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Understanding the Role of Plant Pathogens in Food Security

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Abstract

Biotic factors, specifically plant pathogens, are said to be the biggest threat to food security globally, because of the impacts that they put on crop yields, and food systems integrity. These diseases are claimed by fungi, bacteria, viruses, nematodes, and phytoplasms which ultimately decreases the availability of food, and increases the prices of foods. The consequences of plant disease situations for the economy are manifested most markedly where most of the population depends on agriculture, which results in hunger, malnutrition, and social unrest. The world population keeps growing ever and this puts pressure on food production hence needs to control plant pathogens for sustainable productivity. Environmental change most conveniently through climate shifts increases the risks of diseases by changing the environmental factors within which pathogens thrive hence leading to growth of new diseases and the spread of old diseases to zones they never affected before. This comes as a big blow to disease management frameworks that tend to operate in constantly changing conditions on the ground. Conventional measures of pest and disease management like crop rotation, pesticide use etc continue to be relevant but current practices are made more effective by sophisticated use of bioengineering like genetically resistant crop varieties and new technologies like CRISPR/Cas9. Thus, it is clear that for any giant steps to be made in a significant improvement of world food security through control of plant diseases and pathogens the comprehensive management practices should be coupled to research and policy initiatives. This falling contains specific strategies such as boosting global monitoring and improving early warning, as well as promoting sustainable agriculture. Furthermore, plant breeding is a critical component when trying to create plant varieties that can cope with pathogen invasions for sustainable food production.

Introduction

There is no single universally accepted definition of the food security but the ability to access food that is safe, sufficient in quality and quantity and Biophysical accessibility of food. Since people all over the world are living longer and nowadays the number of people is increasing, the problem of feeding everyone becomes more difficult. Pest and disease are one of the biggest challenges to food security is plant disease since it wipes out crops, reduces yields, and interrupts food supply chains. Biotic factors of diseases include a wide range of pathogenic organisms such as fungi, bacteria, viruses, nematodes and phytoplasms that cause diseases in the important crops like cereals and legumes, fruits and vegetables. These diseases cause yield loss, economic fluctuations, and high food prices and negatively affect the income and productivity of resource-poor farmers mainly in the developing world. The role of plant pathogens in the aggravation of food insecurity, therefore, needs to be understood like never before. Apart from direct impacts on crop yields, plant diseases have secondary consequences concerning the depletion of the planet's biotic diversity; extended reliance on chemical pesticides; and detrimental impacts on the quality of the earth's soil. With the global climate changing and moving gradually, the nature of different plant pathogens also changes, new diseases are spreading in regions that were previously unaffected while some existing diseases are suddenly becoming more virulent. Such condition calls for a rethink of approaches towards control of plant diseases for food security in the future. Incorporating competent strategies to combat plant pathogens and protect food security requires a complex system approach. This comprises enhancing disease control measures and IPM, enhancing plant breeding with an aim of pigeon breeding resistant plant varieties, and applying advanced biotechnology that include use of CRISPR/Cas9 for resistance to pathogens. However, equally important investments in disease surveillance, early warning systems and climate change mitigation will be critical to creating a hedge against loss of production in foods.

Effects of Plant Disease Incidence on Economic Returns to Agricultural Production

These plant pathogens are one of the major causes of yield and food price reductions in the world

economy affecting the farmers directly. There are trade and food production and processing to mention but a few, which obviously suffer as a result of plant diseases. The direct losses as a result of pathogen-caused diseases imply reductions in crop production and hence availability of needed food products cause an increase in prices in the local and international markets. Such diseases like wheat rust and potato blight have in the past become a problem to food shortage and business risks to the affected areas. Major plant pathogens alone have been attributed to cause losses of 10-16% of crop output across the globe; the economic value is estimated at billions of dollars. This impact is worse bas in developing countries; hence, agriculture is the main economic activity and source of employment. However, due to limited resources and lack of proper diseases control techniques or use of modern technology, the smallholders are special vulnerable. An outbreak of disease in crops will lead to complete losses and poor farmers will have no income to feed their households. Taking in account yield losses, disease management costs such as pesticides, fungicides and the labor involved are all expenses due to the presence of plant pathogens. For agricultural practices, these chemical treatments could be expensive to a point where they are an unfavorable investment for farmers. Further, plant diseases can cause reduction or cessation of certain crops export as well as trade bans occasioned by disease prevalence. Plant pathogens place pressure on the amount of money required to feed the population and affect food value chains. Granaries and other reserves are lower and prices go high especially on food haves when crop is destroyed or yield is less than expected. Consequently, this stresses food security, thereby forcing every needy faction to struggle to afford quality foodstuffs. Hence, proper control of plant diseases must be achieved for the interest of agriculturists, the general economy and food security.

