ARTÍCULO DE OPINIÓN

# The influence climate change has on plant pathogens

### Climate change is undeniable

The pace of global climate change is much higher than observed in the geological past. Recently compiled data indicated that the current global temperature shift is significantly higher than ever recorded in earth history [1]. There is now little doubt that this pace is a consequence of anthropogenic influence. The average global temperature has risen in the last 100 years and from the 10 years with the highest recorded yearly global average temperature, 9 of these years have been recorded since the year 2000 (http://climate.nasa.gov). In addition, the highest mean annual temperature was recorded in 2015 (Figure 1). Dealing with the effects of climate change leads to discussions about the future of global food security [2]. Currently between 10 and 16% of crop production is lost to pests, followed by similar losses post-harvest [3]. Recovering losses of major crops to fungi and oomycetes alone could feed 8.5% of today's population [3].

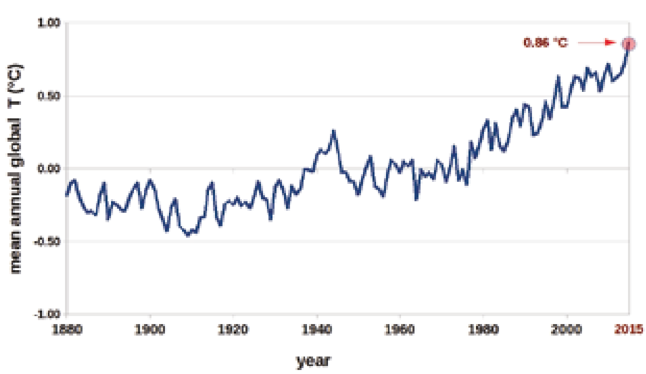


**Figure 1.** Mean annual global temperature (°C) from year 1880 to year 2015.

In Ecuador, there are concerns about the impact climate change has on agriculture and on biodiversity in general. In the Amazon rainforest, significant droughts have recently raised concerns about the influence of global climate change in that region [4]. Climate models predict a seasonal increase in precipitation and an increase in the occurrence of severe drought periods [5].

In the extreme El Niño events of 1982/83 and 1997/98, the eastern region of Ecuador was severely struck by catastrophic floods. The extreme weather conditions caused widespread environmental disruptions, for example they caused the disappearance of marine species and, severe destruction of corals in the pacific and decimation of the native bird population in the Galapagos Islands. Both El Niño events were characterized by an exceptional warming of the sea surface temperatures, which led to speculations that the increased frequency of El Niño events is a consequence of global warming [6]. Recent studies show that global warming in fact, leads to a significant increase in the frequency of catastrophic El Niño events [7].

### Crop plants are under threat

Field crops are bred predominantly for increased yield and secondarily for disease resistance, which are thus constantly under threat of plant diseases [8,9]. The poor genetic variability of these crops has the consequence that when struck by a deadly disease, whole regions and even continents can suffer from sudden disappearance of the crop. Famous events in the past were triggered by devastating fungal plant pathogens, such as the "potato famine" in Ireland, which led to the destruction of the whole potato production, which was the main crop at that time in Ireland. Another example is the "Panama disease" which destroys banana plants and led to the worldwide disappearance of the banana cultivar "Gros Michel".

### Climate change and the pathosystem

However, not much is known about the interactions between climate change, crops and their pests in a so called pathosystem. Every pathosystem is different and depends on many factors, such as geographical region or plant and microbial species. Therefore any attempt to generalize the effects of climate change is impossible. The classic disease triangle (Figure 2) model describes the interactions between plant hosts, pathogens and the environment [10] and how each factor influences the severity of the disease. Climate change, and hence changing environmental conditions, can have a negative effect on plant health. Moreover, climate change can also directly affect the pathogen by extending the amount of time available for reproduction and dissemination, when there is an increase in temperature and by changes in precipitation and moisture. The increase in incidence of root rot in central Europe caused by *Phytophtora* species is a result of enhanced pathogen fitness, which results in higher mean winter temperatures and enhanced precipitation, particularily in winter [11].

