Review Article

IMPACT OF CLIMATE CHANGE ON PLANT DISEASES

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ABSTRACT

Different climatic factors such as temperature, precipitation, CO_2 concentration, UV radiation, moisture etc. has influence on growth and development of plants. It also influences pathogen development and distribution. Change in these climatic factors will change the three pillars of disease cycle i.e. Host, pathogen and environment. Hence, changes in disease scenario in the future resulting from climate change are inevitable. Exact effects of climate change on plant disease cannot be accessed accurately, but various efforts and research has been conducted to determine the influence of climate change on plant disease. This paper scrutinize the impacts of climate change on plant diseases and impacts in Nepal through which understanding the impact of climate change on plant disease we will be able to take proper measures to mitigate the negative impacts on plant disease.

***Key words**: Adaptation, climate change, climatic zones, mitigation and plant diseases*

INTRODUCTION

Climate Change is natural process, which has been changing since the formation of earth and will continue to change on. But the climate change brought by humans because of emission of greenhouse gases like CO_2, SO_2 is a serious matter. Changes in atmospheric concentrations of greenhouse gases (GHGs) and aerosols, land-cover and solar radiation alter the energy balance of the climate system (IPCC, 2007). The temperature of earth has increased by 0.74°C in last 100 years (IPCC, 2007). The year 2018 was the fourth warmest year trailing 2016 (highest), 2015 (second), and 2017 (third) since global records began (Blunden and Arndt, 2019). Changes will probably continue to happen even if greenhouse gas concentrations stabilize, due to the system's thermal inertia and the long period required for returning to a lower equilibrium (IPCC, 2007). Climate change will be an additional burden to bear for developing country such as ours. Climate change has its impact in various sector of development among which agriculture is one of them. Agriculture productivity is directly dependent on climate change and weather. Crop growth and development is linked

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with potential changes in temperature, precipitation and CO_2 concentration (Shanthi, 2018). Plant diseases play a very crucial role in the agricultural productivity (Agrios, 2005) which is also directly linked to climate change and weather conditions. Plant disease can be defined as an impairment of the normal state of a plant that interrupts or modifies its vital functions (Pelczar *et al*., 2020).Viruses, bacteria and fungi cause 47 percent, 16 percent and 30 percent of the reported plant Emerging Infectious Diseases (EIDs) respectively (Sharma *et al*., 2019). For a disease to occur there must be the interaction between the components of disease triangle. The disease triangle is a conceptual model that shows the interactions between the environment, the host and an infectious agent. Controlling one of these factors could impair the disease development, reducing the impact of the outbreak in the production (Scholthof, 2007). This review paper aims to bring out the impact in plant diseases due to change in temperature, CO_2 concentration, moisture etc. Nepal shows a wide spectrum and diversity of climatic conditions which can be reflected by the types of prevailing parasitic pathogen within the country (Amatya and Manandhar, 1992). Twenty-six diseases including 20 fungal, two bacterial, one nematode, one physiological and two viral diseases are known to affect rice (*Oryza sativa* L.) in Nepal, whereas 16 fungal. 3 bacterial and 3 viral diseases of soybean have been observed in Nepal (Amatya and Manandhar, 1992). Burlakoti and Khatri-Chhetri (2004) mentioned the severity and incidence of bacterial diseases namely bacterial leaf blight of Rice (*Xanthomonas campestris* pv. *oryzae*) in terai and mid-hills during hot and humid periods and Bacterial stalk rot (*Erwinia chrysanthemi*) in maize in the plains. Bacterial diseases are the important disease next to the fungal diseases in Nepal. Bacterial wilt of potato and tomato (*Ralstonia solanacearum*), Soft rot of potato (*Erwinia carotovora* pv. *atroseptica*) and Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*) prevailed in most of areas have caused devastating losses (Poudel and Neupane, 2018). Viral diseases are the important diseases next to the fungal and bacterial in Nepal (Poudel and Khanal, 2018). Timila and Manandhar (2011) mentioned clubroot, alternaria leaf spot, downy mildew; sclerotia stalk rot, black rot and damping off as the major crucifer diseases whereas downy mildew, powdery mildew and gummy stem blight were mentioned as major disease of cucurbits. In citrus, canker (*X. campestris* pv. *citri*) and greening (*Liberobacter asiaticum*) were epidemic throughout the country whereas Crown gall (*Agrobacterium tumefaciens*) was major problem in pome fruits (Burlakoti and Khatri-Chhetri, 2004). In Nepal, 30-35% of crop production has been damaged by insect pest, diseases and weeds (PPD, 2012).

