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Tamalika Kumari
Department of Agriculture,
Swami Vivekananda University,
Barrackpore, West Bengal, India

Milan Ghosh
Department of Agriculture,
Swami Vivekananda University,
Barrackpore, West Bengal, India

Ria Mukhopadhyay
Department of Agriculture,
Swami Vivekananda University,
Barrackpore, West Bengal, India

Corresponding Author:
Tamalika Kumari
Department of Agriculture,
Swami Vivekananda University,
Barrackpore, West Bengal, India

The warming world and it's impact on phytopathogens and insects

Tamalika Kumari, Milan Ghosh and Ria Mukhopadhyay

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Abstract

Global warming, driven by human activities releasing greenhouse gases, has significant effects on plant pathogens and insect populations, altering the dynamics of ecosystems and agricultural systems. Higher temperatures can accelerate the development of many plant pathogens, such as fungi and bacteria, leading to increased disease incidence. Warmer conditions can extend the growing seasons of these pathogens, allowing them to reproduce more frequently. This can devastate crops and natural vegetation, impacting food security and ecosystem stability. Elevated carbon dioxide levels associated with global warming may favour some pathogen species over others, further exacerbating the problem.

Insect populations are also affected by global warming as temperature influences insect development rates, altering their life cycles and potentially leading to more generations within a single year. Furthermore, higher temperatures might affect insect behaviour, including feeding habits and migration patterns, potentially exposing plants to different pests or intensifying existing pest pressures. Shifts in climate can also disrupt the delicate balance between plant species and their associated insects, which often rely on temperature and timing for pollination. As plant-pollinator relationships become mismatched due to climate change, it can negatively impact both plant reproduction and biodiversity. The complex interplay of temperature, altered life cycles, and disrupted ecological relationships can lead to increased disease incidence, altered pest pressures, and ecosystem instability.

Keywords: Global warming, plant pathogens, insects

Introduction

Global warming refers to an aspect of climate change, referring to the long-term rise of the planet's temperature. In the last 200 years, environmental changes brought on by both natural and human activity have increased globally. In the twenty-first century, it is anticipated that the rise in greenhouse gases will continue to raise the world temperature and alter water availability. Environmental factors have a significant role in the development of plant diseases; for example, unfavourable environmental circumstances will prevent a virulent pathogen from infecting a susceptible host. Each disease may respond differently to fluctuations in CO_2 concentrations, temperature, and water availability, which can have positive, neutral, or adverse impacts on them (Velásquez *et al*. 2018) [25].

Impact of global warming on pathogens

Changes in CO_2 levels, temperature, and availability of water can have a beneficial or adverse impact on the development of diseases since various diseases may react differently to these changes. It has been predicted that biotic stress will cause direct production losses of 20% to 40% for the main agricultural crop (Oerke 2006; Savary *et al*. 2012) [11, 16]. In order to develop truly effective and long-lasting solutions for preventing, reducing, or managing some of the most devastating plant diseases facing modern agriculture today and in the future, plant scientists must work to accelerate their understanding of the molecular, epidemiological, and ecological bases of plant diseases. There are a variety of pathogens that often infect plants, including intracellular viruses and bacteria, fungus, oomycetes, and nematodes. (Velásquez *et al*. 2018) [25].

The well-known disease triangle theory in plant pathogen emphasises how both the pathogen and the host plant interact with the surrounding environment. A virulent pathogen, a vulnerable plant host, and the ideal environmental conditions for any one of these three factors are required for disease to manifest (STEVENS 1960) [17]. But the changes in climatic conditions due to global warming, is disrupting the mechanisms of pathogen virulence and susceptibility of host plants (Fig. 1). Higher level of CO_2 increased the virulence of the fungal isolate *Fusarium graminearum* and also increased the susceptibility of wheat variety to this fungus (Vary 2015) [24]. *Puccinia striiformis*, the rust pathogen, was incapable of infecting wheat seedlings in the laboratory temperature of 21 °C, though infection still occurred in the field when temperatures fluctuated between 18 °C and 30 °C. (Park 1990) [12]. At higher CO_2 concentrations, in tripartite biotic interactions between wheat, a virus (barley yellow dwarf virus, BYDV), and a vector (the aphid *Rhopalosiphum padi*), uninfected plants exhibited reduced aphid populations, but much higher CO_2 concentrations had no impact on total BDYV infection. Infection of potato by *Phytophthora infestans* a little fluctuation of 5 °C in temperature made the plants more susceptible to the fungus.

