



Potential impact of the climate change on the risk of mycotoxin contamination of agricultural products in Southeast Central Europe

A mini-review

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Abstract. Reports and modelling simulations by expert bodies, specialized institutions of the United Nations as well as everyday observations show that climate changes are occurring in our present epoch. Global warming and meteorological extremities, such as droughts, or even torrential rains, floods, and increasing frequency and duration of “heat waves” are in connection with this climate change, which is one of the greatest challenges of the 21st century. The climate change affects directly and significantly the agricultural production, diminishing thereby food security as well as risking public health, including the safety of our food and water sources. Drought stresses reduce the phytoimmunity of crop plants and extreme precipitations and heat waves increase the opportunity of growth of plant pathogenic microorganisms. Regarding food

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safety problems in connection with climate shifts, the mycological safety of foods and feeds is a subject of eminent importance because the factors mentioned previously could increase the contamination with toxigenic moulds and could increase the production of mycotoxins both prior to and after harvest. Species of the most important toxigenic moulds belong to the genera *Aspergillus*, *Fusarium*, and *Penicillium*. In the geographic region concerned in this review, various cereal grains, particularly maize and wheat, fodder plants, spice paprika as well as certain fruits such as apples and grapes plus their processed products are particularly important from this point of view. The growth and toxin production of such moulds are influenced very much by the eco-physiological factors, mainly the temperature and water activity of the attacked crops and products. Therefore, the relative risks of occurrence of specific moulds and their mycotoxins may change with the changing climatic conditions. Due to the so-called “mediterraneanization” of the geographic area concerned in this review, toxigenic moulds, formerly known as tropical and sub-tropical species may invade this region, which was a temperate climate in the past centuries. A project sponsored by the European Food Safety Authority investigated the possibility and modelling, predicting and mapping of the emergence of aflatoxin B1 in the European Union due to climate change. The main conclusion of the project consortium was that the risk of aflatoxin contamination is expected to increase in maize. In the case of the +2 °C temperature increase scenario as compared to the actual current temperatures, there is a clear increase in aflatoxin risks in the southern European countries, and low and medium risks at harvest in the four main maize producing countries (i.e. Romania, France, Hungary, and Northeast Italy). Several local investigations from countries in our region actually showed an increasing occurrence of *Aspergillus flavus* strains. Regarding *Fusarium* toxins, it can be expected that producers of fumonisins, such as *F. verticillioides* will also become more frequent. *F. graminearum* has become dominant in Europe instead of the previously dominant *F. culmorum*. Recently, so-called black aspergilli, known as ochratoxin and fumonisin producers, have been detected in Hungary also in onions and grapes.

1 Introduction

Reliable reports of expert bodies, specialized institutions of the United Nations as well as everyday observations show that climate changes are occurring in our present epoch. According to the Intergovernmental Panel on Climate Change (IPCC) and the World Meteorological Organization (WMO), a global warming is ongoing, which may be connected with the ever increasing human activities

of a tremendously growing world population since the commencement of the industrial revolution (*IPCC*, 2007; *WMO*, 2010). Meteorological extremities such as droughts, or even torrential rains, floods, and increasing frequency and duration of “heat waves” are in connection with this climate change. It is expected that such phenomena will increase during the coming decades (*Meehl and Tebaldi*, 2004; *Barriopedro et al.*, 2010).

The climate change affects directly and significantly the agricultural production, diminishing thereby the food security as well as creating public health risks, including the decreasing safety of our foods (*Páldy et al.*, 2004; *WHO*, 2008; *Miraglia et al.*, 2009). The present short review attempts to raise attention about a specific but important segment of these problems, with particular emphasis on the climate shift in Southeast Central Europe.

2 Climate change in Southeast Central Europe

The global warming tendency (*BEST*, 2011) and increasing contaminations and stress effects in relation to the meteorological extremities, the safety of foods and feeds as well as that of the water sources may increase infections and poisonings in this region (*Farkas and Beczner*, 2010). Drought stresses reduce the phytoimmunity of crop plants and extreme precipitations and heat waves increase the opportunity of growth of plant pathogenic microorganisms.

Ample evidence of these potential impacts are shown by documents and reports of the specialized agencies of the UN (e.g. *FAO*, 2008; *WHO*, 2008), the European Commission (e.g. *CEC*, 2009), and the relevant scientific literature (e.g. *Miraglia et al.*, 2009; *Tirado et al.*, 2010).