Major Plant Pathogen and Their Host Crops

Microbes which attack plants are quite numerous and can infect numerous types of crop plants, with heftily effects in terms of monetary lost. These plant pathogens are fungi, bacteria, ailmentary viruses, nematodes, and phytoplasma, all of which have specific host plants. Information on the major diseases affecting these plants and crops is necessary in the formulation

of steps to manage the diseases. Fungi are possibly the most universal plant pathogens and cause some of the most destructive plant diseases. For instance, wheat rust caused by Puccinia graminis is a destructive disease that decreases yields of wheat around the world. Potato late blight is caused by a fungus-like organism called Phytophthora infestans and has in the past led to huge crop losses such as in the Irish Potato Famine in the 19th century. Other important fungal pathogens include; the Fusarium species that causes wilt diseases such as banana (Panama) disease and tomato (Fusarium wilt) and the Alternaria species that affects crops such as carrot and tomato. Bacterial agents are also a problem to numerous crops since plants may be attacked at any time and by any one, regardless of age or size. The xanthomonad bacteria which affect rice, tomatoes and peppers as well as having bacterial blights are very infectious; they spread through water such as irrigation water and through rain. Apples and pears are attacked by the fire blight bacterium; Erwinia amylovora in particular can cause devastation in orchards and trees if not well managed. The viruses are chilled with different crop diseases that have an impact on productivity, greatly. TMV is spread through tobacco, tomatoes, and peppers; it results in growth retardation and yield loss. Likewise, Tomato spotted wilt virus (TSWV) affects tomatoes, peppers or a Solanaceous crop which will exhibit symptoms of necrosis and deformity. Some of these are root-knot nematodes or commonly known as the Meloidogyne species: These ‘‘worms’’, penetrate the roots of plants such as tomatoes, cotton and soybeans and partly destroy the root system hence limiting the plants direct access to nutrients hence the weakening of the plant and low yields.

Climate Change and the Changing Dynamics of Plant Pathogen Populations

Current climate change is therefore affecting plant pathogen populations in regard to their distribution patterns, severity of devastating diseases, or virulence. Higher temperatures and altered precipitation and humidity levels are also influencing changes in the spatial distribution of phytosanitary diseases, as well as their life cycles and their relations with plant hosts. Most plant pathogens especially the fungi and bacteria prefer relatively higher temperatures than those prevailed during this time of the year. This has led to an increased pathogen penetration into

areas that are hard to be affected in the past. For example, excessive heat has caused diseases to extend to the northern region such Fusarium wilt disease which impacts on banana and tomatoes. Likewise, another biotrophic pathogen, Puccinia graminis, which infects wheat, has also shifted into higher latitudes, putting at risk those areas that earlier were not at any risk. Weather conditions such as rainfall increase the chance of disease causing pathogens like Phytophthora infestans which infects potato and tomatoes. These pathogens can be washed around by water, either in the form of irrigation or rainfall, thus worsening the disease situation. On the other hand, hot, dry conditions in some areas may stunt the growth of plants and reduce thier resistence to disease, as most stressed plants keep low immunity to diseases. Another significant factor in the management of pathogens is humidity because most of the fungi that attack plants germinate and cause diseases when in a moist environment. This is clear from the invasion of rust and mildrew diseases in crops such as wheat, maize and barley. Climate change is also being felt in the evolution of the pathogen where some of the species are changing becoming more virulent or even developing resistance to currently available control measures. The current and emerging trends in plant pathogens also need contingence management measures such as improvement in plant variety and resilience, effective early disease detection and lastly incorporation of climate change resilience in agriculture to reduce the impact of these changing pathogens to food production.