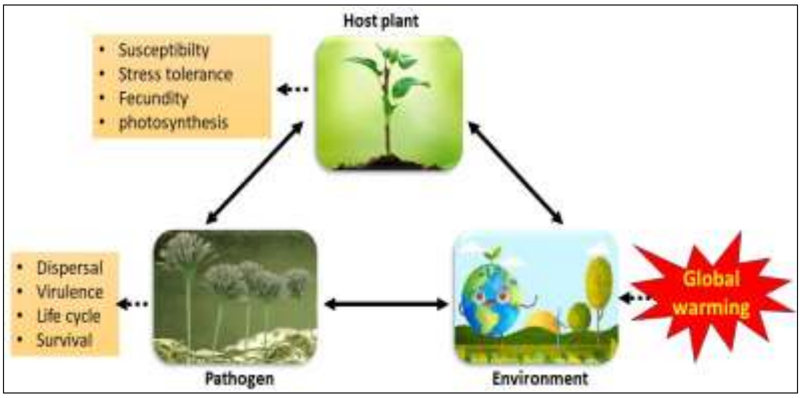

Fig 1: Plant-pathogen interaction under climate change

The fungus *Sclerotinia sclerotiorum* becomes more virulent as air humidity rises, with disease growth in lettuce plants reaching its peak when air humidity exceeds 80% (Clarkson 2014) [4]. Drought conditions have severe detrimental effects on both plants and pests and pathogens. *Magnaporthe oryzae* infects rice aggressively during times of drought, which increases the number of pathogens and the severity of disease symptoms. (Bidzinski 2016) [3].

Impact of global warming on insects

Due to expected global warming, the existing and future difficulties caused by phytophagous insect pests are likely to worsen. Potential effects of this warming include an increase in the frequency of outbreaks and the ability of many pest species to spread across large geographic areas. As a result, there may be greater financial losses and a decline in food security (Sutherst *et al*. 2011, Andrew *et al*. 2013, Thackeray *et al*. 2016) [18, 1, 20]. It's crucial to remember, though, that the effect of rising temperatures on the severity of insect pests could not be uniform. This is due to the fact that insects have unique physiological tolerances and environmental niche needs, and the impact of temperature on their phenology and life cycle might differ. Due to these sensitivities, regional climate warming could, in fact, lead to local population declines or even extinctions (Taylor and Hastings 2005; Thackeray *et al*. 2016) [19, 20].

Additionally, pest ranges frequently cover a variety of settings, including various types of managed landscapes (Tscharntke *et al*. 2012) [22], creating complex and dynamic matrices of interactions between pests and ecosystems (Bebber *et al*. 2013; Karp *et al*. 2018) [2, 7]. Last but not least, assessments frequently ignore the whole range of possible pest responses to temperature increases and instead concentrate on a particular response, such as range extension (Bebber *et al*. 2013) [2]. These may be divided into at least four different categories (Urban *et al*. 2016) [23]: modifications to spatial distribution (Pecl *et al*. 2017), life-history traits, survival and infestation on host plants (Robinet and Roques 2010) [15] (Fig. 2.).

