How can AI help mycotoxin research and management?

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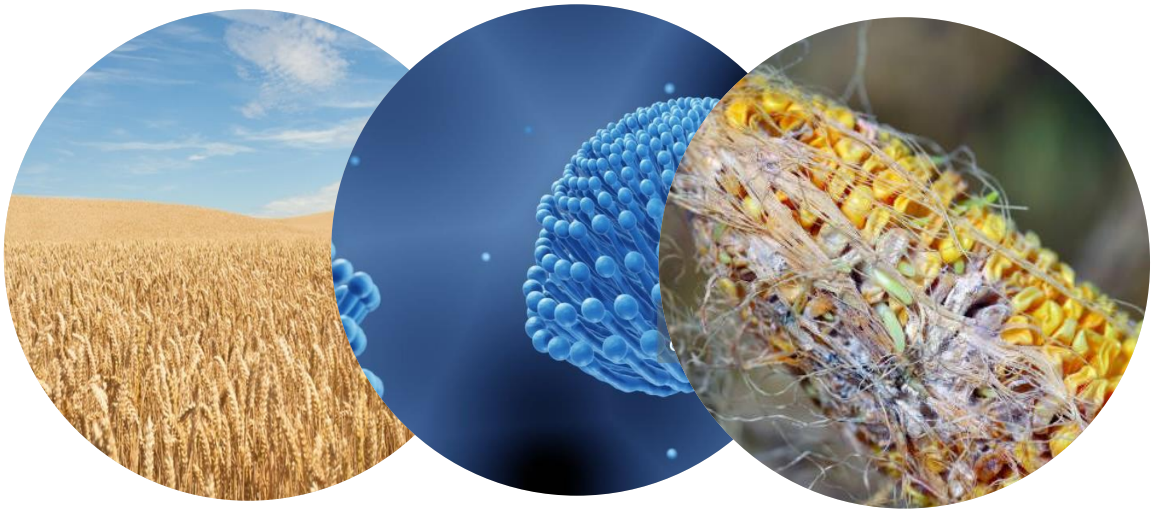
WMF, Wageningen food safety research, April 2025



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Mycotoxins: ongoing problem

More knowledge

Changing environment and conditions

Use of Artificial Intelligence promising

Why using AI?

- Handle high amount of data, High predictive power
- Combining many different data sources
- Learning aspect
- …

But, AI use in mycotoxin research and management still in its infancy

Transforming Mycotoxin Research and Management with AI

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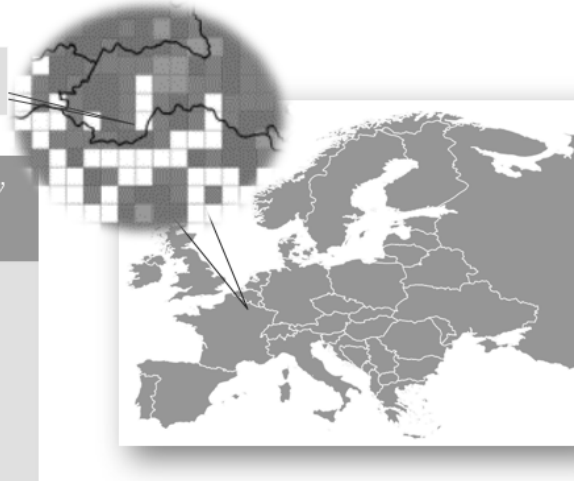
Case 1

AI-Driven Mycotoxin Prediction for Cereals under Climate Change (pre-harvest)

- XGBoost to predict mycotoxin contamination in European wheat at regional level
- Estimate climate change impacts

Data linking at grid level

*Mycotoxin data 25km*25km*	*Weather data (weekly) 25km*25km*	*Crop phenology 25km*25km*
•Type of mycotoxins *•Contamination level*	• *Maxt* • *Mint* • *Meant* • *Sump* • *RH*	• *FD* • *HD*



- Data 2010-2018 split in model training (80%) and internal model validation set (20%)
- Data 2 new years used for external validation.

