Climate Change and Mycotoxin Contamination: *impact and trends*

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❑Presentation Framework

1. Introduction/ Background on Climate Change (CC)

2. Climate Change and Mycotoxin Contamination of Foods: trends and impacts

3. Conclusions

1. Introduction/ Background on Climate Change (CC)

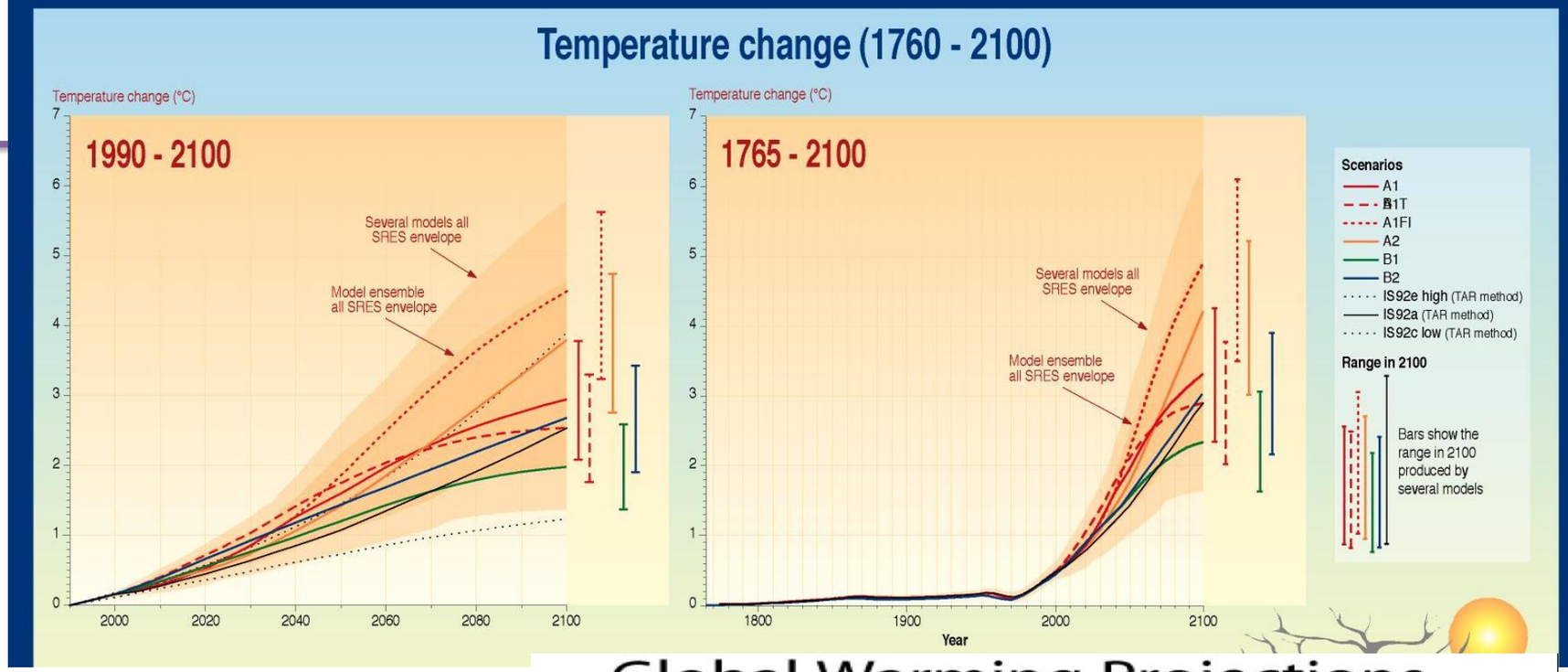
- Weather vs Climate

- Global warming & temperature rise are due to human activities.

- Given current trends, temperature extremes, heat waves, and heavy rain frequencies will be on rise.

