



## PLANT DISEASES AND CLIMATIC VARIATIONS: TRENDING CHALLENGES FOR FOOD SECURITY

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### AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. Authors MK and FUR are the main authors of the review. All other authors have equally contributed in literature collection and editing of the review.

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### ABSTRACT

To accommodate the estimated demand of the worldwide people by 2050, global food production must raise by 50%. Meeting this daunting challenge would be made much more challenging if climate change causes the damages in Agricultural Crop Production (ACP) which result in threats to Global Food Security (GFS). Over last 40 years, disease and pest management has helped to double agricultural production, but diseases still demand 10–16 percent of the world output. We look at how climate change affects the many dynamic interaction mechanisms that cause pest and pathogen effects, as well as how these associations can be controlled to minimize these impacts. Integrated Disease Management (IDM), as well as international coordination in their execution, are deemed necessary. In this Review, we have reviewed the plant pathogens, climate change and their impacts on GFS, along with the key disease management strategies.

**Keywords:** Food Security; climatic variations; plant pathogens; fungal diseases; bacterial diseases; viral diseases; integrated disease management.

### ABBREVIATIONS

AMF : Arbuscular Mycorrhizal Fungi;  
FS : Food Security;

ACP : Agricultural Crop Production;  
RLF : Rate Limiting Factors;  
BC : Biological Control;  
FAO : Food and Agriculture Organization;

<i>Ppm</i>	: Part Per Million;
<i>GFS</i>	: Global Food Security;
<i>IDM</i>	: Integrated Disease Management;
<i>SMV</i>	: Soybean Mosaic Virus;
<i>SCNs</i>	: Soybean Cyst Nematodes.

## 1. INTRODUCTION

The climate of the earth always has a change with respect to the corresponding changes of different influencing factors [1,2] and changes occurring in cryosphere, hydrosphere and biosphere. Human activities are now affecting the global atmosphere greatly [3]. The discharge of harmful gases in the atmosphere has increased to a great extent since 1750 which should be minimized. Carbon based fuels are being used in the industry and this is a major reason of increasing CO<sub>2</sub> concentration in the atmosphere. By the last 100 years the mean temperature of earth has gone to increase by 0.74 and the quantity of CO<sub>2</sub> has accelerated from 280 ppm to 368 ppm in 1750-2000 [4]. By 2095 the increase of temperature is by 3.4°C and that of CO<sub>2</sub> concentration is 1250 ppm [3]. However, momentous studies describe that local and periodic disparity are not reported in classical procedures [5]. That procedures had a lot of issues like pest or yield contagions, crop spreading.

There are number of diseases in crop which is caused by large number of pathogenic viroids [6,7]. They show slight symptoms to many disasters which may causes destruction of many crops [6,8]. Shattering plant problems aggravate the existing discrepancy of nutriment stock which shows about 800 million people are ineffectively nourished. It is difficult to control the number of plant pathogen which is inconstant in time, specie, and place. It is essential to determine the problems and pursue the solution, so that problems that causing losses should be minimize. Biologically, it is required that there is correct determination of causative agent, correct estimation of disease harshness and its causes on crop. If there is decrease in inoculum of pathogen, fall in process of virulency and raise in variety. Conventional breeding of plant is used for resistance. There is transgenic modification of genes which cause resistance.

Over 80% of human diet is directly or indirectly related to ACP because food and agriculture are interrelated. Plants and plant products are essential part of balanced diet for human [9]. Thus, plant health is a crucial factor for the availability of adequate, safe and nutritious food. The fruits and vegetables category of plants are source of various essential nutrients. Fruit and leafy vegetables are good source of folic acid, vitamin B-6, B-12, dietary fiber and vitamin C [10]. These nutrients are essential for

human diet for preventing different diseases including atherosclerotic, cardiovascular diseases, various site-specific cancer, constipation and also help in bowel movement and lowering cholesterol levels. Therefore, plant health is necessary because the plant pests and diseases can cause severe threat to global food security.

Over the years, plant pests and diseases had caused severe devastation and death of millions of people across the world due to famines, food shortages and food spoilage. Examples of such cases are Brown spot fungus in India in 1942-43 resulted in 50-90% destruction of rice crop and death of two million people due to food shortage [11]. Late blight of potatoes spread by *phytophthora infestans* also caused huge Irish famine in 1845 due to which more than one million people died and many emigrated [12]. The developing countries are at great risk of food shortage due to plant diseases because of increasing population and dependence of maximum number of people on locally produced food from single crop. The disease outbreak of that staple food due to plant pests can cause major threat to GFS and also cause food shortages.