Plant Pathogenic Diseases and their Meaning for Plant Health and Food Safety

Actually, efficient eradicating of plant pathogens is one of the significant factors that can help to achieve food security as the plant pathogens are capable of causing considerable losses in crop productions, food scarcities, excessive prices for food products, and fluctuations in the economy. For the international population continually growing, protection of crops cannot be overemphasised at any one time. Plant pathogen management entails prophylactic measures, disease diagnostics and the application of integrated and sustainable control measures to reduce the effects of plant diseases in plant production systems. Historically, chemical pesticides, crop rotation and resistant variety are the techniques that have always been employed to control plant

pathogens. But then, these methods do not prove very effective in the time of upgraded viruses and struggles in fluctuating environmental factors. Integrated pest management (IPM) has become an important tool that adopts bio-control, cultural, mechanical and chemical methods in the least environmentally adverse manner in containing disease outbreaks. For instance, good bugs to suppress bad bugs and disease, with resistant varieties, is a better way to manage the fungal pathogens than by employing the chemical control methods. Scientific break throughs in molecular biology and biotechnology have also transformed the management of plant pathogens. Through genetic engineering, and other techniques such as CRISPR/Cas9 gene editing, crops with improved immunity levels to certain diseases can be bred without the need for chemical input. Remote sensing perception and molecular detection methods can quickly determine the occurrence of epidemics so that early strategies may be applied and little harm would be inflicted on crops. The general importance of plant pathogen management in food security cannot be overemphasized. This suggests that without adequate disease management, world food production supply chain will suffer massive crop losses and eventually food insecurity where most of the population depends on agriculture for food supply. To reduce the negative impacts of communicable diseases, enhance the capability to identify warning signs in food production and to increase the use of resistant crop varieties, we can safeguard existing food production systems and guarantee future food security at reasonable prices.

Bacteria and world food systems

Biotic agents are a major threat to companies directly involved in food production several ways through which plant pathogens threaten food value chains include. While plant diseases are extending their area or country in any region, it results in large scale yield loss of crops, thus creating a scarcity and fluctuation in prices. This has implications to food supply, food price and vulnerability of food systems globally. The rise in international exchange and transport of horticultural produce have aggravated the risks associated with pathogen transgression as infected plants and contaminated produce can be transported to new geoclimatic regions. Thus, plant pathogens cause a significant threat to food organizations and supply chains. Supply shocks

resulting from disease outbreaks such as wheat rust or potato blight or rice blast which ravage crops obviously affect the food production and processing industries as well as retailers. Discharged crops which … may led to reduction of crop yield and consequently crop prices that impacts ones who use inputs to grow crops and buyers of crops. For instance, Bovista 2003 in the U.S attacked corns and forced the prices up and everyone felt this in the international market for corn. Global supply chains also grave at risks of restrictions in the importation of planting materials as countries attempt to fight the diseases. Infected products or contaminated seeds can lead to quarantines, trade bans and restrictions, and changes in the flow of goods international trade of food stuffs and overall market unpredictability. Disruptions as such are particularly damaging when occurring for nations dependent on the export or import of agricultural produce. To reduce the effects of plant pathogens on food security supply chain, there is increased consciousness on monitoring, identification, and restricted containment. Further, innovation, sustainability in farming, crop option or diversification, and pathogen-resistant are the measures to minimize vulnerability. Through enhancing these safeguards we can effectively reduce the impacts of plant diseases on the global food systems and feed the rapidly growing population.

Plant Breeding in Disease Resistance

Crop improvement is one of the key components in improving pathways toward increasing the resistance of plants to diseases as a significant determinant of yield. This serves a goal of making plants less susceptible to threats from disease causing organisms like fungi, bacteria, virus and nematodes through plant breeding. Genetically modified seeds offer less susceptibility to diseases and hence less likelihood of the disease affecting large area of crops hence less chemical pesticide use and more environmental friendly practices. Conventional methods of plant breeding remain the key strength of resistance to disease. Through back crossing plants with resistant genes of wild relatives or other cultivars of crops, breeders can incorporate the variability into crops. For instance, the breeding for resistance to Puccinia graminis that causes wheat rust has greatly diminished the effects of this disease to current global wheat production. Likewise, breeding programs for effectiveness in the resistance of potatoes to P. infestans (the cause of