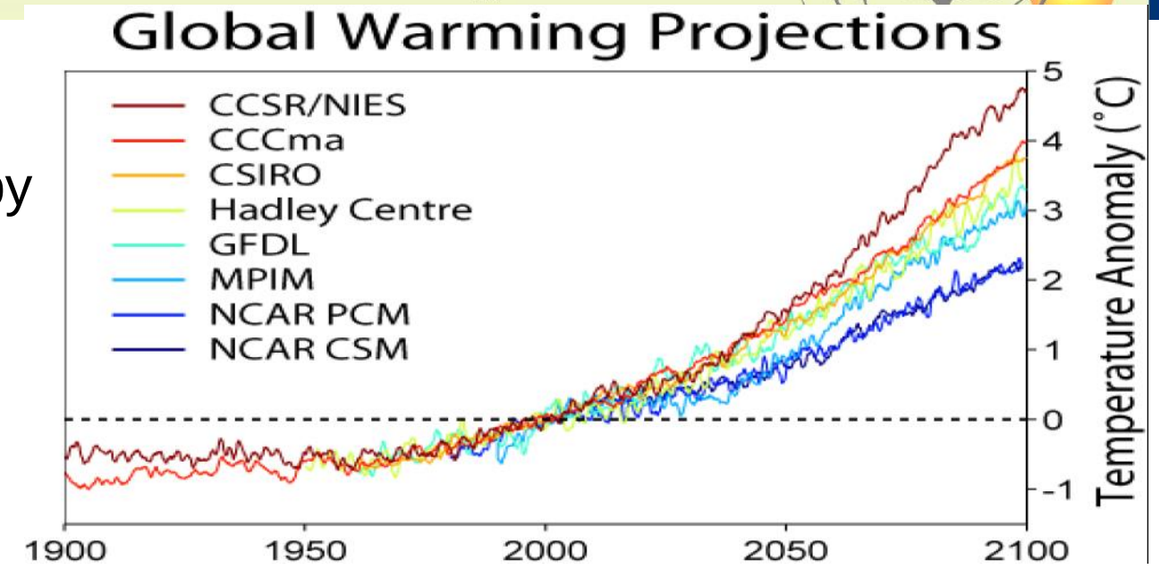
- The earth's temperature and seas will continue to rise into the next millennium.

- A double or triple atmospheric CO_2 concentration change from 350 to 700 or 900-1000 ppm is expected (IPCC, 2007).



IPCC (2014) report predicts global temperatures increase by up to 4.8°C by the year 2100.

■Predicted change in temperature/Climate (IPCC, 2007; 2014)



