CLIMATE CHANGE AND MYCOTOXIN CONTAMINATION IN CENTRAL EUROPE: AN OVERVIEW OF RECENT FINDINGS

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ABSTRACT
Climate change accompanied by global warming affects food security and food safety at different levels. Climate change has a direct impact on local weather conditions. Higher temperatures and elevated humidity or drought will increase the infection of crops by different fungi and therefore increase the probability of mycotoxin occurrence. Fungi have optimum temperature ranges within which they can infect agricultural crops more severely. Increasing average temperatures could lead to changes in the range of latitudes at which certain fungi are able to compete. The production of several mycotoxins including aflatoxins, ochratoxins or fumonisins is favored by moisture and high temperature. Recently, several papers have dealt with the effects of global warming caused by climate change on the appearance of mycotoxin producing fungi and mycotoxins in agricultural products. In this review, we wish to give a general overview on the potential effects of climate change on the occurrence of mycotoxin producing fungi and their mycotoxins in Central Europe.

Keywords: climate change, global warming, mycotoxins, *Aspergillus*, *Fusarium*

INTRODUCTION

There is now overwhelming scientific consensus that climate change accompanied by global warming is happening, and is a phenomenon induced mostly by human activities (IPCC 2007). Recent years show increasing temperatures in various regions, and/or increasing extremities in weather patterns (METZ ET AL. 2007). Regarding temperate regions in Europe and North America, the plant stresses caused by weather extremes could raise the spectrum of widespread mycotoxin contamination. Fungi have optimum temperature ranges within which they can infect agricultural crops more severely. Increasing average temperatures could lead to changes in the range of latitudes at which certain fungi are able to grow and infect plants. The growth of several mycotoxin producing fungi and the production of mycotoxins including aflatoxins, ochratoxins or fumonisins is favoured by moisture and high temperature (MIRAGLIA ET AL. 2009). In this review, we wish to give a general overview on the potential effects of climate change on the occurrence of mycotoxin producing fungi and their mycotoxins in Central Europe, with special emphasize on the economically most important mycotoxins, aflatoxins.

Aflatoxins

Several papers have dealt with the effects of global warming caused by climate change on the appearance of mycotoxin producing fungi and mycotoxins in agricultural products (COTTY AND JAIME-GARCIA, 2007, TIRADO ET AL. 2010, MIRAGLIA ET AL. 2009). All these studies emphasize that aflatoxin producing fungi and consequently aflatoxins are specifically expected to become more prevalent with climate change. Indeed, in 2003, prolonged hot and dry weather caused an outbreak of *A. flavus* contamination of maize in Northern Italy, with consequent problems of aflatoxin contamination that had previously been uncommon in Europe (GIORNI ET AL. 2007). Several other recent reports have indicated the occurrence of aflatoxin producing fungi and consequently aflatoxin contamination in agricultural commodities in several European countries that did not face with this problem before. In western Romania, CURTUI ET AL. (1998) found that all the examined maize samples were free from aflatoxins in 1997. However, more recently, TABUC ET AL. (2009) have found that about 30% of maize samples collected between 2002 and 2004 in southeastern Romania were contaminated with aflatoxin B_1 (AFB_1), and in 20% of these samples the level of toxin exceeded the European Union limit of 5 µg/kg. In Serbia, JAKIC-DIMIC ET AL. (2009) could isolate *A. flavus* from 18.7% of the maize samples analyzed, and aflatoxins were also detected in 18.3% of the samples, while JAKSIC ET AL. (2011) detected aflatoxins in 41.2% of the analyzed maize samples in the range of 2-7 µg/kg. POLOVINSKI-HORVATOVIC ET AL. (2009) detected aflatoxin M_1 in 30.4% of milk samples collected from small farms in Serbia in amounts exceeding the allowable legislation of the European Union. Similarly, TORKAR AND VENGUST (2007) detected aflatoxin M_1 above the EU limit in 10% of the examined milk samples in Slovenia. HALT (1994) detected aflatoxins in 9.4% of Croatian flour samples, and could isolate *A. flavus* from 38% of the flour samples in 2004 (HALT ET AL. 2004). Although HABERLE (1988) could not detect aflatoxins in Croatian milk samples, BILANDZIC ET AL. (2010) and MARKOV ET AL. (2010) could detect aflatoxin M_1 above the EU limit in some milk samples collected in Croatia. Regarding Hungary, RICHARD ET AL. (1992) examined the mycotoxin producing abilities of 22 isolates collected from various sources in Hungary, and none of the isolates were found to produce aflatoxins. However, more recently, BORBÉLY ET AL. (2010) have examined mycotoxin levels in cereal samples and mixed feed samples collected in eastern Hungary, and detected AFB_1 levels above the EU limit in 4.8% of the samples. DOBOLYI ET AL. (2011) identified aflatoxin producing *A. flavus* isolates in several maize fields in Hungary. Aflatoxin contamination of maize (2003) and milk (2007, 2011, 2012) originating from Hungary, Serbia, Romania and Slovenia have also been detected recently in the frame of the Rapid Alert System for Food and Feed of the European Union (https://webgate.ec.europa.eu/rasff-window/portal/). In recent surveys, *A. flavus* was also identified in various agricultural products including maize, wheat and barley in Hungary (TÓTH ET AL. 2012).