METHODOLOGY

The review paper was drafted after the collection of necessary information through various literatures available on the internet on climate change that includes impact in plant diseases due to change in temperature, moisture, carbon dioxide concentration and UV radiation. Impacts in plant disease in Nepal due to climate change along with mitigation and adaptation strategies were also collected through the literatures. All the findings from the literatures were summarized and concluded.

RESULTS AND DISCUSSION

Effect of climate change on plant diseases

The impact of climate change on plant disease cannot be accessed accurately as climate change may favor the pathogen or inhibit the pathogen or have no any impact at all depending upon climate, host plant distribution & resistance, presence of vector, virulence of pathogen, its adaptability and interaction with the host plant (Sharma *et al.,* 2019). Climate change modify host physiology and resistance, and alter the stages and rates of development of pathogens e.g., increased over summering and overwintering of pathogens, increase transmission and dispersal of pathogens (Mina and Sinha, 2008; Singh *et al.,* 2018; Yanez *et al.*, 2012). Climate change is also likely to have a profound effect on geographical distribution of host and pathogens. New disease complexes may arise, while some diseases may cease to be economically important (Mina and Sinha, 2008; Singh *et al.,* 2018; Yanez *et al.*, 2012). Deberdt *et al.* (2014) proposed that climatic factors could change the nature of microorganisms turning them into opportunistic pathogens. In the presence of susceptible hosts, pathogens with short life cycles, high reproduction rates and effective dispersion mechanisms respond quickly to climate change, resulting in faster adaptation to climatic conditions (Gregory *et al*., 2009). In case of vector transmitted diseases, climate can substantially influence the development and distribution of vectors influencing disease occurrence and severity (Ahanger *et al.*, 2013; Gautam and Bhardwaj, 2011)

Effect due to change in temperature

Temperature plays an important role in disease cycle from inoculation to reproduction and colonization which may lead to fall or rise in disease severity (Campbell and Madden, 1990). Elevated temperatures reduce plant stress during the winter but increase the stress on the plant during the summer (Elad and Pertot, 2014; Wang *et al*., 2003) altering the growth stage, development rate and pathogenicity of infectious agents, and the physiology and resistance of the host plant (Chakraborty *et al*., 1998; Chakraborty and Datta, 2003; Gautam and Bhardwaj, 2011). Warm winters with high night temperatures facilitate the survival of pathogens; accelerate life cycles of vectors and fungi and increase sporulation and aerial fungal infection (Harvell *et al*., 2002). Robinet *et al.* (2011) suggested that warmer temperature increases the transmission rate of the invasive pathogens. According to Kocmancova *et al*. (2009) change in temperature regimes provide wider opportunities for overwintering of sexual stages, thereby accelerating gene recombination and opportunities for the event of more aggressive pathogen strains. The longer growing seasons that will result from global warming will extend the amount of time available for pathogen reproduction and dissemination (Legler *et al*., 2012). In North America, needle blight (*Dothistroma septosporum*) is reported to be spreading northwards with increasing temperature and precipitation (Madden *et al*., 2007).Similarly, northward shift was observed in leaf spot of sugar beet caused by *Cercospora beticola* in Southern Germany (Richerzhagen *et al.,* 2011; Mari and Martini, 2015). Stripe rust isolates (*Puccinia striiformis*) was indicated to increase in aggressiveness, suggesting that rust fungi can adapt to and benefit from higher temperatures (Mboup *et al*., 2012; Mari and Martini, 2015). Host plants such as wheat or oat become more susceptible to rust whereas some forage species become resistant with increased temperature (Mboup *et al*., 2012). Diseases like common bunt (*Tilletia caries*) and Karnal bunt (*Tilletia indica*) in wheat can be of significance under changing scenarios of climatic conditions in regions with low productivity if proper seed treatment isn't followed in this crop (Oerke, 2006; Gautam and Bhardwaj, 2011).