1. Introduction/ Background on Climate Change (CC)

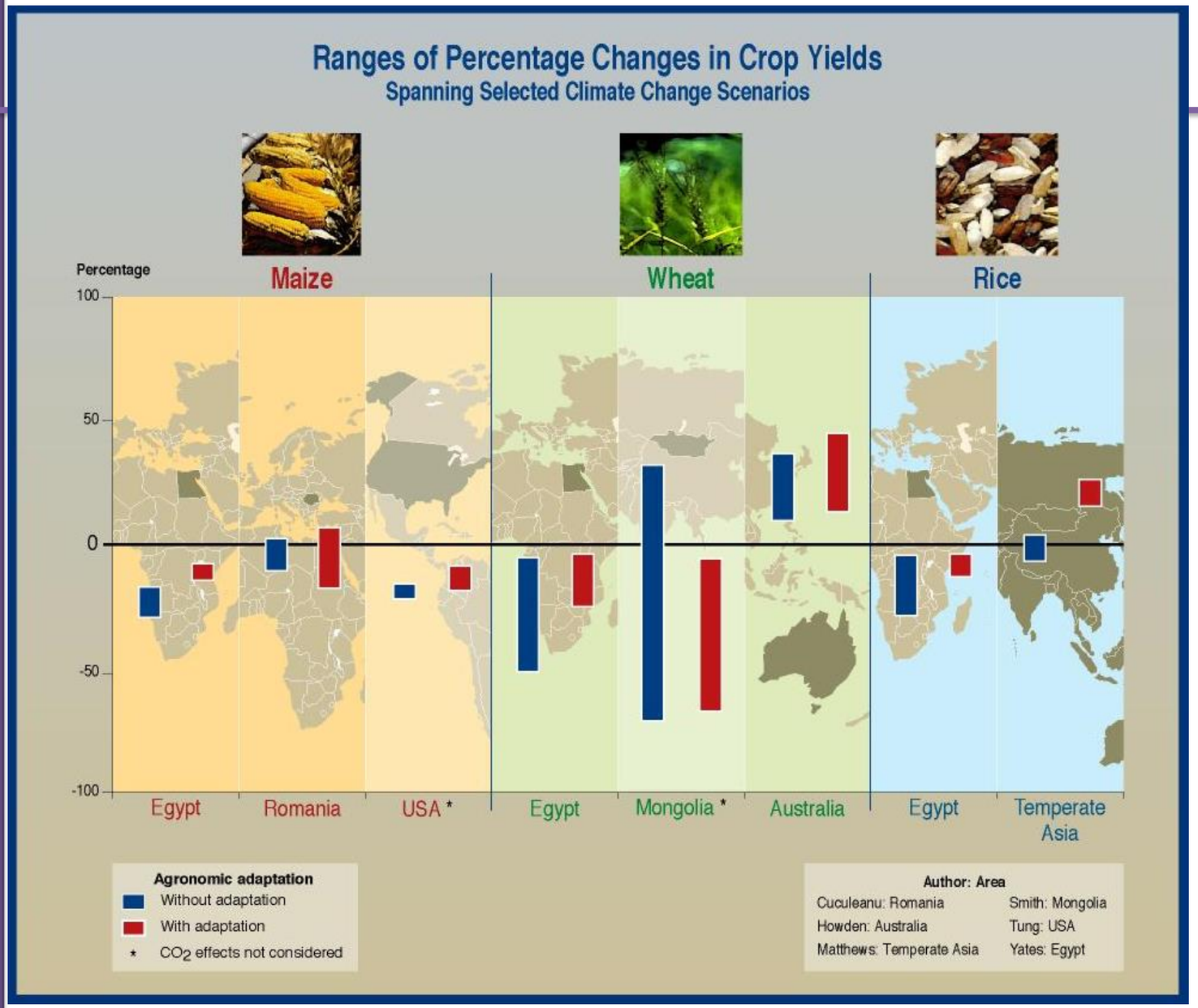
Agriculture/Food security *vis-a-vis* population growth!

- World's population will reach 9 billion by 2050.
- FAO estimates that agricultural production will increase by 60% by 2050. Human practices in this regard will impact CC.
- Climate change adds extra challenges in reaching this goal – esp. developing countries where food insecurity & poverty are prevalent.

1. Introduction/ Background on Climate Change (CC)

e.g, due to CC, there will be negative effects on agriculture including:

- Decrease in food production, loss of soil fertility through erosion of top soil, changes in soil moisture and temperature, heat stress on plants, etc.
- Reduced crop yields (in hot areas, and vice versa in cold areas) from rain-fed agriculture by up to 50% in many countries (Cline, 2007).
- Reduced productivity and increased production cost of livestock (reduced feed and fodder availability).
- Increased food insecurity and poverty.



- Projected changes in crop yields due CC (IPCC, 2007)

2. Climate Change and Mycotoxin Contamination of Foods: impact

Environmental & Biological factors

+ water activity (a_w)