Other *Aspergillus* mycotoxins and their producers

Apart from aflatoxins, *Aspergillus* species are able to produce a range of other mycotoxins including ochratoxins, fumonisins and patulin, which are frequently encountered on cereal products (*Figure 1.*).

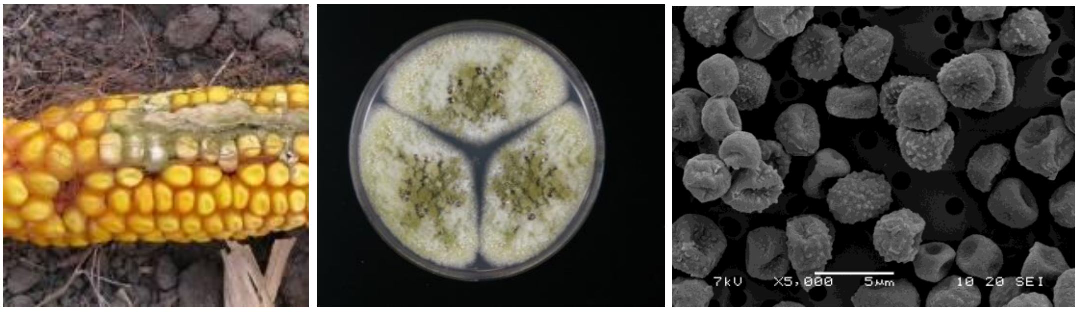

Figure 1. *Aspergillus flavus* infection on a maize cob (left), colony morphology on Czapek-yeast agar (middle), and scanning electron microscopic picture of the conidia (right).

Source: J. VARGA (unpublished)

The contamination of agricultural products by other *Aspergillus* mycotoxins is also influenced by climatic conditions. For example, climate is considered as an important risk factor for the increase of the contamination of wines with OTA. In fact, the occurrence of ochratoxins, as well as that of black Aspergilli, is higher in grapes grown in Southern European regions compared to those of the North. According to a geostatistical analysis performed by BATTILANI ET AL. (2006), an increase of the incidence of black *Aspergilli* on grapes from cooler regions of northern Europe to warmer Mediterranean regions of the south can be seen. This phenomenon is due to the ability of black Aspergilli to grow at higher temperatures than other filamentous fungi potentially present on grapes. Climate change is likely to cause the migration of OTA producing black Aspergilli to regions where these species had not been widely found previously (PATERSON AND LIMA, 2010). Indeed, ochratoxin producing black Aspergilli have been identified in Hungary, and low levels of ochratoxin contamination was observed in some of the Hungarian wines tested recently (VARGA ET AL. 2005, 2007). Ochratoxin producing black Aspergilli have also been identified recently in onions and red pepper harvested in Hungary (FAZEKAS ET AL. 2005, VARGA ET AL. 2012). These observations strongly indicate that climate change does affect the distribution of thermotolerant Aspergilli and their mycotoxins, leading to the migration of aflatoxin- and ochratoxin producing Aspergilli to areas with temperate climatic conditions.

The occurrence of *Aspergillus, Penicillium* and *Fusarium* species and their mycotoxins on maize was investigated in Hungary after harvest in two consecutive years (TÓTH ET AL. 2012). Surface-sterilized cereal seeds were placed on selective media, and the isolated fungal strains were identified using morphological methods. In 2010 and 2011, 81.94% and 14.33% of the samples were found to be contaminated with potentially toxigenic isolates (*Table 1.*). The species identification of selected isolates was carried out using sequence-based methods. Besides *A. flavus* isolates, several other mycotoxin producing species were also isolated, including black *Aspergilli*, which potentially produce ochratoxins and fumonisins, and *A. clavatus*, which produces patulin. In 2010 a large number of *Penicillium* species occurred in the samples, possibly due to the colder weather conditions. Penicillia are able to produce a wide range of mycotoxins, including e.g. ochratoxins or patulin. The mycotoxin content of the samples was also analysed using the ELISA and HPLC techniques. Aflatoxins were not detected in any of the samples, while ochratoxins and fumonisins were successfully identified in some of the maize seeds.