Salinari *et al*. (2006) studied the current and future impact of downy mildew on grape (*Plasmopara viticola*) in Italy under the conditions of increased temperatures and decreased precipitation. The results predicted increased levels of disease pressure in future decades (2030s, 2050s, and 2080s) and more favorable temperature conditions during the months of May and June. It was anticipated that two more fungicide spray would be needed under the most negative climate scenario compared with the current management program. Ghini *et al*. (2007) predicted that in the future periods (2020, 2050 and 2080), areas favorable for the development of the Black Sigatoka disease of banana (*Mycosphaerella fijiensis*) will decrease. Changes within the geographical distribution will occur from one month to another, with unfavorable areas becoming favorable and vice-versa. However, extensive areas will still continue to be favorable for the occurrence of Black Sigatoka. Temperature sensitivity to resistance has been reported for leaf rust (*Puccinia recondita*) in wheat, black shank (*Phytophthora nicotianae*) in tobacco, bacterial blight (*Xanthomonas oryzae* pv. *oryzae*) in rice and broomrape (*Orobanche cumana*) in sunflower (Gregory *et al*., 2009; Gupta *et al*., 2018). The sunflower plant expresses resistance to parasite (*Orobanche cumana*) by causing degeneration and death of tubercules of parasite which is temperature dependent factor. Higher level of resistance through degeneration of more tubercules can be seen as temperature rises. (Eizenber *et al.*, 2003).In Chili, the incidence of diseases namely bacterial wilt (*Ralstonia solanacearum*), bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) and Phytophthora blight (*Phytophthora capsici*) increased under elevated temperature along with elevated CO_2 whereas, the incidence of anthracnose (*Colletotrichum acutatum*) was decreased at elevated temperature (Shin and Yun, 2010). Climate change is expected to influence the latency period of leaf rust (*Puccina recondita* f. sp. *tritici*) on triticale showing a threat of faster disease development (shorter leaf rust latency period) (Wójtowicz *et al*., 2020). In India, within the last decade the disease scenario of chickpea and pigeon pea has changed drastically; dry root rot (*Rhizoctonia bataticola*) of chickpea and Phytophthora blight (*Phytophthora drechsleri* f. sp. *cajani*) of pigeon pea have emerged as a possible threat to the production of these pulses (Pande and Shanna, 2010).Temperature is one of the most important factors affecting the occurrence of bacterial diseases like *Ralstonia solanacearum, Acidovorax avenae and Burkholderia glumae*. These heat-loving plant pathogenic bacteria are emerging as a significant problem globally (Schaad, 2008;

Kudela, 2009). N Gene responsible for resistance against Tobacco Mosaic Virus is sensitive to high temperature. Thus, above 27°C plants become susceptible to TMV (Wright *et al.,* 2000). The incidence of viral, vector borne diseases and survival of aphids is also altered due to temperature fluctuations (van Munster *et al*., 2017). In the case of insect-vectored diseases, warmer temperature results additional insect generations. This will increase transmission rates of the invasive pathogen (Robinet *et al.,* 2011; Ahanger *et al.,* 2013).The impact of temperature fluctuations brought by the climate change on plant diseases has not been accessed at all in Nepalese context. An increase in temperature was found to cause an increase in the severity of blast in rice and in the area under the disease progress curve in cold subtropical areas (Luo *et al*., 1995; Bevitori and Ghini, 2014). Prevalent diseases such rust which can adapt and benefit from higher temperature (Mboup *et al*., 2012), blast and other bacterial diseases can be serious threat in Nepal.

Effects due to change in CO_2 concentration

Increase in CO_2 concentration in atmosphere will influence disease scenario. An increase in CO_2 levels may favour the production of plant biomass. A high concentration of carbohydrates within the host tissue encourages the development of biotrophic fungi such as rust (Chakraborty *et al.*, 2002; Eastburn, 2011). Environmental factors such as elevated levels of CO_2 or increased temperature or drought, may cause changes in the physiology of a host species that will deeply alter the colonization of host tissues by biotrophic pathogens. Similarly, changes such as high temperature or ozone levels will accelerate tissue death and favour necrotrophic fungi (Elad and Pertot, 2014; Mari and Martini, 2015).New races may evolve rapidly under elevated CO_2 concentration as it can result in increase in fecundity and infection cycle for some pathogen which can increases the severity of disease (Singh *et al*., 2018). Modification of pathogen aggressiveness/host susceptibility due to increased CO_2 concentration causes delay of initial establishment of pathogen reducing severity. C:N ratio is important factor affecting the decomposition of litter. Increased CO_2 concentration in atmosphere not only increases the biomass, it also decreases the rate of decomposition of litter. Along with the increase in winter temperature, the chance of survival of pathogen increases due to lower decomposition of litter and greater biomass. This directly increases the initial level of inoculum for infection (Singh *et al*., 2018). Under elevated CO_2 conditions, potential dual mechanism of reduced stomata opening and alteration of leaf chemistry results in reduced disease incidence and severity in many plant pathosystems where the pathogen targets the stomata (Mcelrone *et al*., 2005). Changes brought by high CO_2 concentration like reduced stomatal density, production of papillae and accumulation of silicon at the sites of appressorial penetration and altered leaf chemistry increased resistance to powdery mildew (*Blumeria graminis*) in barley (Hibberd *et al*., 1996).