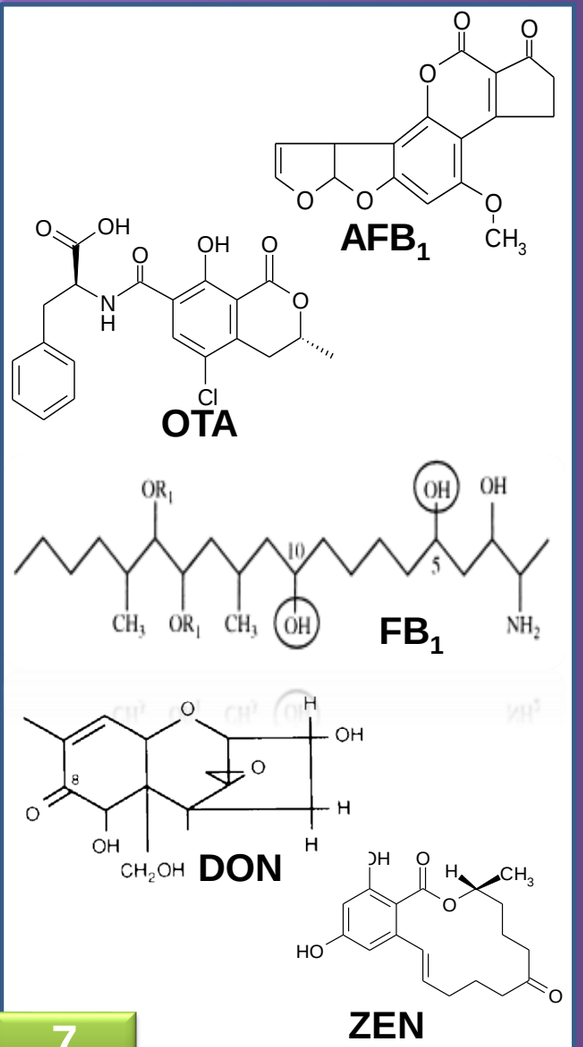
+ temperature (T^o)

+ pH

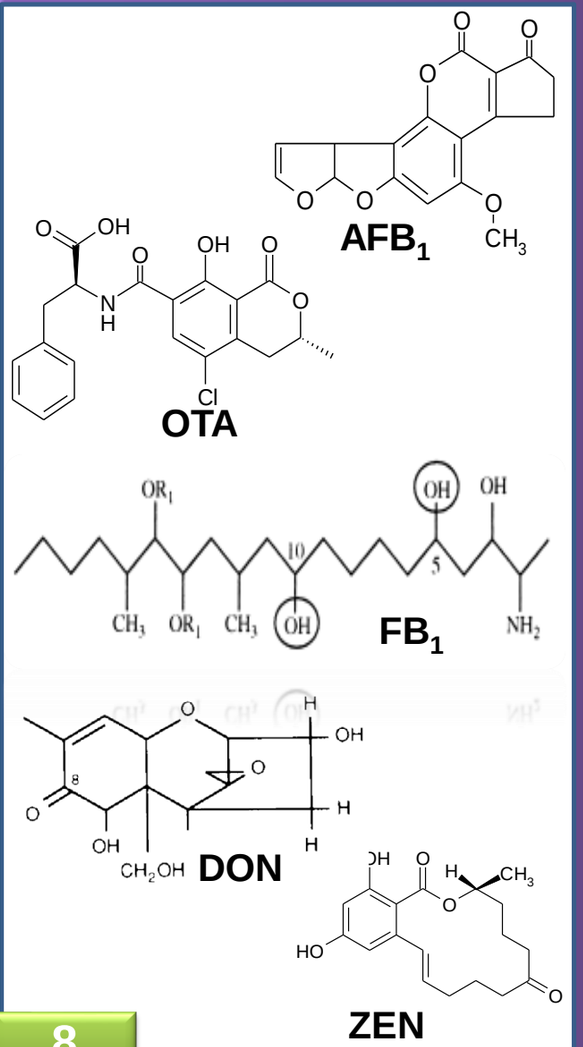
+ competition

+ nutrient availability

Toxigenic fungi often contaminate agricultural commodities and under favourable conditions (e.g., temperature, moisture), they produce mycotoxins



2. Climate Change and Mycotoxin Contamination of Foods: impact



- a_w x T^o stimulates toxin biosynthetic gene expression in different mycotoxigenic fungi (Schmidt-Heydt et al., 2008)

- CC interacting with a_w x T^o affects the relative expression of genes in the biosynthetic pathway of AFB_1 production (Abdel-Hadi et al., 2012).