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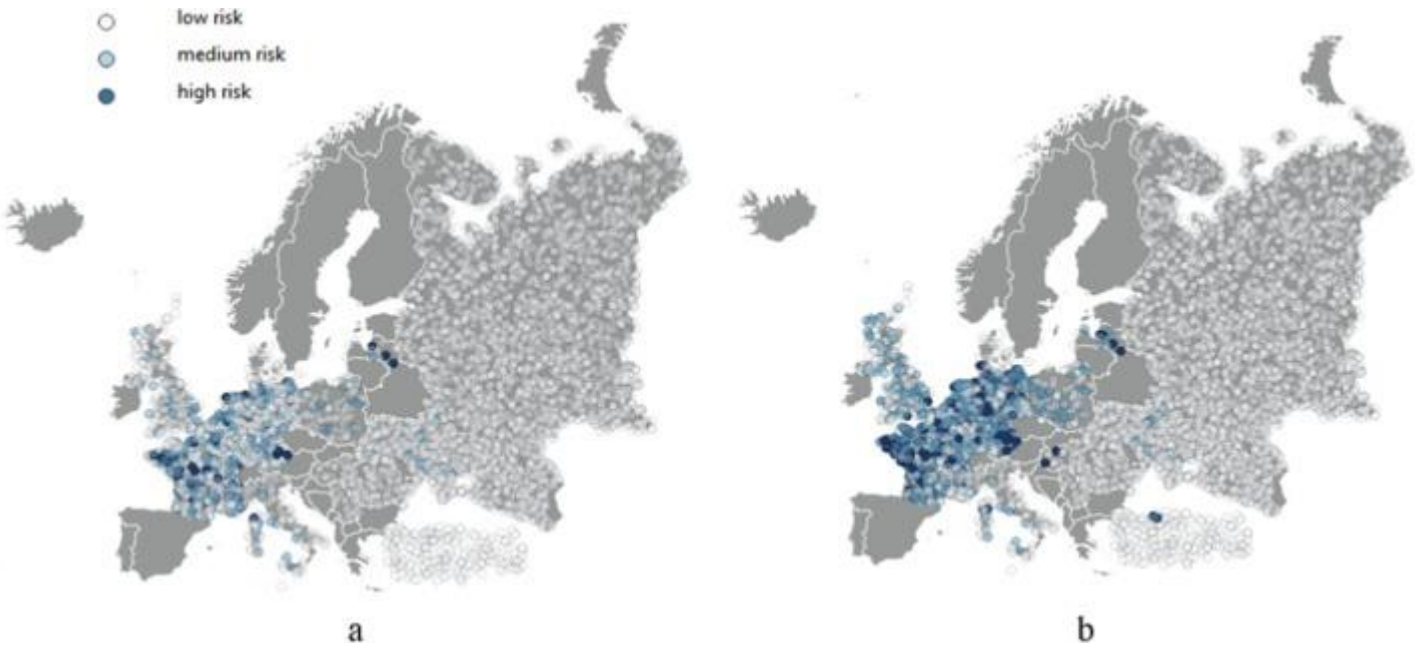
Case 1