In the study of an effect of elevated CO_2 and O_3 concentration on soybean diseases, namely downy mildew(*Peronospora manshurica*), brown spots (*Septoria glycines*) and sudden death syndrome (*Fusarium virguliforme*), severity of downy mildew was reduced in contrast to brown spot whose severity was increased whereas no any significant effects were observed in sudden death syndrome. Elevated CO_2 and O_2 induced changes in the soybean canopy density and leaf age likely contributed to the variation in disease expression (Eastburn *et al*., 2007). Rice plant grown on higher concentration of CO_2 were more susceptible to rice blast (*Pyricularia oryzae*) and sheath blight *(Rhizoctonia solani*). Susceptibility to rice blast may be due to CO_2 reducing the silicon content and sheath blight may be due to CO_2 increasing the number of tillers causing the chance for fungal sclerotia to adhere to leaf sheath at the water surface (Kobayashi *et al.*, 2006). Gória *et al*. (2013) also observed difference in area under disease progressive curve i.e. higher at higher CO_2 concentration and lower at low CO_2 concentration in rice blast. Under higher concentration of CO_2, the risk of potato blight caused by *Phytophthora infestans* has been predicted to be significantly higher (Carter *et al.,* 1996).Overall, the effects of elevated CO_2 concentration on plant diseases can be positive or negative, although in a majority of the cases disease severity increased (Manning and Tiedemann, 1995). According to Chakraborty and Pangga (2004) of the 26 diseases studied, severity of most of the disease was found to increase in CO_2 enriched environments.

Effect due to change in precipitation

Quantity of precipitation would act as regulator in deciding increase or decrease in disease severity and spread (Woods *et al*., 2005). Climate change model by Mahlman (1997) predict an increase in global mean concentrations of water vapor in the lower troposphere (approximately 6% per °C warming). This increase in water vapor concentration is bound to favor disease development in plants (Sharma *et al*., 2019).Some pathogens such as apple scab, late blight and several vegetable root pathogens are more likely to infect plants with increased moisture content because forecast models for these diseases are based on leaf wetness, relative humidity and precipitation measurements. Other pathogens such as the powdery mildew species tend to advance more under conditions with lower (but not low) moisture (Coakley *et al*., 1999). Drought conditions can favor dry root rot disease and powdery mildew disease in legume crops (Gautam and Bhardwaj, 2011). Drought may hinder the production of plant defense substances or growth, promoting the development of the pathogen. Conversely, several diseases are less severe when moisture availability is limited (Elad and Pertot, 2014). Pathogens such as *Mycosphaerela phaseolina* that can survive in dry soils were benefitted by carbohydrate concentration in host tissue brought by drought stress(Mayek Perez *et al*., 2002) and is expected to spread to new regions under most climate change scenarios (Fones and Gurr, 2017; Gupta *et al.,* 2018). Drought conditions in maize favor the growth of *Aspergillus flavus* which is responsible for the production of Aflatoxin that reduces corn quality as it bears risk on human health (Sharma *et al.*, 2019). Drought stress has been found to affect the incidence and severity of viruses such as Maize dwarf mosaic virus and Beet yellows virus (Clover *et al*., 1999).

Effect due to UV radiation

The release of CFC's and other harmful gases has led to a gradual thinning of ozone layer allowing more and more of UV radiation to pass through which can directly affect plant diseases by damaging the structures of pathogen and bio-control agents. It can also indirectly influence plant disease by interfering with host resistance (Ghini *et al.,* 2012*)*. Concentration of CH_4, other greenhouse gases, UV light and sunshine hours will also have different effects on pathogens and host pathogen interactions, resulting in varied response in incidence and severity of diseases. Increased UV radiation after inoculation tends to reduce disease, possibly due to direct damage to the pathogen, although responses vary remarkably between and within pathogen species (Paul, 2000). Also, Bacteria and fungi are commonly more sensitive to damage by UV radiation in plants (Caldwell *et al*., 2007). Hence, climate change could predispose plant to pathogens.