Crucial doubt is significant for investigation of alteration of climate for expectations of deterministic representations but also for organic procedures. When there is consideration of suggestions of climatic alteration on security of food then there are larger number of doubts occur. Food Security (FS) is distinct as “when all people having corporeal and commercial contact at a time, to enough, harmless, and nourishing food for nutritional purposes and food partialities for healthy life”. Basically, FS is combined effect of different food accessibilities, contact and defaults. They may be predisposed due to number of issues like financial collapse, pollution of water, exchange variation, enemy, war, trading and its contracts, changes of climate. There are many factors of FS like studies, bad contact to food market, high rates, joblessness.

## 2. PLANT DISEASES

Agriculture is an important sector of Pakistan economy [13]. Proper food is not available to about 800 million people [14]. About 10% worldwide food making is decreased due to diseases of plant. A lot of food for consumption is provided by fourteen crop plants. There are few plants that can show exhaustive growth until their nutritional necessities are not met. Major group of pathogens are viruses, bacteria, fungi, nematodes, parasitic plants and oomycetes. These causes major problem to plant security. Potato blight is produced by *phytophthora infestans*. In 1840s, Potato blight hit the Europe similarly as a blot from

blue. Millions of people died due to malnourishment in Ireland. This occurs due to a virulent strain of pathogen in potato which came in Europe as Irish depends on potato, absence of resistance in plant against pathogen.

During 1970-1971 in USA, there is southern corn leaf epidemic occurred, and 1943, there is great Bengal famine occurred in USA [15]. There was a lot of people died due to highly dependence on a crop. There is great number of populations which is reliant on a single crop or few numbers of crops worldwide. If disaster diseases occur on crop then these population are at great risk. Presently in developing countries, risk is great due to continuous increase in population and widespread lack of food. Agriculture globalization shows that food crops should be produced away from that of their parental origin and that of pathogens. Due to this process, there is production of resistance against new pathogens.

There are various plant diseases like viral, fungal, bacterial and parasite.

### 2.1 Viral Diseases

A significant number about 700 identified infections related to plant that is source of annihilating the diseases. They have extensive varieties of hosts. Soybean Mosaic Virus (SMV) has been spread globally [16]. They can contaminate more than 150 Poaceae types, together with a large portion of the staple grains like oats, maize or rice.

A significant food safety yield, is cassava, aimed at smallholder ranchers, especially in short-revenue, food-deficit nations, attributable for standing unwavering quality. Mosaic viruses also cause diseases to plants [17].

### 2.2 Bacterial Diseases

Types of microscopic organisms having a place with a few kinds are wrecking plant microbes. For instance, about 350 diverse plant sicknesses may cause by types of *Xanthomonas* [18]. One of them is bacterial blight which is brought about by *Xanthomonas Oryzae* pv. *Oryzae*. this is a significant diseases of rice in humid Asia and entirely assortments of basmati rice are exceptionally helpless. Lamentably, microbes are available in the whole basmati rice-developing zone in India and creations are seriously obliged [19]. As of late, a serious infection of banana has been accounted for Uganda [20].

### 2.3 Fungal Diseases

There are few reasons for plant diseases caused by fungi;

- The spores, giving bounteous inoculum, may contaminate other plants.
- The idle time like the period among disease or the production of additional irresistible propagules, generally reproductive structure, might be a couple of days.
- The spores, in the event that they are wettable, might be spread as high-thickness inoculant at outer space of water or in beads by downpour sprinkle. Then again, non-wettable spores might be conveyed significant detachments by the breeze.
- They may deliver intensifies that are phytotoxic or potentially a source of proteins that demolish the assembly of the plant [21].
- Microbes can draw supplements with the help of the monetarily significant piece of plant by the development and acceptance for development controllers, for example, cytokinins, and thus decrease yields [22].

### 2.4 Nematode Diseases

*Dorylaimida* and *Tylenchida* are two orders out of 17 nematode orders which have plant parasites as their members. That kind of parasites causes a lot of disasters crop losses. *Ditylenchus dipsaci* is dangerous nematode species which attacks on about 450 plants like weeds. Crop plant like groundnut, carrot, sugar beet and onion are attacked by *Meloidogyne* species called *M. hspla*. Soybean Cyst Nematodes (SCNs) are major species whose direct effect on crop is not occurred but yield is highly affected by it. *Dorylaimida* nematodes are based like a virus's vector as Tobacco Rattle Virus is transmitted by *Paratrichodorus anemones* which effect the ornamental flowers and vegetable crops.

### 2.5 Parasitic Diseases

There are more than 3000 types of parasitic plants. *Striga* and *Orobanche* are the most devastating plants [23]. *Striga* species contaminate about 2/3 of the 73 million ha of grains and vegetables which are grown up on the African mainland, influencing the survival of more than 100 million individuals in 25 nations. Misfortunes might be entire, or an invasion of some areas might be incredible on such an extent that the development of certain harvests must be deserted [24].

