface. This may also affect the cloudiness and precipitation (Uprety, 2015).

Researcher predicting a gradual rise in carbon di

oxide concentration due to industrialization and temperature all over the world. Increase in atmospheric carbon di oxide concentration can have a positive impact on crops yield by increasing the photosynthesis. Studies have shown that increased carbon di oxide leads to fewer stomata development on plant leaves result in reduced disease incidence where the pathogens aims the stomata for the invasion (Mcelrone *et al*., 2005). An increase in carbon di oxide levels encourages the production of plant biomass, but plant growth is also dependent on availability of water and nutrients. Many crops will benefit from increased atmosphere carbon di oxide concentrates and low levels of warming, but higher level of warming will negatively affect growth and yields. Goswami *et al.*, 2015 have observed that increase in carbon di oxide concentration had significant effect on physiological parameters in kinnow and lemon. The photosynthetic activity in kinnow and kagzikalan was higher than control under 450 and 550 ppm, respectively. Similarly elevated level of carbon di oxide concentration influenced the concentration of total chlorophyll. At the same time their is a competition among the weeds, diseases and insects to take best benefit from warming. This is a menace and is require more attention. Increase in biomass in other words high concentration of carbohydrates in the plant tissues promotes the development of rusts (Chakraborty, 2005). The nitrogen content of plants is likely to decrease while the carbon content increases resulting in reduced protein levels and reduced nutritional levels. Studies suggest that temperature increases may extend the geographic range of some insect pests currently limited by temperature. Increase in carbon di oxide expects to have positive physiological effects by increasing the rate of photosynthesis. Increased atmosphere carbon di oxide concentration has a direct effect on the growth rate of crop plant and also weeds. Increase in carbon di oxide is correlated with the rise in temperature metabolic rates of fungal pathogens and increase infection (Thompson *et al*., 2010).

Effect of precipitation :

The key factor which affects the agriculture crops is rainfall which consequently comes under the key factors influenced by climate change. Indian agriculture is mainly dependent on rain and is a crucial factor for crop production. The amount of precipitation over an area for extended period of time has many effects on farmland and crops. Drought conditions result from a lack of precipitation and this has many effects on the surrounding land and weather conditions. Drought can have many devastating effects on surrounding environment. If crops are not able to receive any water, farm lands can dry out and crops die. Managing water resources is a critical priority in future. An intermittent rain from flowering to pod development stage of the crop favours the infection and development of foliar diseases in groundnut (Pande *et al*., 2000). *Sclerotinia spp.* is more destructive under heavy plant growth and wet weather conditions (Yadav and Upadhyay, 2015). *Sclerotinia* is a non host specific fungal pathogen and attack about 400 plant species worldwide and now it is considered as a serious threat to many economically important crops.

Global warming would cause a increase in rainfall in some areas, which would lead to an increase of atmospheric humidity and the duration of wet season. Whenever high humidity combined with higher temperatures these could favour the development of fungal diseases. Similarly, because of higher temperature and humidity there could be an increased pressure from insect-pests and vectors of viral diseases. In India fruit rot of arecanut (*Areca catechu L.*) caused by *Phytophthora meadii* (Mc Rae.) mainly occurs during rainy season (southwest monsoon period). Frequent and extreme precipitation event (2500–3000 mm) with high humidity (>95%) and optimum temperature (23–28°C) favours the epidemics leading to heavy crop loss (Sarma *et al*., 2002). Precipitation in many regions may dramatically alter water resources because of the change in timings (Smith, 2011). Variability and extremes in rainfalls are more important than mean conditions in ecosystem process (Reyer *et al*., 2012, Thompson *et al*., 2013). The quantity and timing of rain fall are strong drivers of ecological process. According to Dorrance *et al*., 2003, abiotic factor such as humidity, precipitation

and temperature are affect fungal pathogens virulence and transmission. At the same time seed and seedling mortality from fungal pathogens may be reduced due to lower rainfall condition (Givnish, 1999) because moisture may be required to induce sporulation. In other words drought induced stomatal closure may prevent foliar fungal pathogens from penetrating plant tissues (Garrett *et al*., 2006). A local increase in summer precipitation due to climate change has been found to be responsible for the increase and spread of needle blight in British Columbia (Woods *et al*., 2005). The occurrence of water logging due to excess rain fall between sowing and at the end of tillering can reduced the number of tillers per plant, number of kernels per head, plant height and grain yield. However, the major climate changes due to more drought, heavy rainfall and storms influence the crop failure in agriculture. Human influence on the climate system is clear and recent anthropogenic emission of green house gases are the highest in history. Recent climate changes have has widespread impacts on human natural system. Generally increase in CO_2 concentration would increase the rate of plant growth. Climate change will increase some diseases risk in crops and decrease others.