Impact of climate change on plant disease in Nepal

Nepal being a mountainous country is more at risk against climate change as mountain regions are more vulnerable due to increased warming trends as well as extreme changes in altitude over small distances and also because of its location between two rapidly growing economies, India and China, Nepal is facing a greater impact on climate change (Karki *et al.,* 2009).The average temperature increase in Nepal was recorded as 0.06℃ per year (INDC, 2016) and that in Terai and Himalayas was 0.04℃ and 0.08℃/year respectively (Shrestha *et al.,* 1999; Malla, 2008). Also, the warming is occurring at much higher rates in the high-altitude regions than in the low altitude areas (Karki *et al.,* 2009).Climate change is also reported to cause a shift in the geographical distribution of host pathogens. Many studies have suggested that number of pathogens moving northward will increase as increasing temperature makes the previously inclement areas more conducive (Gautam and Bhardwaj, 2011; Mina and Sinha, 2008; Yanez *et al.*, 2012). Shifting of climatic zones may result in significant reduction in alpine and cryospheric ecosystems. Lower Tanahu district is unable to provide suitable chilling requirement for citrus. Tropical crops like cucumber, chili, tomato and others could be grown in the mid and high hills. Diseases like rust and blight have shown their impact in the high hills too (Kalauni, 2017). In response to the warming temperature, mountain ecosystems (plants and animal species) are predicted to slowly migrate and shift their distribution northward or upward (Karki *et al.,* 2009). As Nepal has three ecological zones i.e. Terai, Hills and Mountains, shifting of pathogens from one ecological zone to another is more likely. Shifting of climatic zones has been observed in the country. Some pathogens of important crops from Terai zones has adapted in hills and mid-hills (eg. rust and foliar blight) which will adversely affect the agricultural production (Malla, 2008).Foliar blight (spot blotch caused by *Bipolaris sorokiniana* and tan spot caused by *Pyreophora tritici-repentis*) was recorded as severe during the 2014-2016 wheat seasons, across the entire plain region. Foliar blight was moderate in the mid hills, especially the

Kathmandu valley. Leaf rust was severe at several places in the mid hills. This could be due either to climatic conditions or varieties susceptible to the prevailing pathotypes (Baidya *et al*., 2016). Diseases such as Barley stripe, Cercospora leaf spot, Blast, Fusarium kernel rot and Leaf blight caused by *Pyrenophora graminea*, *Cercospora penniseti*, *Pyricularia oryzae*, *Fusarium moniliforme* and *Helminthosporium sativum* respectively have been observed in barley, millet, paddy, maize and wheat (Bhandari, 2013). Also negative impacts of climate change are observed for food crops which are already infected by diseases and pests such as club root of crucifiers, blight of solanaceous, rust of wheat, blast of rice and leaf spot of maize and red ants which have become menace leading to decreasing crop productivity (Paudel, 2015).

The topography of Nepal is also challenging which has created difficulties for accessing the climate and to develop model that considers the influence of local topography on climatic factors (Karki *et al*., 2009). Hence, the exact influence of climate change on plant diseases has not been accessed at all in Nepalese context though some researches have been conducted to observe the influence of increased temperature and CO_2 concentration of productivity. Study on impact of climate change in rice in Nepal Agriculture Research Council showed that the rice yield increased under elevated CO_2 in the terai, hills and mountains initially. But it dropped to 3.4 % in the terai and continued to increase by 17.9% in the hills and by 36.1% in the mountains, when the temperature was increased by 4℃ (Malla, 2008). But since the average maximum temperature is already above this threshold, rice yield will likely diminish with any further increases in maximum temperature (Karn, 2014).

