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Are plant diseases too much ignored in the climate change debate?

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Abstract Ignoring plant diseases misinforms the climate change and food security debate. Diseases are expected not only to cause more severe crop loss in many areas in the world and threaten food security, but also to decrease the climate change mitigation capacity of forests, of other natural ecosystems and of producing crops. However, if research, policy and industry join forces to obtain the multidisciplinary knowledge necessary to adapt integrated pest management (IPM) to the changing climate, it is expected that sufficiently resilient cropping systems can be developed in time. This was the main conclusion of the International Conference on Climate Change and Plant Disease Management held in Evora, Portugal, in November 2010.

Keywords Climate change · Plant diseases · Resilient cropping systems

Before the mid-point of this century, twice as much food needs to be produced to feed the growing world population, using half the inputs to meet sustainability criteria. Food security is therefore a major challenge for the 21st century. As pests and diseases are and will be responsible for crop losses which may amount up to 40% world-wide, (Oerke 2006), reduction of their impact is more relevant than ever, not only to produce enough food and commodities but also to reduce wastage of production inputs and unnecessary emission of CO_2. Next to food production, plants and notably the forests of the northern hemisphere are extremely important to sequester CO_2 and mitigate part of the greenhouse gasses (GHG) responsible for climate change. Climate change will definitively affect the distribution and severity of pests and diseases in crops and forests, but whether such changes will cause more devastating plant disease epidemics, has received little attention in the current scientific debate on climate change.

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This lack of attention prompted the European Foundation of Plant Pathology, (EFPP), the Royal Netherlands Society of Plant Pathology (KNPV), the American Phytopathological Society (APS), and the Portuguese Phytopathological Society (SPF), to organize a conference focused on plant diseases, as they are even more ignored than plant pests. The participants discussed the following key questions.

- Will climate change increase the frequency of crop disease epidemics, with an accompanying threat to food security?
- What is the role of plant disease control on mitigation of climate change effects by greenhouse gases?

- What climate change adaptation strategies are needed to ensure effective management of plant diseases?
- What can be expected from research to support adaptation strategies?

Will severity of crop diseases increase and threaten food production because of climate change?

The question whether climate change will cause more devastating plant disease epidemics to occur cannot be answered in general terms. Climate change is not the same as weather change. Climate models predict a gradual rise in CO_2 concentration and temperature all over the world, but are not very precise in predicting future changes in local weather conditions. Local weather conditions such as rain, temperature, sunshine and wind in combination with locally adapted plant varieties, cropping systems and soil conditions can maximize food production as long as plant diseases can be controlled. Currently we are able to secure food supplies under these varying conditions. However all climate models predict that there will be more extreme weather conditions, with more droughts, heavy rainfall, and storms in agricultural production regions. Such extreme weather events will influence where and when disease will occur, and therefore impose severe risks on crop failure.

The complexity of the translation of climate change in relation to local weather conditions and the effects on crop growth and the occurrence of plant diseases has been presented at the conference as 'Opinions and Trends' reviewed from the current literature (Pautasso et al. 2012). Some striking effects of climate change on plant – disease interactions are apparent. First, some features of climate change will definitively affect disease phenology. Higher temperatures will speed up the life cycle of many pathogenic fungi, multiplying inoculum in a shorter time and consequently increasing the infection pressure. A second effect is that prolonged generations of diseases will be able to infect crops at a later growth stage then at present. As an example it has been calculated that Phoma would cause a 10–50% decrease of total yield of oil seed rape in the UK by future climate change conditions. (Barnes et al. 2010). Another effect of climate change is that anthesis in e.g. wheat will be earlier in the season, presenting a more favourable timing for Fusarium earblight infection, and consequently enhancing the opportunity for mycotoxin presence in the cereal grain (Matgwick et al. 2011). Evaluation of climate change modelling on a variety of diseases in crops of north-west Europe showed a variety of possible effects, from little change to increase, and in some cases to unknown effects (West et al. 2012). However if the timing of infection changes as an effect of climate change, it might be that the direct effects on the yield is negligible, but the indirect effect (e.g. easier transfer to another host, better surviving in the host) might lead to enhanced problems the subsequent year.

Third, climate change will affect the expression of the plant resistance traits in a positive or negative way. Resistance breeding takes a long time and present resistant varieties are bred for present agricultural conditions. Experimentally it has been found that the expression of quantitative resistance against Phoma in oilseed rape dropped dramatically when temperature was raised from 20 to 25C, leading an increase of the% leaf area infected from 5% to 50% (Huang et al. 2009). This shows that the expression of resistance genes in the host plant and the efficacy may decrease dramatically with climate change. In addition one can envisage that the increased generation cycles of pathogens due to climate change might easily select a more aggressive pathogen population. Such selection in the pathogen population in combination with a compromised resistance in the host will lead to unprecedented opportunities for disease epidemics.

Fourth, when over a large cropping area the genetic variation of the crop is low and a new or adapted strain is becoming dominant in the pathogen population, the effects can be dramatic. An already classical example is wheat production in the CWANA area (Central and West Asia and North Africa) which feeds over one billion of people. Although many wheat varieties are grown in this huge area all have a similar genetic background. With a slightly increased temperature and decreased rainfall as observed over the past decades a new yellow rust type has been able to move from Africa to India within 15 years leading to widespread epidemics, (Solh 2010). It shows how vulnerable such cropping areas are with even slight climate changes occurring.

Therefore the conclusion of the conference was that we cannot take the risk that plant diseases might threatening food security in the 21st century because of climate change.