- The 3-way CC interacting factors (a_w, T^o and CO_2) increased the relative expression of genes in the AF production biosynthetic pathway resulting in increased phenotypic AFB_1 production (Medina et al., 2014)

frontiers in
MICROBIOLOGY

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Effect of climate change on *Aspergillus flavus* and aflatoxin B_1 production

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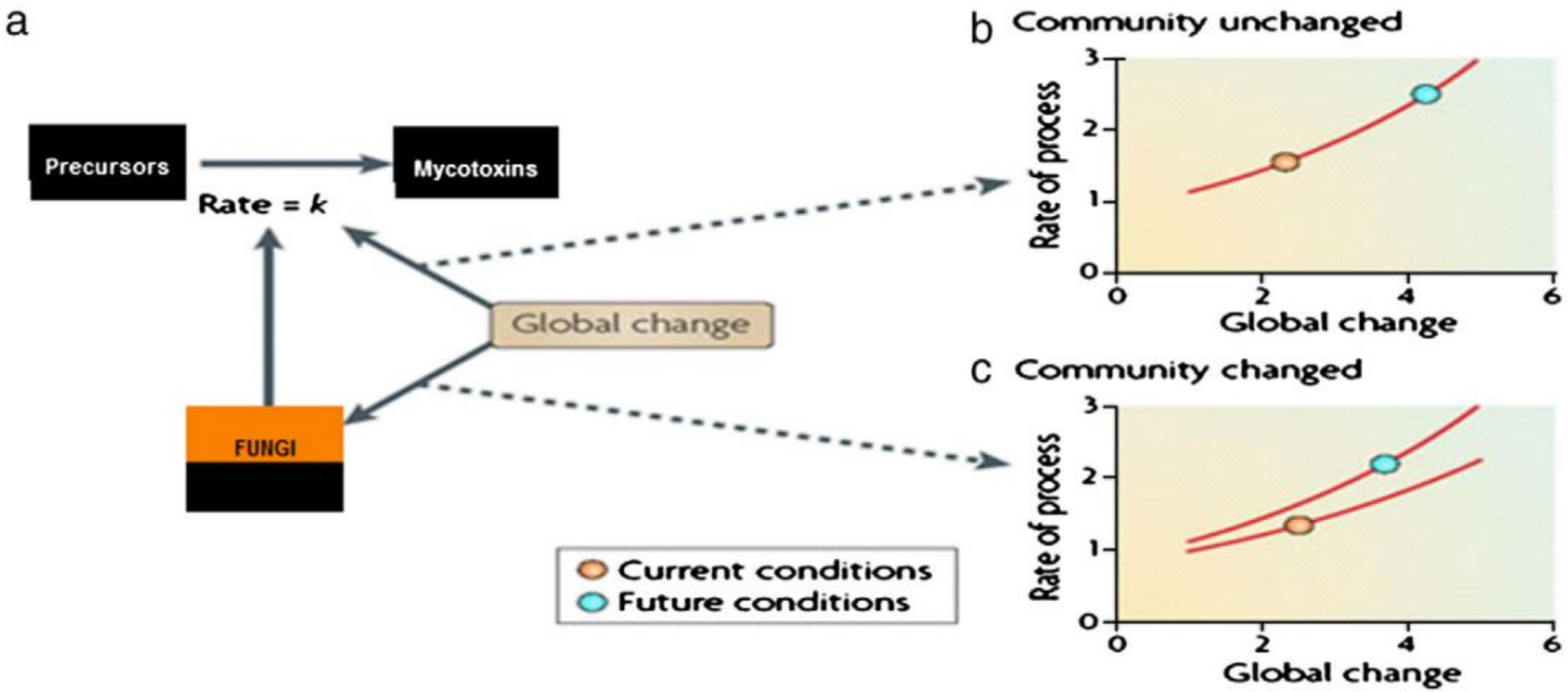
This review considers the available information on the potential impact of key environmental factors and their interactions on the molecular ecology, growth and aflatoxin production by *Aspergillus flavus in vitro* and in maize grain. The recent studies which have been carried out to examine the impact of water activity × temperature on aflatoxin biosynthesis and phenotypic aflatoxin production are examined. These have shown that there is a direct relationship between the relative expression of key regulatory and structural genes under different environmental conditions which correlate directly with aflatoxin B1 production. A model has been developed to integrate the relative expression of 10 biosynthetic genes in the pathway, growth and aflatoxin B_1 (AFB_1) production which was validated under elevated temperature and water stress conditions. The effect of interacting conditions of a_w × temperature × elevated CO_2 (2 × and 3 × existing levels) are detailed for the first time. This suggests that while such interacting environmental conditions have little effect on growth they do have a significant impact on aflatoxin biosynthetic gene expression (structural *aflD* and regulatory *aflR* genes) and can significantly stimulate the production of AFB_1. While the individual factors alone have an impact, it is the combined effect of these three abiotic factors which have an impact on mycotoxin production. This approach provides data which is necessary to help predict the real impacts of climate change on mycotoxigenic fungi.