Mitigation & adaptation strategies

Changing disease scenario due to climate change has highlighted the need for better agricultural practices and use of ecofriendly methods in disease management for sustainable crop production (Boonekamp, 2012; Gupta *et al.,* 2018). Disease management strategies should be reoriented in changing conditions with amalgamation of new strategies for sustainable food production. Now, emphasis must shift from impact assessment to developing adaptation and mitigation strategies and options (Gautam *et al*., 2013). In such scenarios, weather-based disease monitoring, inoculum monitoring, especially for soil-borne diseases and rapid diagnostics would play a significant role (Gautam and Bhardwaj, 2011). Other multipronged approaches include healthy seeds with innate forms of broad and durable disease resistance, and intercropping systems that foster refuges for natural bio control organisms. Additionally, monitoring and early warning systems for forecasting disease epidemics should be developed for important host–pathogens which have a direct bearing on the earnings of the farmers and food security at large (Boonekamp, 2012). Use of botanical pesticides and plant-derived soil amendments such as neem oil, neem cake also help in mitigation of climate change because it helps in the reduction of nitrous oxide emission by nitrification inhibitors such as nitrapyrin and dicyandiamide (Pathak, 2010).

IPCC (2007) recognizes indigenous knowledge as an invaluable basis for developing adaptation and natural resource strategies in response to environmental problem. Organic agriculture in Nepal could serve the twin objectives of climate change mitigation and adaptation (Khanal, 2009). Juroszek and Tiedemann (2011) stated that preventive control measures, such as the use of a diversity of crop species in cropping system, adjustment of sowing or planting dates, use of disease-resistant cultivars, stress-tolerant cultivars, use of reliable systems for forecasting epidemics, application of an integrated management strategy, and effective quarantine systems, may become particularly important in the future. Systemic monitoring and recording of disease occurrence and frequency over time, disseminate proper knowledge on impacts of climate change and adaptation measures will help minimize the impacts of climate change (Sharma *et al*., 2019). Devkota *et al.* (2017) mentioned that rice farmers in rural Nepal have practiced different adaptation options. The most common adaptation practice made by the rice farmers in Nepal are increase use of chemical fertilizer, use of climate smart varieties and change in nursery date. Similarly, practices such as selecting short duration rice crops, increase in use of vitamins, increasing use of pesticides and insecticides, changing size of land under cultivation, off farm activities (like diversifying from farming to non-farming activities), water harvesting schemes and change in irrigation practices were adopted. (Devkota *et al.,* 2017; Phuyal *et al.,* 2017). Adaptation practices such as mulching, hedge row planting, change in crop variety, and change in harvesting time have been practicing by the farmers to adapt to climate change, with the resultant increase in productivity (Subedi, 2018). Needs for further research and capacity development on developing stress tolerant varieties, upscale the early weather forecasting system, improving soil organic carbon for enhancing antagonist soil microorganism that suppress disease pathogens, promote indigenous practices, conserve agro-biodiversity might be the way forward for future for coping effect of climate change on plant disease.

CONCLUSION

From the findings it is cleared that climate change will likely bear impact on agriculture and plant diseases. With the changes in the temperature, CO_2 concentration, precipitation and effect of UV radiation changes has been found in the plant disease occurrence. Though the positive effect of climate change is observed in disease concentration in the initial years, in the later stage its negative effect is increasing. One of the major impacts of climate change in plant disease relevant to Nepal is the change in climatic zones. The disease common to only one zone is spreading to other zones which were not the refuges of the pathogens before. This may create serious problem in the yield as some of the diseases are responsible for the loss in yield up to 100 percent. This could become serious threat to our country Nepal as there are different climatic zones with profound climatic variation. The presence of different climatic zones in our country allows us to cultivate diversified crops in same season in terai, hills and Himalayas which may change with the changing climatic conditions resulting in conversion of different climatic zones into singular similar climatic condition everywhere. Also, in case of mitigation measures and adaptation strategies, there is hardly any option for our country as we are a developing country and lack the forecasting systems for diseases occurrence. The initiation of disease forecasting must be prioritized to protect the farmers from bearing loss. There are also things which we can start from our side like using of botanicals and starting climate resilient farming by adopting different climate resilient technologies and practices. Raising awareness among the farmers can assist in mitigating the impact of climate change somehow. Coordinated efforts to access the impact of climate change on agriculture and plant disease along with adoption of short term and long-term sustainable measures is a must against impeding effects of Climate Change. Developing stress tolerant varieties, improving soil organic carbon for enhancing antagonist soil microorganism that suppress disease pathogens, promote indigenous practices, conserve agro biodiversity might be the way forward for future to cope effect of climate change. Moreover, focus needs for further research and capacity development.

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