potato late blight) have reduced the possibility of crop damage in areas prone to attacks of this pathogen. Specifically, molecular techniques and genomic tools have provided added symmetry to the plant breeding endeavours in the last couple of years. Using the method of MAS, the desired resistance genes with improved accuracy can be selected, which will reduce the time to develop resistant varieties. The after-mentioned system also provides the extra advantage of more specific techniques like CRISPR/Cas9 that enable the introduction, or even the strengthening of disease-resistant traits in crops at a much larger scale and pace. Such biotechnological developments have resulted in development of crops with enhanced resistance to various pathogens and hence making availabe to farmers better ways of controlling diseases affecting plant production. Secondly, one of plant breeding for disease resistance approaches involves enhancing the plant's ability to recognize and to react for example by enhancing the plant's immunity. Sustained resistance breeding where plants can continue to remain resistant to diseases is a major conserve for modern breeding programs.

Socio economic and Environmental Consequences of Plant Pathogens

Biotic diseases cause similar or even single crop yield and even affect the economy, farmers or growers, food prices, and the environment. Just as diseases reduce the yields in the plantations, the impact is felt at national level wherever agriculture forms the backbone of the economy. The cost involved in plant disease management accounts for the reduction of crop yield as a result of disease impacts on production, high cost of disease control, and resulting quarantine measures and ban on exports. Plants diseases are devastating to farmers since they end up receiving low yields, low quality products, or in the worst-case scenario lose their entire crop. For everyday smallholder farmers especially in developing nations, loss due to diseases can prove financially catastrophic. Additional statutory management costs such as insecticides, manpower, and other implements and other disbursements prove to put more pressure on scarce resources. Moreover, supply chains follow pathogen-led shifts in market values, which ultimately influences customer and producer pricing for consumables such as food.

The effects of plant pathogens to the environment are also felt. The extensive application of the

chemical pesticide in an effort to combat diseases adversely affects the environment in terms of pollutants emitted and absorbed by soil and water, reduced bio-diversity and negative impact on other soil useful microbes such as pollinators and natural enemies of pests. Unfortunately, the evolution of resistance to pesticides by the pathogens compounds these problems, thus resulting in a growth in chemical usage. Also, the transplant of new invasive plant pathogens that are normally introduced by trade activities and climate change affects ecosystems. The pathogens will therefore change the abundance and species composition of plants in the affected ecosystems, affect the level of diversity, and change the function of ecosystem service such as nutrient cycling and water retention. For instance bio-control agents such as Phytophthora species when introduced in natural forests, result in vast tree death, thereby unhappy ecosystems, and foremost the products they sustain in terms of services to people as well as wildlife.

Conclusion

The damage of plant pathogens on crop, environment and food safety cannot be overemphasized hence calls for effective pathogen control. Since climate change, globalization, and innovative methods of agricultural practices affect the epidemiology of plant diseases, integrated and lasting solutions have never been so obligatory. The social effects of the plant pathogens can as well be investigated for the growing Smallholder farmers in the developing world where crop losses due to diseases may compromise income most importantly food security. As the amount of chemical pesticide use rises to gain a temporary reprieve, problems such as environmental deterioration and resistance become more intense and continue to muddy the waters of disease management. In plant breeding, biotechnology, and integrated pest management (IPM) there are new weapons that play an important role in preventing plant diseases. Sustainable disease control, marker assisted selection, and the inoculants replace chemical dependent practices of pest control. In a similar vein, knowing more about how the constituents of the Peoples work; soil health, microbiome and plant immunity systems play in disease resistance would go a long ways in engineering better and sturdier crops. Such milestones discovered through scientific advancement together with the usual practices like crop, organic farming, and ecosystem farming

can help reduce the detrimental impacts of plant pathogen.

Nevertheless, solving issues of a socioeconomic and environmental nature demands the coordinated actions of all countries and the support of local legislation. Focus on surveillance systems and efficient early warning systems can protect the food production potential and would go far in improving food security through resilience in plant varieties. Finally, helping farmers, disease diagnosis, and cooperation with other countries are significant steps required to develop a strategy to protect the plant pathogen threats and to achieve a long-term food security.

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