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The Impact of Environmental Conditions and Crop Practices on the Contamination of Emerging Mycotoxins in Cereals

Massimo Blandino[1], Valentina Scarpino[1], Francesca Vanara[1], Michael Sulyok[2], Amedeo Reyneri[1]

[1]Dep. di Scienze Agrarie, Forestali e Alimentari, Univ. Torino, IT, massimo.blandino@unito.it
[2]Dep. for Agrobiotechnology (IFA-Tulln), Univ. Natural Resources and Life Sciences, Vienna (BOKU), AT

Introduction

Mycotoxins are natural contaminants, toxic to humans and animals, that frequently occurred in cereal chains in temperate areas. Five mycotoxin classes are considered to be largely economically and toxicologically important in grain in several areas throughout the world: aflatoxins and ochratoxins, deoxynivalenol (DON), zearalenone (ZEA) and fumonisins (FBs) (Atkins and Norman 1998).
Although the previously reported are the most common mycotoxins found in cereal grain in temperate areas, they are only one group of the approximately 400 mycotoxins known to date (Berthiller et al., 2013). These other mycotoxins, which have not yet received a detailed scientific attention, are commonly indicated as “novel” or “emerging” (Streit et al., 2013). The European Food Safety Authority (EFSA) is currently working on establishing a scientific opinion on the risks to public health related to the presence of emerging mycotoxins in feeds and food. Moreover, there is also a greater interest in individuating the field conditions that could lead to a higher contamination of these emerging mycotoxins. Better knowledge of the conditions that promote their occurrence is essential in order to set up a more inclusive Good Agricultural Practices (GAP) to minimize also their occurrence. The aim of this study was to investigate the role of different agricultural practices on the contamination of novel or emerging mycotoxins in common and durum wheat and maize.

Methods

A monitoring was carried out on maize from 4 Regions (Piedmont, Lombardy, Emilia-Romagna and Veneto) during the period 2012-2013 and on wheat in Piedmont in the 2011-2015 period. In addition, a series of field experiments have been conducted in North West Italy, over a period of 8 growing seasons (2008-2015), in order to evaluate the effect of different crop practices on the contamination of emerging mycotoxins in common and durum wheat and in maize grains. All the experiment have been carried out under naturally-infected conditions and the following agricultural practices have been considered: varietiy susceptibility, tillage, fungicide application for wheat; tillage, planting time and density, N fertilization, insect control for maize. Detection and quantification of mycotoxins was performed through a multi-mycotoxin method able to detected more than 300 different molecules (Malachova et al., 2014).

Results

Applying the multi-toxin method 25 of the most abundant mycotoxins were detected in maize samples: fumonisin B_1, B_2, B_3, B_4 (FBs), moniliformin (MON), fusaproliferin (FUS), fusaric acid (FA), bikaverin (BIK), beauvericin (BEA), equisetin (EQU), aurofusarin (AUR), deoxynivalenol (DON), deoxynivalenol-3-glucoside (DON-3-G), 3-acetyldeoxynivalenol (3-ADON), 15-acetyldeoxynivalenol (15-ADON), zearalenone (ZEA), zearalenone-4-Sulfate (ZEA-4S), culmorin (CULM), butenolide (BUT) and aflatoxin B_1, B_2, G_1, G_2 (AFs), ochratoxin A (OTA) and B. Moreover, a larger number of different mycotoxins were detected in wheat samples: DON, DON-3-G, 3-ADON, 15-ADON, CULM, ZEA, ZEA-4S, nivalenol, enniatin A, A_1, B, B_1, B_2 (ENNs), EQU, AUR, MON, BIK, BEA, FBs, FA, BUT, toxin T2 and HT2, tentoxin (TENT), decalonectrin, alternariol (AOH), alternariol methyl ether (AME), infectopyrone, secalonic acid and ergot alkaloids (mainly ergocristine, and ergometrine).

The relative percentage of presence of mycotoxins produced by Fusarium section Liseola (FBs, FA, BIK, BEA, MON, FUS) in maize commercial lot samples was 100% (Tab. 1). The occurrence of other mycotoxins was clearly influenced by growing season, with remarkable and hazardous AFs contamination values in 2012. The content of mycotoxins produced by *Fusarium* spp. of Liseola section, such as FBs, MON, FUS, FA, BIK and BEA was significantly reduced by insecticide application to reduced insect ear injuries, while it was increased by N stress and late planting times. Conversely, DON, DON-3-G, ZEA, CULM, AUR and BUT contents, produced by *Fusarium* spp. of Discolor and Roseum sections, were not affected significantly by the presence of insect injuries, while were clearly related to excess of N fertilization, high plant density and no tillage conditions.
The most abundant mycotoxins in wheat samples were DON and CULM, while *Alternaria* and *Claviceps* toxins are less frequent and clearly related to certain environmental and agronomical conditions. By comparing different environmental and agronomic conditions, the use of tolerant cultivars and the fungicide usually applied to control the FHB and DON content, also consistently reduces the main emerging mycotoxins of winter wheat in temperate areas. Minimum or no-tillage results always in a higher contamination of DON, CULM, MON, ENNs, BUT, TENT, AOH and ergot alkaloids, compared to ploughing.

Table 1. Mean mycotoxin contamination in maize commercial samples collected in the 4 Regions of North Italy monitored during the period 2012-2013.

Main fungi producers	**Mycotoxin**	**2012** µg kg^{-1}	**2013** µg kg^{-1}	**Positive samples**[1] %
Fusarium section Liseola	FBs	8997	6151	100
	FA	959	1551	100
	BIK	356	1236	100
	BEA	852	344	100
	MON	294	853	100
	FUS	187	195	100
Fusarium section Gibbosum	EQU	40	55	90
Fusarium section Discolor and Roseum	DON	223	2923	77
	DON-3-G	132	595	95
	CULM	109	2621	78
	ZEA	16	367	80
	BUT	41	383	81
	AUR	161	3929	91
Aspergillus	AFs	31	8	55
Aspergillus, Penicillium	OTA	2	nd	2

[1] Percentage of sample above the limit of quantification considering 94 maize samples collected in 2 growing seasons. nd. not detected.

Conclusions

The results obtained in the current study remark the crucial role of the environmental, but also of the agronomical conditions on the occurrence of novel or emerging mycotoxins. This work contribute to individuate integrated managements strategies for the overall control of mycotoxins in cereals.

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