Parasitic weeds like Broomrapes are widespread in numerous nations like Central Asia and the Mediterranean [25]. They contaminate the dicotyledonous root crops. They don't contain chlorophyll, derive their whole supplement necessities from their hosts.

### 3. FOOD SECURITY AND PLANT PATHOLOGY

According to the FAO, 102 billion people went starving in 2009, the top number of starvation ever reported, owing primarily to decline in agricultural investment [26]. Land depletion, urbanization, and the conversion of agriculture and agricultural fields for non-food cultivation are intended to reduce ACP by 8–20 percent by 2050 [27]. This reality, coupled with water shortages, makes growing crop yields by 50% to meet expected need of the world's largest population by 2050 a daunting challenge. Environments will become much more complicated if climate change causes melting of parts of the Polar ice, disrupts the rainy season cycle, and enhances flooding/drought in Asia, as this will influence 25% of the entire of the world's cereal crops due to higher uncertainties about the water availability for irrigation and much more regular floods, which will have a devastating impact on livelihoods. There are a lot of threat to plant biosecurity like weather changes, redesigning, increase of inhabitants and exchange [28]. Major problem is that there is no investigation of reason of threat [29]. In plants, microorganism like pathogen can spread speedily in dormant form [30]. Due to worldwide trading systems, new type of pathogenic organism having unique characteristics are introduced [31]. These pathogens cause a lot of diseases in plants. Bioterrorism is also a threat for plants.

Food security is not defined solely by total agricultural production, since food has to be simultaneously healthy and nutritious. Besides that, food has social values that are inextricably linked to the value chains of processing, supply, and consumption. Food must've been easily accessible, inexpensive, and in the amounts and forms desired. This is reliant on systems and applications for processing, delivery, and shipping. Changing climate may have an effect on all of these variables, and some are influenced both actively and indirectly as a result of pest or pathogen-mediated variations caused by climate change.

### 4. INTEGRATED DISEASES MANAGEMENT

Due to abnormal physiological function of pathogenic organism, plant diseases occur. Plant shows response against disease causing agent [32]. The response later turns out to be more far reaching and histological changes occur as symptoms. This may cause plant growth reduction, even it causes plant death. Diseases of plant present at time of seed sowing, during harvesting or at the time of storage, may cause a lot of human losses.

Yield safety should be measured by mean of combined methods meanwhile pesticides are used on crop in case of any danger. There is disturbance of procedures possession due to crop safety element. These procedures are defined as danger extenuation and improvement. These procedures are caused due to difficult connections between remediate and enhancement. Every procedure is organic scheme with different mechanism due to climatic alterations.

The plant diseases are figured out how to diminish financial and aesthetic harms brought about by plant microorganisms. Using synthetic compounds, plants are protected from diseases. Interruption of niche, resistance caused by pathogens and adulteration in climate due to high utilization of chemicals has debilitate the use of chemicals. There should be development of new standards which are safe like advancement of resistant varieties, reproduction of desired traits, appropriation of biological control.

Various technologies should be evaluated for their reliability, volatility, or vulnerability, as well as the efficacy of exploiting them. Improving crop endophytic development, for instance, has the potential to improve biotic and abiotic factors resistance, increased executive impact of climate change in certain crops. However, the extent of the results is probably small, and several crops may lack suitable endophytes. There seem to be a number of practical problems that have yet to be resolved in terms of developing and sustaining colonization.

In addition, deploying a main gene for resistance that is successful under a wide range of environmental conditions results in high effectiveness for a clearly defined target disease management with a short term and significant contributor. Improved effectiveness can be achieved by integrating variability into both the crop and risk management methods, efficiently extending risk, although at the cost of optimum benefit from less resilient choices such as the use of resistant cultivars in comprehensive monoculture or the use of a specific fungicide extensively [33]. Even then, it would be tough to claim for an alternative solution that does not achieve the highest possible yields if the goal of growing agricultural production by 50% of total by 2050 could only be achieved by introducing cultivars with multiple simultaneous resistant strains or by using fungicides.

Biological Control (BC) includes the presentation of extraordinary species which is already present in biological system naturally. It also includes the initiation of resistant plants with the help of inconsistent microorganism [34]. One of the most harmful microbial agents which cause serious plant diseases is fungus. Biological agents are used to

control the fungal microbes which cause diseases on leaves, fruits, flowers, bark, legumes or vegetables. In cereal, fusarium infection is common. There are many biological policies. One of the most common biological policy against *Fusarium* infection in cereal is Arbuscular Mycorrhizal Fungi (AMF) [35].