Table 1. Average contamination of maize grains by fungi in 2010-2012 in Hungary
(modified after TÓTH ET AL. 2012)

Year	**Fungal infection of grains (%)**	***Aspergillus* sp.**	***Penicillium* sp.**	***Fusarium* sp.**
2010	81.94	2.02	27.56	70.30
2011	14.33	8.27	0.00	60.25
2012	9.16	15.91	7.95	68.18

Effect of climatic conditions on the occurrence of Fusaria and their mycotoxins

Fusarium species are among the most important mycotoxin producing pathogens of maize worldwide. These species are important pests of cereals, and contaminate grains with various mycotoxins including trichothecenes, zearalenone and fumonisins. The most important fungal pathogens of cereals are *F. graminearum, F. culmorum* and *F.*

verticillioides. Regarding maize, MESTERHÁZY AND VOJTOVICS (1977) examined the mycobiota of infected maize kernel between 1972-1975, and found that the predominant *Fusarium* species were *F. graminearum* and *F. verticillioides*. Recently, we examined the occurrence of *Fusarium* species and their mycotoxins in 6-6 maize hybrids collected from two maize fields in 2010-2011, and compared the obtained data with those recorded 35 years ago (MESTERHÁZY AND VOJTOVICS 1977). The species distribution of Fusaria was slightly different from that observed 35 years ago: in 2010, when the weather was rainy, *F. graminearum* and *F. subglutinans* dominated, while in 2011 with hot and dry summer *F. verticillioides* was the predominant species identified. *F. culmorum* could not be detected in any of the samples, in contrast with the results of the 1977 survey. *F. graminearum* favors higher temperatures than *F. culmorum* and the observed shift might be due to the different weather conditions and climate change. Differences could not be observed in the species distribution of Fusaria in different locations.

Fumonisin and DON content of the maize samples was also analyzed using HPLC-MS. All samples were contaminated by these toxins under the EU limit (data not shown).

CONCLUSIONS

There is overwhelming evidence in the scientific literature that climate change is in progress. Global warming and other effects of climate change may strongly influence the occurrence and distribution of mycotoxin producing fungi and mycotoxins in agricultural products in regions with temperate climate, including Central Europe. In this review several examples have been presented to support the role of climate change in the occurrence of *Aspergillus flavus*, other Aspergilli, *Fusarium* species and their mycotoxins in Central Europe. These observations strongly indicate that climate change does affect the distribution of thermotolerant species and their mycotoxins, leading to the migration of these species to areas with temperate climatic conditions, and the occurrence of their mycotoxins in years with warmer climates. Further studies are needed to clarify the possible consequences of further global warming on these fungi.

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STUDIES CONCERNING THE YIELD/M^2 OF SOME PAPRIKA PEPPER VARIETIES CULTIVATED IN SOLARIUM

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ABSTRACT

History of pepper culture begins with 3000 – 4000 years ago, in Peru, in the ancient Inca Empire. The fruits of bell/chilli pepper are consumed at technical or physiological maturity, fresh or processed. Some varieties with small, sharp and erect fruits are used as ornamental plants. In Europe, the main producing countries are Spain, Italy, Hungary, Romania and Serbia.

In Romania, pepper was cultivated from the 19th century. The first fruits were set up around Timisoara (Cenadul Mare, Tomnatic, Lovrin), around year 1923.

The experiment developed during the year 2011, at the Didactic and Research Base of the Faculty of Horticulture and Forestry, from B.U.A.S.V.M. Timisoara.

The biological material used in the trials was represented by 5 cultivars (hybrids and lines): Délibáb F_1, Sláger F_1, Bolero F_1, SJD 5 and SJN 5. The experience was set up according to the monofactorial method with randomised blocks and four replicates.

Hybrid Délibáb obtained the highest yield for the planting scheme 80/40x20 cm, with yield increases between 18% from Bolero and 38% from SJN 5. The yield/m^2, registered a gradual decrease by reducing the plant density per row from 20 to 30, 40, 50 cm, to all five genotypes.

Keywords: paprika (*Capsicum annuum* L.), culture in solarium, yield/m^2, planting scheme

INTRODUCTION

Over the time, in the weather conditions of the Carpathian region, the cultivation of paprika spread, providing livelihood for many householders generations (MARKUS & KAPITANY, 2001).

In Romania, paprika was introduced in the 19th century by Bulgarian vegetable growers. The first paprika fruits (*Capsicum annuum* L.) were grown around Timisoara (Cenadul Mare, Tomnatic, Lovrin), around year 1923.

The importance of pepper culture lies in the nutritional value of the fruits, through the high content in vitamin C (150-300 mg/100 g) and carotenoids (1,8-4,5 mg/100 g), also the vitamins B_1, B_2 and P (INDREA ET. AL., 2009).

Regarding the content in vitamin C, pepper occupies first place between the cultivated vegetables. The high content in vitamin C was demonstrated at the early 1930, by doctor and biochemist Szent-Györgyi Albert, which after analysis performed to the paprika, discovers ascorbic acid. He mentions that paprika pepper has the highest content in C vitamin at the end of ripening (MARKUS & KAPITANY, 2001).

Paprika powder is used in seasoning and colouring different meat products. It is used in big quantities for colouring and seasoning different products, in the canning industry (BALÁZS, 1994).