Effect of Climate Change on Mycotoxins Produced by Plant Pathogens Affecting Our Field Crops

Wheat heads infected by the Fusarium pathogen. The infected seed will contain mycotoxins.
(credit: D. Fernando)

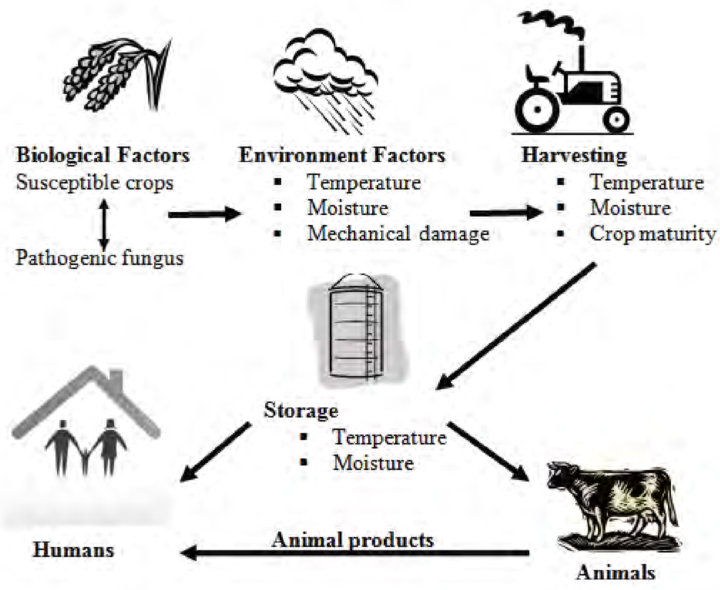
What's going on?

Mycotoxins are low molecular weight toxic compounds produced by filamentous fungi, which contaminate food and feeds. The mycotoxins of greatest concern in North America are deoxynivalenol (DON), aflatoxins, and fumonisins. These mycotoxins cause adverse effects to human and animal health. Severe health problems and deaths have been reported due to mycotoxin consumption, so government regulations have been set to control the maximum limits of mycotoxins in food and feed[1]. Production of mycotoxins on crops depends on climatic factors such as temperature and relative humidity so a changing climate has a direct impact on mycotoxin production.

What's coming up?

Although it is predicted that a warmer climate can increase global food production in currently cooler regions, this will affect the biological environment of crops such as the abundance of pests and plant pathogens[2]. This may have a greater impact on plant–pathogen interactions because most plant pathogens have optimum temperatures for their growth and mycotoxin production. Mycotoxins are among the major foodborne risks that are most susceptible to

Dilantha Fernando, Ph.D., P.Ag., is a Professor in Plant Science at the University of Manitoba specializing in canola and wheat pathology.



Factors affecting the mycotoxin production in the food chain (Adapted from CAST[10]).

Table 1: *Optimal temperature (°C) for mycotoxin production and in vitro growth of important plant pathogens (Adapted from Paterson & Lima[8]).*

Fungus species	Type of mycotoxins	Optimum temperature for mycotoxin production	Optimum temperature for *in vitro* growth
Alternaria alternata	Alternaria toxins	25	23
Aspergillus flavus	Aflatoxins	33	35
Fusarium verticilliodes	Fumonisins	15-30	30
Fusarium graminearum	Deoxynivalenol	30	20-22
Fusarium culmorum	Deoxynivalenol	26	20-25
Penicillium verrucosum	Ochratoxin A	25	26
Claviceps sp.	Ergot alkaloids	23-26	30

climatic change. The ability of fungi to produce mycotoxins is largely influenced by temperature, relative humidity, insect attack, and stress conditions in the plants[3]. Additionally, Miller[4] has reported that more extreme rainfall and drought events would favour formation of DON and fumonisin, respectively. Therefore changes in global temperature would directly affect their growth and mycotoxin production capacity. Table 1 shows the optimal temperatures for mycotoxin production and growth *in vitro* for some important plant pathogenic fungi.

Global warming will not only act on pathosystems already present in certain regions, but will facilitate the emergence of new diseases and new pathogens because the changes in climatic factors can modify the present behaviour of pathogens and enhance the development of new mechanisms to fit into the new environment. This would ultimately result in emergence of new strains with (possibly) mycotoxins with novel characteristics.

Why does it matter?

Fusarium head blight (FHB), caused mainly by *Fusarium graminearum*, is one of the most destructive global diseases of small cereal grains worldwide. Severe epidemic outbreaks of FHB have been reported in North America, South America, Asia and Europe. While Manitoba is the 'hot bed' for FHB disease in Canada, climate change could cause all prairie provinces to be affected heavily with the disease and mycotoxin spread. The most devastating effect of this disease is the deposition of mycotoxins in the grain. Deoxynivalenol (DON) and its analogs 3-ADON, 15-ADON and NIV are the major mycotoxins produced by the fungus. Studies have been conducted on the effects of weather, crop and pathogen-related factors on the accumulation of DON in wheat grain. Results from these studies have been effectively used in developing DON–prediction models such as DONcast. Temperature plays an important role in the entire disease cycle of FHB, from infection of wheat heads to production and dispersal of inoculum, so a slight change in temperature may influence FHB disease incidence and severity. The role of climate change in a population shift of chemotypes has been observed in North America. The chemotype distribution across Canada showed an interesting longitudinal cline in which the frequency of 3-ADON producers gradually increased in each province when moving from East to West[5]. In western Canada, the percentage of 3-ADON is highest in Manitoba, where nearly half of the isolates studied were 3-ADON. Studies of FHB pathogen diversity revealed that 3-ADON producing *F. graminearum* are now widely prevalent in North America and there has been a significant population shift in FHB pathogen composition towards 3-ADON producers[5,6]. Between 1998 and 2004 the frequency of 3-ADON producers in western Canada has increased more than 14-fold, suggesting that they have a selective advantage over the native 15-ADON chemotypes.

> *"Mycotoxins are among the major foodborne risks that are most susceptible to climatic change"*

High temperatures and drought stress can increase the risk of aflatoxin contamination in the Maize-*Aspergillus flavus* pathosystem. High temperatures and dry conditions favour growth, conidiation, and dispersal of *A. flavus* and reduce growth and development of maize. Crops grown in warm climates have greater likelihood of infection by aflatoxin producers compared to other regions due to the thermotolerant capability of *A. flavus*[7,8]. Aflatoxin-producing fungi are native to tropical, warm, arid, and semi-arid regions: changes in climate result in large alterations in the quantity of aflatoxin producing fungi and could possibly spread to other regions growing maize[9].

In conclusion, climate change will add new challenges related to the dynamics of pathosystems and Prairie food production. We will need to continuously monitor the changes in climate and mycotoxin profiles, and to provide solutions to adapt to these changes.