There are several potential intervention areas in the crop-pest/pathogen relationship, but which ones should be evaluated will be determined by a blend of their probable effects and the viability of managing them in a helpful and appropriate manner. Many therapies necessitate the above-mentioned original investment in capability and resource development, but if the possible advantages are significant, it should direct investment. Workable alternatives must be accompanied by estimated costs for different stages of implementation in order to be an accurate contribution to policy discussions. For example, failures from *Leptosphaeria maculans* phoma stem canker of oilseed rape could be reduced with a 'reduced' effective approach, which may entail certain grower reforms to follow management strategies, but 'elevated' level sustained achievement would require major changes and improvements from the public and private sectors, such as the farmers [36].

## 5. CLIMATE CHANGE AND FOOD SECURITY

Climate changes may affect the food production and for security in many ways [37]. Climate changes can affect either on plants during the production of food or during marketing in the form of availability and price of food items [38]. Changes in climate may be natural or by human activities such as industrial pollution. Majority of population is malnourished because of unavailability of safe food due to severe climate changes [39]. About 2 billion global population is at risk of food shortage.

Soil is a dynamic environment that includes a number of biological systems that are all influenced differently by weather parameters [40,41]. We just notice a few of the potential effect of these, which will manifest themselves as direct effects on plant growth and impacts on the crop climate. The latter effectively implement on other species such as weeds, parasites, and advantageous and non - pathogenic elements of microbiota frameworks [42], as well as influences on the crop itself through impacts on root and canopy structure [43]. Pathogens like sharp eyespot *Ceratobasidium cerealis*, for example, may be reduced in magnitude in low-tillage conditions, owing to the increased utilization of organic antagonists or competitors [44, 45]. That being said, such variations are largely responsible for the

different soil conditions, and there are few oversimplifications that can be attributed to changing climate. The limitation of water is one of the most important factor that put constraints to the FS. In plant grow and development, the factor of low availability of water is an essential Rate-Limiting Factor (RLF) for lower latitudes. However, here on the higher latitudes, irradiation is also an important RLF [46].

There is proper calculations of amount of change in precipitation. The prominent historical evidence is present in changed distribution patterns in case of both seasonally as well as regionally [47]. These variations will result in changes of cropping that will directly or indirectly affect the availability of food through various resultant variations in severity and incidence of pest and pathogen.

Plant defense experts should work on general changes and their impacts, so that plant problems should be minimized to enhance the security of food crops. Human population is decreased due to plant diseases or pest attack with 80% yield of cotton and 50% of other crops [48]. During 2001-2003, 37.8% losses occurred in rice due to 10.8% pathogens, 10.2% weeds, 14% viruses and 15.1% pests [49]. Every year, around 10-16% worldwide yield is vanished due to diseases. It causes lose of cost around US 220\$ billion [50].

Increase in CO<sub>2</sub> by fermentation effect causes the increase in biomass of crops and that of yield. Reduction in yield due to high temperature and that of water restriction may cause increase in crop productivity. About last 40 years, crop production is twice due to better protection mechanism and enhanced agricultural techniques. Action of agriculture against tasks of fortifying, nutritious and safe food is increases according to climatic changes. Climate changes maybe in the form of change in global temperature, rainfall Patterns and change in soil properties during the mid of 19th century. Global temperature is increasing day by day due to increasing industrial pollution. Emission of toxic gases is also increasing due to greenhouse effect. The concentration of carbon dioxide and ozone has increased in the atmosphere and due to increased concentration of these harmful gases the agricultural crops are adversely affected which in turn cause threat to global food security. Elevated concentrations of carbon dioxide and ozone gases also cause population increase of plant pests which damage the crops and food system. Climate change may cause spread of plant pathogens and many diseases originate which may destroy the entire crop. Plant pests may also spread by aphid vector and by other abiotic stress. The stress conditions such as drought also led to the

unavailability of sufficient food. The stress or shock conditions in turn cause unrestrained impact on FS. Other than this, accumulation of heavy metals to the plants resulted in compromised FS.

## 6. CONCLUSION

Plant pathogens vary in size from viruses with a mere hundred nucleotides to larger plants that cause infections in agricultural fields. Their incidence varies from minor symptoms to catastrophic events that result in the destruction of vast sectors of the food crops. Catastrophic climate change alleviates the global food supply shortage, which has left nearly 800 million people hungry. Plant pathogen communities are hard to monitor as they vary in space, time, and genetic background. Most subversively, they grow, frequently facing opposition that was perhaps the crop breeder's difficult accomplishment. It is important to identify the issue and pursue solutions in effort to fight the damages that cause. At the genetic level, quick and precise recognition of the causative agent, reliable estimates of disease severity and its impact on production, and recognition of its pathogenic processes are all needed. By reducing the pathogen's inoculum, inhibiting its virulence mechanisms, and encouraging biological variation in the plant, infection can be reduced. Traditional plant genetics for resistance has a critical part to play, and indicator assisted choice will now make it easier. Including genes that impart tolerance, transgenic engineering may also play a role. Environmental changes pose a danger to our food supply, and sufficient resources must be allocated to their management at the public level.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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