AI-Driven Mycotoxin Risk Prediction for Cereals under Climate Change



Predicted (a) vs observed (b) mycotoxin classes

Internal and external validation resulted in > 0.90 in prediction scores

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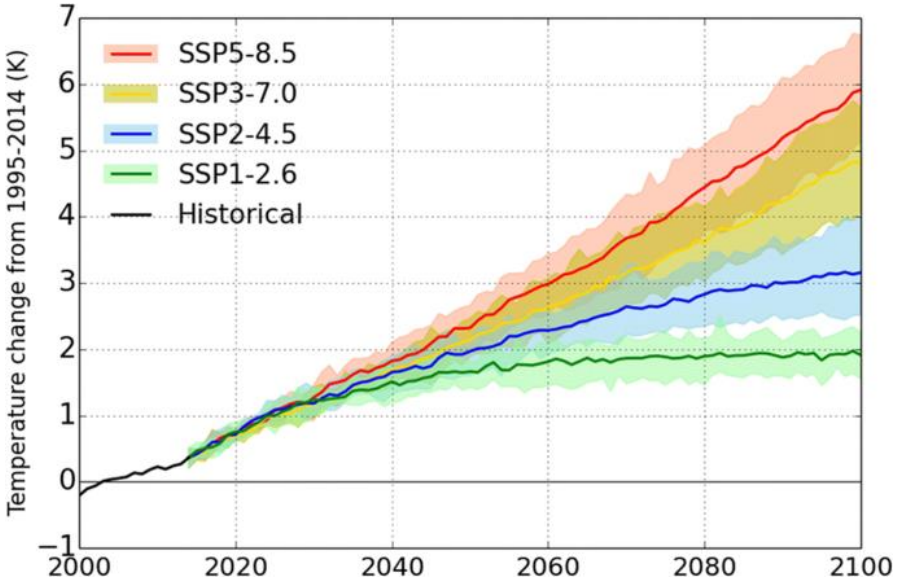
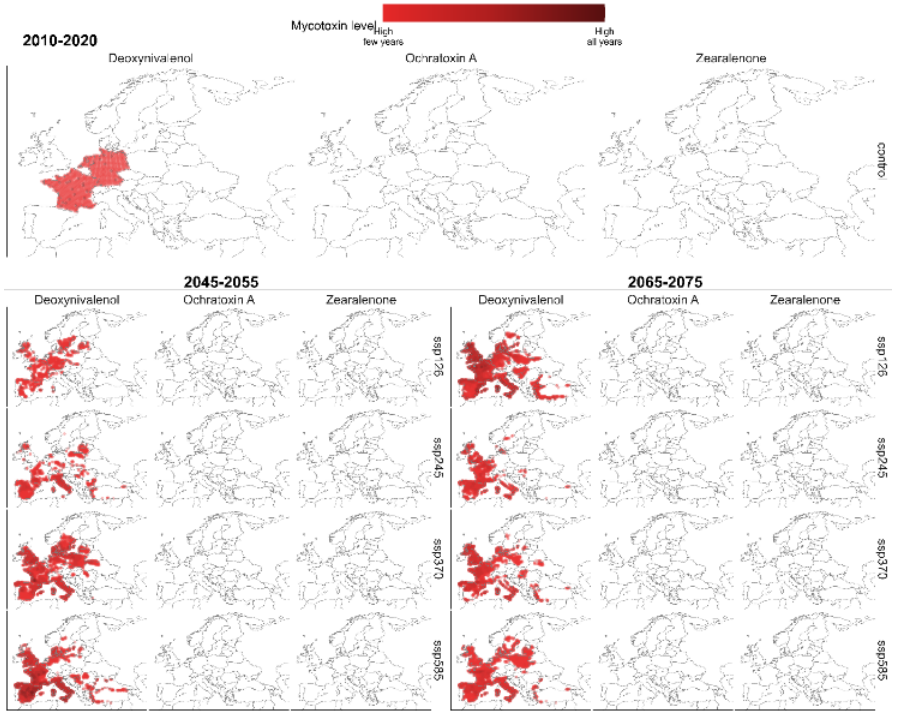
Case 1

AI-Driven Mycotoxin Risk Prediction for Cereals under Climate Change





Historical period: DON limited to specific areas in Western Europe, particularly France
Future Projections: DON expanded from Western Europe to cover large parts of Central and Eastern Europe

Case 2

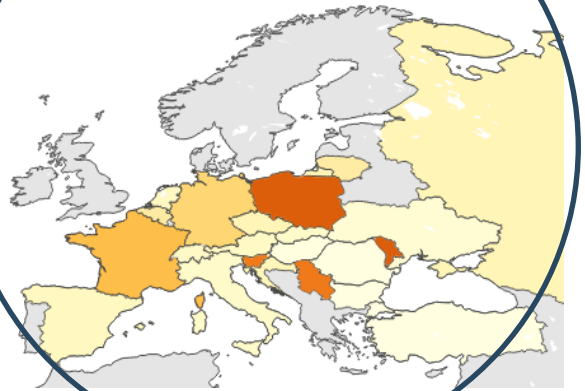
Holistic AI models for mycotoxin prediction