Does disease control help to mitigate climate change?

The question about the impact of plant disease control on mitigation has barely been raised in climate change debates. Participants in the Evora conference presented two cases. One was a study in the United Kingdom, showing that good disease control in arable crops improves the CO_2 balance. In a more detailed comparison of different cropping systems it was found that successful crop protection will be by far the most important factor to decrease GHG emissions by arable crops in the future (Carlton et al. 2012). The second case concerned forests in British Columbia. It turned out that almost all pine species and varieties are sensitive to Dothiostroma needle blight, but the pathogen was never highly virulent in the northern forests. However the recent large-scale outbreaks of the disease which have defoliated large areas of forests in a short period, could be ascribed to recent climate change effects (higher temperatures and humidity) over the last years in this area (Woods 2011). Both studies clearly show that plant diseases pose a serious risk in terms of decreasing the mitigating capacity of cultivated land and of forests.

What climate change adaptation do we need to control diseases?

In general climate change models ignore possible effects on population dynamics and infectivity of pests and diseases. The most important reason is that we do not have long term monitoring data or an empirical approach to input into modeling systems that might be used to predict impacts and mitigation scenarios, as already noted almost 10 years ago (Scherm 2006). In addition this pattern of climate change factors is not equally distributed over our globe, large differences will occur: a general shift of a milder climate towards the poles improving the potential of crop production, but hotter and dryer in many already semi-arid areas of the world, limiting the possibilities for agriculture. Therefore it is not likely that general models can ever be developed.

However all climate models predict a higher frequency of extreme and fluctuating weather conditions, which would influence the interactions of crops, pests and diseases in an unpredictable way, and consequently increase the risk of complete failure of current crop protection strategies. Therefore it important to increase our knowledge on these interactions to be able to adapt current integrated pest management (IPM) strategies to a more diversified level, in order to create more robust and resilient cropping systems, which are less sensitive to fluctuating weather conditions resulting from climate change. Even more important is the ability to develop the more resilient IPM strategies for each region/cropping systems, as weather fluctuations in e.g. southern Europe will be completely different from the northern areas.

What can be expected from research?

It is improbable that research could provide science-based tools for crop protection which would be robust under all those varying and extreme fluctuations of weather. Fortunately, current integrated pest management (IPM) strategies, designed to decrease dependence on fungicides, can be used to improve elements that are needed for diversifying crop protection strategies in adapting to future climate change. The building blocks include healthy seeds with innate forms of broad and durable disease resistance, fertile soils, strategic landscaping and intercropping systems that foster refuges for natural bio-control organisms. Monitoring and early warning systems for forecasting disease epidemics will enable early control (fungicides and alternatives such as biological and physical precision measures for control) before the disease spreads. All such building blocks for a diversified crop protection are elaborately exemplified in a comprehensive study on an integrated approach to control all foliar diseases in barley (Walters et al. 2012). However, despite 20 years of research on integrated pest management, such schemes are still poorly adopted in farming systems and are often insufficiently robust. With the extreme weather fluctuations predicted, maintaining robust crop protection strategies will be a much greater challenge than today and substantial progress needs to be made in the next 20 years.

There is an urgent need for research on the mechanisms and expression of multiple resistance genes in plants under extreme weather conditions and the genetic basis and external factors that enable pathogens to render ineffective the resistance of plants. More work is needed to examine the impacts of climate change on the efficacy of fungicides and alternative control measures and the risks of selection for pathogens that are better adapted to new climates. Furthermore it is necessary to design resilient systems for each local situation. As the number of variables to be considered under climate changing scenarios is great, designing systems only by means of experimentation is not feasible. New modelling methods are urgently needed and adequate data from various regions of the world collected to validate these models.

In conclusion, the conference and the participating phytopathological societies urgently recommend that research is started to support production systems with diversified crop protection strategies that are adapted to climate change. Such systems are needed to secure food production and climate change mitigation according to the sustainability criteria of the 21st century.

References

Barnes, A. P., Wreford, A., Butterworth, M. H., Semenov, M. A., Moran, D., Evans, N., et al. (2010). Adaptation to increasing severity of Phoma stem canker om winter oilseed rape in the UK under climate change. *Journal of Agricultural Sciences, 148*, 683–694.

Huang, Y. J., Pirie, E. J., Evans, N., Delourme, R., King, G. J., & Fitt, B. D. L. (2009). Quantitative resistance to symptomless growth of *Leptosphaeria maculans* (phoma stem canker) in *Brassica napus* (oilseed rape). *Plant Pathology, 58*, 314–323.

Matgwick, J. W., West, J. S., White, R. P., Semenov, M. A., Townsend, J. A., Turner, J. A., et al. (2011). Impacts of climate change on wheat anthesis and fusarium ear blight in the UK. *European Journal of Plant Pathology, 130*, 117–131.

Oerke, E.-C. (2006). Crop losses to pests. *Journal of Agricultural Sciences, 144*, 31–43.

Scherm, H. (2006). Climate change: can we predict the impacts on plant pathology and pest management. *Canadian Journal of Plant Pathology, 26*, 267–273.

Solh, M. (2010). Ensuring food security in a changing climate: How can science and technology help? In: Proceedings of an International Conference 'Food Security and Climate Change in Dry Areas' 1–4 February 2010, Amman, Jordan (Mahmoud Solh & Mahan C. Saxena, eds), pp 5–12.

Woods, A. (2011). Is the health of British Columbia's forests being influenced by climate change? If so was this predictable? *Canadian Journal of Plant Pathology, 33*, 117–126.