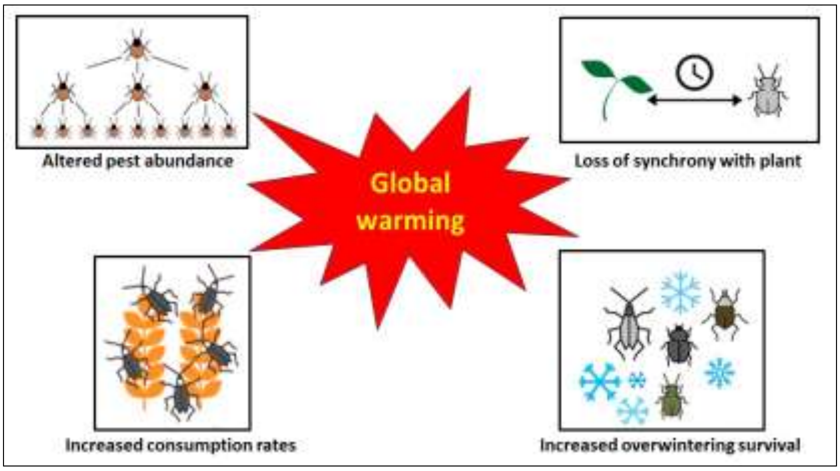

Fig 2: Impact of global warming on insects

In a study by Lehmann *et al*. (2020) [8], 29 (94%) of the 31 insect pest species chosen for assessment were said to be responding to the current climatic warming, with 28 (90%) showing multiple responses. Out of the 29 species exhibiting some sort of reaction, 26 (90%), 18 (62%), 16 (55%), and four (14%) showed modifications in geographic distribution, population dynamics, life history (traits related to phenology and voltinism), and trophic interactions, respectively. While almost all of these species are predicted to experience increased pest intensity (e.g., due to range expansion or increased abundance), 59% (17/29) of these species also showed responses that were probably intended to lessen pest damage (e.g., decreased physiological performance and range contraction). Reductions in pest impacts were often observed alongside other reactions that were likely to enhance their effects. The most frequent severity-reducing responses were reductions in pest population densities. A total of 17 out of 29 pest species were found to have varying reactions in different parts of their habitat. These pest species had previously shown sensitivity to increasing temperatures. For instance, the population density of the Colorado potato beetle (*Leptinotarsa decemlineata*) has increased in central European regions during the past several decades, causing the beetle's range to be expanded farther north in Europe. The winter moth (*Operophtera brumata*), in a similar fashion, has expanded its range to higher latitudes and latitudes, and decreased its range to lower latitudes (Lehmann *et al*. 2020) [8]. Insect pests of annual (mainly agricultural pests) and perennial (largely forest pests) crops showed comparable response patterns to global warming. The extent of pest damage to annual crops was lower compared to perennial crops (such as trees), which was unexpected given differences in feeding or host ecology and evolutionary restrictions. We categorized species based on their historical and present socioeconomic and ecological consequences, as well as the current implications of rising temperatures on those impacts, in order to estimate the prospective impact of agricultural and forest pest responses to global warming. According to reports, social and ecological effects have generally worsened over the geographic ranges of animals that have responded to climate change (Andrew *et al*. 2013; Bebber *et al*. 2013) [1, 2]. Furthermore, 85% (17/20) of annual crop pests now have relatively modest ecological repercussions outside of the cropping systems they infest, despite the fact that all perennial crop pests evaluated in this study already have considerable ecological impacts. (Lehmann *et al*. 2020) [8].

Insect pests may quickly adapt in response to ongoing climate warming (Parmesan 2006; Hoffmann 2017; Diamond 2018), and if evolutionary adjustments are not taken into account, predictions of insect pest reactions to rising temperatures (Andrew *et al*. 2013) [1] may be unreliable. In reality, predictions for some of the 31 species have been impacted by rapid evolutionary change or might be impacted in the future. (Lehmann *et al*. 2020) [8].

Studies shows that the effects of global warming will further magnify the reduction in pollinator populations, endangering both local and global food security and ecological stability. The pollinators mainly the honey bees are in trouble which is a matter of great concern that is spreading around the globe as it can negatively impact both plant reproduction and biodiversity (Marshman *et al*. 2019) [9].

Conclusion

It is obvious that the current changes in climate patterns have the potential to endanger the already precarious global food security in a number of ways, including by worsening serious plant insects and diseases and by fostering the emergence of deadly new pests in key food-producing regions. It is predicted that certain diseases and insects will be a serious problem for global food security based on present climatic trends and plant and pathogen responses to key climatic elements in this century.

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