Monitoring data

Drivers of change

Prediction model

Mycotoxin contamination



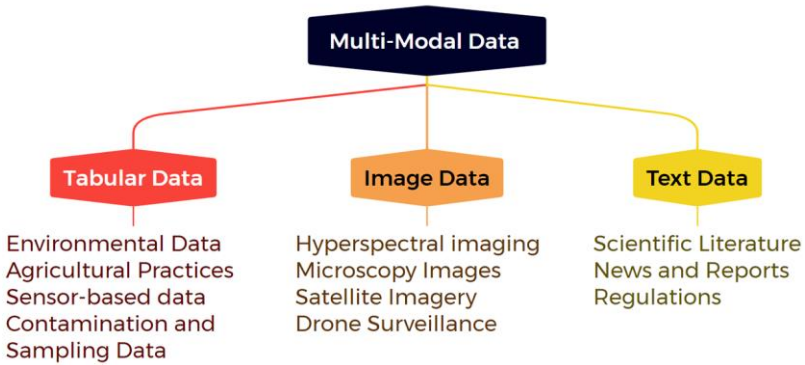
Case 2

Holistic AI models for mycotoxin prediction

AI to integrate multiple data sources:

- Monitoring data (food safety)
- Sensor data
- Image data
- Text data
- Domain knowledge

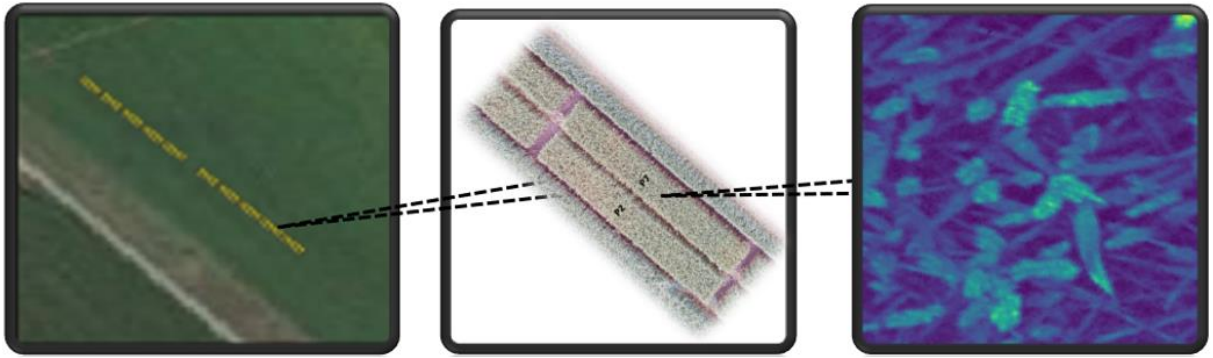
Multi-model modelling



Case 3

AI-Driven FHB detection for wheat (pre-harvest)

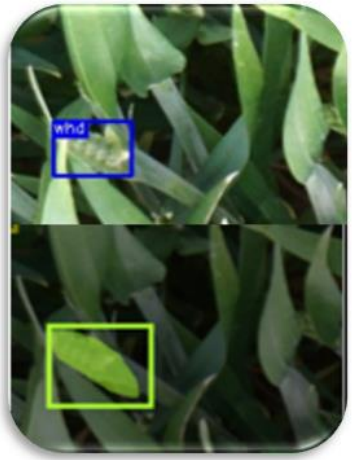
To develop a site-specific early warning model for FHB prediction in winter wheat using imaging spectroscopy and deep learning techniques.