Management strategies :

Integrated disease management solution less effective and harder implement in the case of climate change. Biological control agents can be effective against diseases, insect-pests or weeds even they have develop resistance against fungicides, insecticides and herbicides The spread of insect-pests and diseases through human activity will continue to become a problem, as they become more tolerant to environmental condition. Evans *et al*., 2008 developed a prediction model which predicts range and severity of Phoma stem canker disease by global warming. This again is combine with climate change to predict that epidemics will not only increase in severity but also spread north words by 2020 such prediction can be used to guide policy and practice in adaption to effects of climate change. Protected cultivation technology can be adopted to combat climate change. The cultivation of vegetables and flower crops under green shade net houses, poly houses, low tunnels and walking tunnels now popular in different parts of the country. The technology maintained an ideal micro climate of the crops and also protects them from insect-pests and viral diseases. Cucumber mosaic virus (CMV) incidence was found minimum in cucumber, round melon and long melon grown under protected conditions (Gangwar *et al*., 2015). Alteration in sowing time was also found effective by several workers to minimize the effects of climate change. Agriculture is responsible for over a quarter of total global greenhouse gas emission (IPCC) Innovative agricultural practices and technologies can play a role in climate mitigation and adaption creating new and necessary agricultural technologies and harnessing them to enable developing countries to adopt their agricultural system to changing climate. Improved understanding of plant and ecosystem responses to extreme precipitation and seasonal changes in precipitation will enable better understanding of vegetation carbon and water resources in future climatic change (Zeppel *et al*., 2014). The application of biotechnological approaches in crop improvement can contribute significantly in minimizing the problem of stress. Both biotic and abiotic stresses can be successfully managed by the use of biotechnology. The use of genetic and genomic tools, such as genome sequencing, isolation of expressed sequence tags and the establishment of genetic and physical maps etc. is very effective in crop improvements. The biotic and abiotic stresses can be successfully over come with marker-assessed breeding, genetic transformation, tissue culture, gene expression etc. Development of transgenic plants by using biotechnological tools has been another important in plant stress biology. The previous works on genetics and molecular approaches have showed that most of the abiotic stress tolerant traits are mutagenic. Therefore, to improve the stress tolerance several stress related genes need to be transferred.

Disease management is a combination of many inter-related components such as species of pathogens, beneficial organisms, natural enemies and available control measures. The development of an integrated disease management (IDM) model that fits into a

sustainable farming system requires analysis of the agro ecosystem. Crop growth simulation models have been used for several applications in the area of disease management which helped to increase the efficacy of actions in the field. These will be even of greater relevance in new emerging research area such as climate change impacts on diseases and crop yield, pest risk analysis and disease forewarning.

Impact on plant disease :

Global warming would cause an increase in rainfall which would lead to an increase of atmospheric humidity and higher temperature which could favour the development of fungal diseases. There are also reports of increase in insects pests and vectors. Evans *et al*., 2008, studied how global warming can increase the range and severity of plant disease of worldwide importance within the next 20 years. The effect of climate change nay be on the pathogen the host or the interaction between host and pathogen (Coakley *et al*., 1999; Garrett *et al*., 2006). The maximum temperature (33–35^{0}C) and mean relative humidity (>80 per cent) were found to be highly correlated with leaf spots severity of groundnut crop (Gangwar *et al*., 2014). . The Humid Thermal Ratio (HTR) was also estimated and describes congenial weather conditions criteria for disease development. The geophytopathological model was developed based on HTR, mean temperature and mean humidity and this model explained 72 per cent leaf spot variability. Climate change will increase the range and severity of phoma stem canker (Howlett *et al*., 2001; Fitt *et al*., 2006; Evans *et al*., 2008).

Future approaches :

India is large country with diverse climate, diverse seasons, diverse crops and cropping systems. Two third area of the country is dependent on rain water and monsoon. The uncertainty about weather condition is one of the key risks factor associated with Indian agriculture. The present strategies are needed to be improved as system may change more rapidly. In future, for sustainable agriculture, climate change prediction should be linked with agriculture production. A data base can be prepared on climate change impacts on agriculture and more research and studies are required in this direction. Technologies are made popular among the farmering community through demonstration to cope with current climate variability.

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