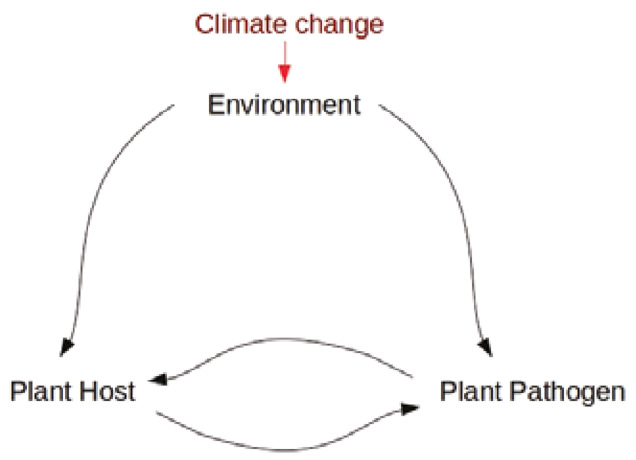


**Figure 2.** The classical disease triangle is influenced by climate change.

**Effects of climate change on plant pathogens in Ecuador**

The largest consequences of global warming are expected to happen close to the equator, because tropical species react more sensitively to changes in temperature. These species are perfectly adapted to a narrow and optimal temperature range [12].

Ghini and collegues [13] studied the potential impact of black Sigatoka (*Mycosphaerella fijiensis*), the most economically costly disease to banana's worldwide. Interestingly, the study predicts a reduction in the disease in some areas of Brazil, resulting in a reduction in relative humidity to levels below 70%. The predictions, which show future spatial distributions until 2080, indicate a seasonal difference with a high presence of *M. fijiensis* between November and April and with a significant decrease in the presence of the disease during the remaining month.

Panama disease (*Fusarium oxysporum f. sp. cubense*) is another important disease which is feared in all banana growing regions [14]. In contrast to black Sigatoka, studies predict that there will be an increase of Panama disease as a consequence of climate change [15]. This is explained by future rising temperatures and enhanced periods of drought, which will make banana cultivars more susceptible due to stress, and hence an increase in the incidence of *F. oxysporum f. sp. cubense*.

Another study expects an increase in the presence of *Papaya ringspot virus* (PRSV-P), which is transmitted by aphids and which shows more severe symptoms higher temperatures (26°C – 31 °C) [16]. The expected increase in in global temperature will enhance the damage caused by PRSV-P.

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Bernreiter Andreas was born in 1974 in Hollabrunn, a small city close to Vienna, the capital city of Austria. During his school career he developed interest for nature and ecology and consequently he studied biology at the University of Vienna. With the growing importance of molecular studies in life science, he decided to focus his studies on genetics and finished his Master in Genetics in 2001. His diploma thesis was dealing with the identification and characterization of novel protein receptors present on the surface of human immune cells.

The PhD work was focusing on the fungal model organism *Aspergillus nidulans*, which serves as a model for physiological processes in lower and higher eukaryotes. Aim of the studies was to reveal the molecular mechanism of nitrate assimilation, which knowledge is important for agriculture. He used a diversity of molecular biology, genetic and biochemistry methods for his studies. After the PhD he was awarded a scholarship to lead a research project at the University of Lancaster (U.K.). In the project he shifted the studies of nitrate assimilation from *A. nidulans* to the plant model organism *Arabidopsis thaliana*. Afterwards he got involved in a project studying the influence of mRNAs on plant development at the University of Heidelberg. There he used high throughput mass spectrometry approaches to identify protein-protein interactions and he used bioinformatics to analyse the data. Interested in bioinformatics he then studied programming (Java, C#), database management (MySQL) and web design (JavaScript, HTML5, php, CSS3). Finally, he was awarded a Prometeo Project to conduct a project at AGROCALIDAD, Ecuador. The aim of the project was to identify plant pathogens of major crop plants and forest trees in Ecuador and to develop molecular methods for quick and easy identification of these.

**Recommendations for dealing with climate change:**

1. Collect extensive data about the location of pests, the severity of the disease and climatic factors, such as precipitation, temperature, humidity and more. This will help to improve predictions about plant/pest interactions in a changing climate.
2. Invest in crop pest resistance breeding in order to avoid the consequences of devastating pest outbrakes, such as the “Panama disease”.
3. Implement strong quarantine measures to control any new emerging pathogens and to prevent the spread of pathogens into new areas. This is because of the alterations in disease distribution both geographically and temporally.
4. Invest in research for biologial control: Particularily soilborne pathogens will remain more difficult to control once the soil is infested, because some pathogens can survive for years, even in the absence of a susceptible host. Antagonistic microbes, such as *Trichoderma harzianum* or *Bacillus subtilis*, should be tested for activity in changing environments. *T. harzianum* is a promising candidate to use in a changing environment, as studies indicate that it is more active against *Botrytis cinerea* (grey mold) at higher temperatures and with relatively low humidity levels [17].

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