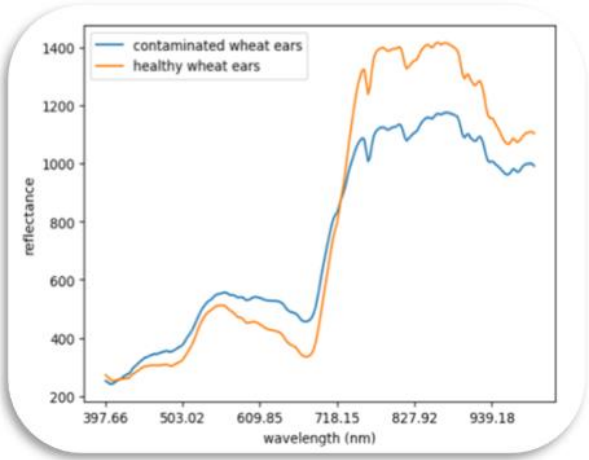


a b c

Case 3

AI-Driven Fusarium head blight detection for wheat (pre-harvest)





Contaminated or not?

Wheat ear detection and segmentation

Wheat ear spectra information extraction

A predictive model based on spectra information

Case 3

AI-Driven FHB detection for wheat (pre-harvest)

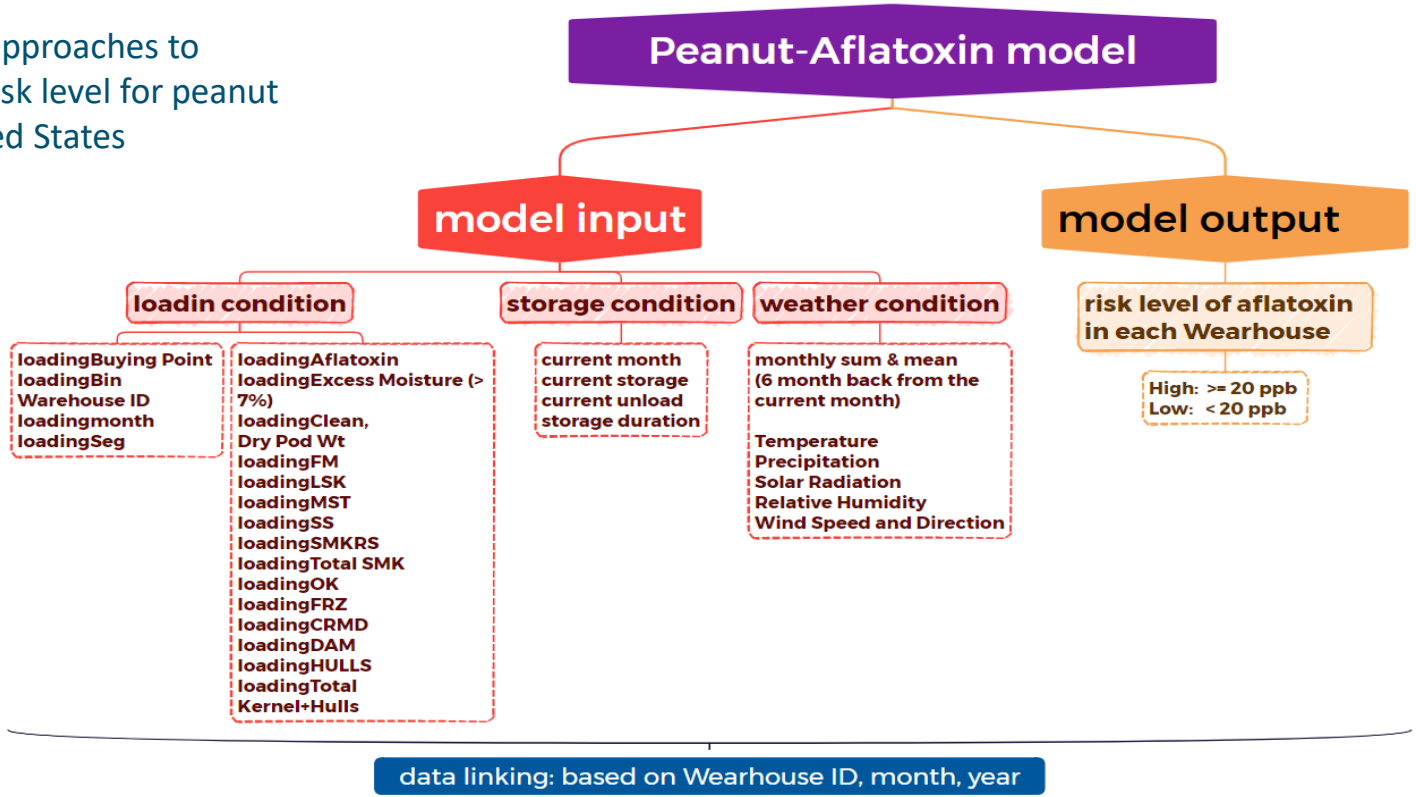
- Spectral data (wavelength) from the pixels within the wheat ears (healthy ones and infected ones) used as input
- Deep learning able to automatically detect and segment the ear of wheat (accuracy of 89%)
- Significant spectral reflectance differences were observed between contaminated and healthy wheat ears (600-800 nm)
- Using HSI and deep learning can automatically identify if a spot in the wheat field is contaminated or not