3 Mycological food safety

Regarding food safety problems in connection with climate shifts, the mycological safety of foods and feeds are a subject of eminent importance because the factors mentioned previously could increase their contamination with toxigenic moulds and could increase the production of mycotoxins both prior to and after harvest (*Cotty and Jaime-Garcia*, 2007; *Patterson and Lima*, 2010, 2011). Species of the most important moulds in this regard belong to the *Aspergillus*, *Fusarium*, and *Penicillium* genera. In the geographic region concerned in this review, various cereal grains, particularly maize and wheat, fodder plants, spice paprika as well as certain fruits, such as apples and grapes plus their processed products are particularly important from this point of

view (Kovács, 1998; Fazekas et al., 2005; Varga et al., 2005 a, b). The climate-stressed crops are increasingly sensitive to mould attacks and create increased mycotoxin risks thereby (Guo et al., 2008). Consequently, moulds growing as plant pathogens and those that are mainly “post-harvest” mycotoxin producers in the food supply chain are of important hazards with special regard to aflatoxins, ochratoxin A, and fumonisins (Farkas and Beczner, 2009).

The growth and toxin production of such moulds are influenced very much by the eco-physiological factors, mainly the temperature and water activity (equilibrium relative humidity) of the attacked crops and products. Therefore, the relative risks of occurrence of specific moulds and their mycotoxins may change with the changing climatic conditions. It is an important consideration that the invasion by toxigenic moulds can be assisted also by those vectors, such as insect pests which migrate in relation to the climate shifts, too (Patterson and Lima, 2010). Due to the so-called “mediterraneanization” of the geographic area concerned in this review, toxigenic moulds, formerly known as tropical and sub-tropical species, may invade this region, which was of temperate climate in the past centuries. This is the reason why the Emerging Risks Unit of the European Food Safety Authority (EFSA) issued a call at the end of 2009 to perform a project to investigate the possibility and modelling, predicting and mapping of the emergence of aflatoxin B₁ in cereals in the EU due to climate change. The results of this project, performed by a consortium of Italian and Dutch experts, have appeared recently (EFSA, 2012). The main conclusion of the project consortium based on the predictive model developed for *A. flavus* growth and AFB₁ production linked to crop phenology data is that the risk of aflatoxin contamination is expected to increase in maize. In the +2 °C climate change scenario as compared to the actual current temperature, there is a clear increase in aflatoxin risk in areas such as the central and southern region of Spain, the south of Italy, Greece, North and Southeast Portugal, Bulgaria, Albania, Cyprus, and European Turkey. Besides high aflatoxin risk in these southern European countries, low and medium aflatoxin risk at harvest in the four main maize producing countries (Romania, France, Hungary, and Northeast Italy) were predicted. The aflatoxin risk indices above zero were defined as high when they were found between 141 and 180, medium between 101 and 140, and low between 41 and 100 AF risk index values. According to the risk maps for EU regions produced by the *A. flavus* AF model, wheat would present a negligible aflatoxin risk and rice no risk at all in the period between 2000 and 2010. The estimated AF risks cannot be quantitatively correlated with EU legal maximum levels of aflatoxin contamination. According to this important report and in agreement with a previous review (Tirado et

al., 2010) – in an agricultural context –, mycotoxin risk assessment should include a wider concept of risk evaluation. This is because "new mycotoxins could arise for new fungus and plant associations, making the occurrence of new risks or mycotoxins not yet considered as a new potential human and animal health threat".

Recently, several local investigations from countries in our region actually show an increasing occurrence of *Aspergillus flavus* strains capable of producing aflatoxins (Torkar and Vengust, 2008; Tabuc *et al.*, 2009, 2011; Borbély *et al.*, 2010; Dobolyi *et al.*, 2011).

Regarding *Fusarium* toxins, it can be expected that producers of fumonisins, such as *F. verticilloides* become more frequent related to rainfalls following dry periods. As a consequence of series of warm summers, *F. graminearum* has become dominant in Europe instead of the previously dominant *F. culmorum*. Stroia and co-authors (2010) found the presence of *Fusarium* species in all of the 56 samples of cereals (maize, wheat, barley, and oat) from Western Romania (different areas of Banat region), and the most frequent species were *F. graminearum* and *F. culmorum*. Besides DON and ZEA, *F. graminearum* produces NIV toxin (Miller, 2008). It is probable that formerly less known mycotoxins (e.g. moniliformin) may become important, too.

Recently, the so-called black aspergilli, known as ochratoxin and fumonisin producers, have been detected in Hungary also in onions and grapes (Varga *et al.*, 2007) while the appearance of *Pithomyces chartarum* as a pathogen of wheat was noted (Tóth *et al.*, 2007).

It can be concluded from this short review that due to the changing climate of the region concerned, one has to count continuously with the toxigenic species of *Penicillium* and *Fusarium* genera, and the species of both the widely spread aspergilli and those that were considered as associated with the warm areas may gain increasing importance. Preparing for an improved prevention of fungal infections and a better adaptation to the increasing mycotoxin risks, it is important to support investigations/researches for the better understanding of the eco-physiological connections of growth and the toxigenesis of moulds.

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