Keywords: climate change factors, water activity, temperature, elevated CO_2, growth, gene expression, aflatoxin

2. Climate Change and Mycotoxin Contamination of Foods: impact



- Effects of CC on mycotoxin production (Paterson & Lima, 2011)

❑Examples of CC-Mycotoxin reports in PR journals

Food Research International 44 (2011) 2555–2566

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Review

Further mycotoxin effects from climate change

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ABSTRACT

Climate change will affect mycotoxins in food. The 2007 Intergovernmental Panel on Climate Change report is reinterpreted herein to account for what may occur with mycotoxins. Warmer weather, heat waves, greater precipitation and drought will have various impacts, depending on which regions of the world and mycotoxin systems are considered. The humidity issues are more complex as some areas will experience drought and others greater precipitation: *in vivo* data on the effects of moisture on mycotoxins in crops are more ambiguous than those for temperature. *In vitro* data on fungal growth and mycotoxin production may not relate directly to the situation in the field or post harvest, but are useful for base-line assumptions. The effects of climate in various regions of the world, i.e. Africa, Europe, Asia, Latin America and North America are considered in terms of mycotoxin contamination. Crops introduced to exploit altered climate may be subject to fewer mycotoxin producing fungi (the "Parasites Lost" phenomenon). Increased mycotoxins and UV radiation may cause fungi to mutate on crops and produce different mycotoxins. Whereas there is relevant information on aflatoxins, deoxynivalenol, and ochratoxin A, more mycotoxins require to be considered: Data on patulin are missing. The current paper considers uniquely ergot alkaloids. Amelioration strategies are provided. There is considerable urgency in the need to address these issues.

2. Climate Change and Mycotoxin Contamination of Foods: trends - e.g., AF in maize (Battilani et al., 2016)

	Average_present	Average_+2 °C	Average_+5 °C
Maize			
Mean (*Median*)*	38.20 (0.00)	73.25 (1.23)	95.09 (108.49)
Conf. interval§	35.54–40.92	69.63–76.82	92.18–98.06
Range	(0.00–225.18)	(0.00–235.01)	(0.00–221.54)
St. dev. Mean#	9.404	14.998	25.297
Max St. dev. Site+	44.821	69.987	57.176
Wheat			
Mean (*Median*)*	0.67 (0.20)	1.08 (0.32)	1.44 (0.68)
Conf. interval§	0.63–0.72	1.01–1.14	1.36–1.52
Range	(0.00–7.01)	(0.00–9.60)	(0.00–18.39)
St. dev. Mean#	0.753	1.229	1.667
Max St. dev. Site+	10.305	15.412	17.817

Summary statistics for estimated aflatoxin risk index (AFI) values in maize and wheat in Europe for 100 years, in the present, +2 °C and +5 °C climate change scenarios (copied from Battilani et al., 2016).

2. Climate Change and Mycotoxin Contamination of Foods: trends

SCIENTIFIC REPORTS

OPEN

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Aflatoxin B_1 contamination in maize in Europe increases due to climate change

P. Battilani[1], P. Toscano[2], H. J. Van der Fels-Klerx[3], A. Moretti[4], M. Camardo Leggieri[1], C. Brera[5], A. Rortais[6], T. Goumperis[6] & T. Robinson[6]

Climate change has been reported as a driver for emerging food and feed safety issues worldwide and its expected impact on the presence of mycotoxins in food and feed is of great concern. Aflatoxins have the highest acute and chronic toxicity of all mycotoxins; hence, the maximal concentration in agricultural food and feed products and their commodities is regulated worldwide. The possible change in patterns of aflatoxin occurrence in crops due to climate change is a matter of concern that may require anticipatory actions. The aim of this study was to predict aflatoxin contamination in maize and wheat crops, within the next 100 years, under a +2 °C and +5 °C climate change scenario, applying a modelling approach. Europe was virtually covered by a net, 50 × 50 km grids, identifying 2254 meshes with a central point each. Climate data were generated for each point, linked to predictive models and predictions were run consequently. Aflatoxin B_1 is predicted to become a food safety issue in maize in Europe, especially in the +2 °C scenario, the most probable scenario of climate change expected for the next years. These results represent a supporting tool to reinforce aflatoxin management and to prevent human and animal exposure.

2. Climate Change and Mycotoxin Contamination of Foods: trends

- Impact of climate change on agriculture and food security has been extensively investigated and discussed at almost all relevant high level meetings worldwide. However, limited attention has been paid to food safety from mycotoxin perspective, requiring urgent attention.

- Presumably/partly for this reason, in 2009, the European Food Safety Authority (EFSA) launched a project to predict how climate change could increase the amount of AFB_1 in cereals (Guy Montague-Jones, 15-Jul-2009).

- Today, more investigations into the impact of CC on mycotoxin production is being conducted, although more is needed to convince policy makers and get their attention to further protect populations from CC-provoked mycotoxicosis.

2. Climate Change and Mycotoxin Contamination of Foods: trends

THE CITIZEN

29 JULY 2016

Tanzania: Food Poisoning Linked to 14 Deaths in Two Regions

Tagged: Food and Agriculture • East Africa • Health • Tanzania

Photo: Daily News

Aflatoxins are toxic, carcinogenic by-products of fungi that colonise maize and groundnuts, among other crops (file photo).

By Syriacus Buguzi

Dar es Salaam — Results of laboratory tests conducted on blood and urine samples of people who died or fell ill after eating food believed to have been contaminated in Dodoma and Manyara regions have revealed shocking levels of aflatoxins, The Citizen can report.

The US-based Centre for Disease Control (CDC), which carried out the tests on 19 urine and blood samples, has also isolated the most poisonous and cancer-causing substance known as Aflatoxin B1. Medical sources say this type of aflatoxin damages the liver.

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East Africa »

- East Africa: East African Countries Create Fund to Support Dr. Tedros's WHO Bid
- Kenya: 'Govt Failed to Cooperate With Hague Court'

❑Examples of CC-Mycotoxin reports in PR journals

Climate change and mycotoxin prevalence
Broadening Horizons N°8, May 2014
*By Paula Kovalsky**

Climate change and its impact on fungal profile
The Intergovernmental Panel on Climate Change (IPCC) report of 2014 shows different global trends

❑Conclusion

- CC affects agricultural productivity with negative impact on crop yields.

- More attention is needed to mitigate effects of CC on agriculture, food security and food safety (e.g., from mycotoxin production perspective).

- Evaluation of impact of CC on mycotoxin production requires several years of monitoring of T^o, rainfall and mycotoxin profiles in staples.

- Impact of CC on mycotoxin contamination of foods is influenced by the 3-way CC interacting factors of $a_w \times T^o \times CO_2$