Case 4

AI-Driven Mycotoxin Risk Prediction for Peanut (post-harvest)

Project aim: utilize AI approaches to forecast the aflatoxin risk level for peanut warehouse in the United States

Collaboration with the USDA-ARS Food and Feed Safety Research Unit (New Orleans, Louisiana) and the Peanut National Laboratory.



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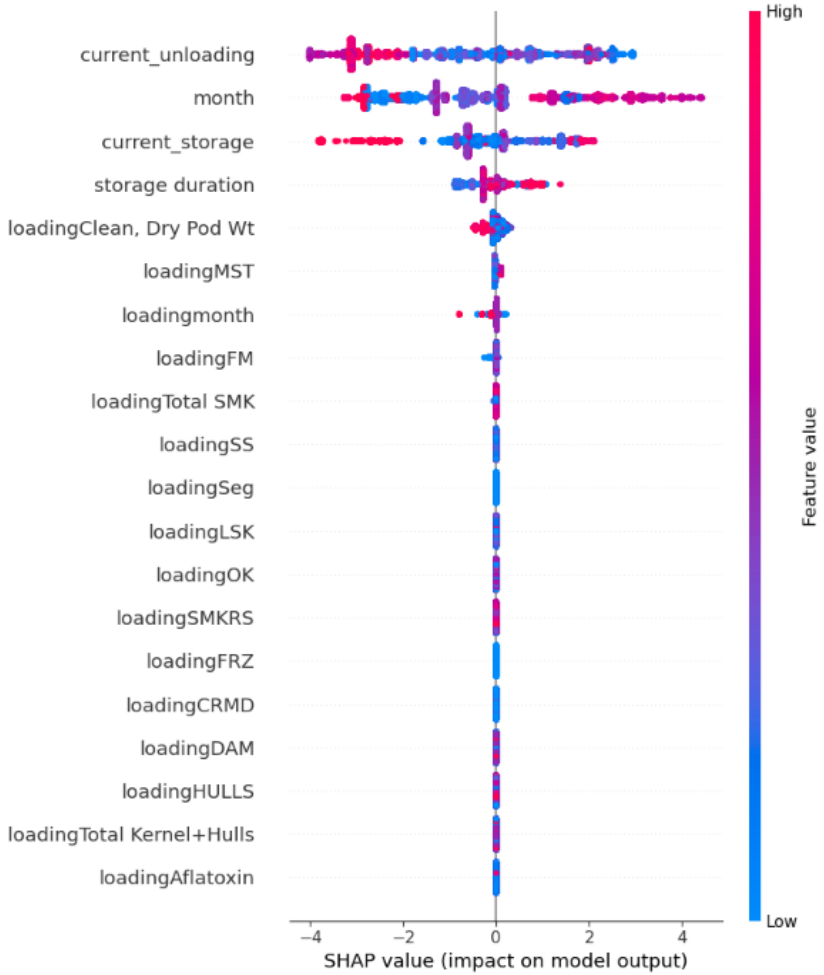
Case 4

AI-Driven Mycotoxin Risk Prediction for Peanut

Feature Importance Ranking using

Explainable AI

Most critical features in determining the model's predictions are related to storage volume and storage duration.



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Case 5

Early warning system for food safety hazards

- To predict food safety hazards in feed ingredients, per origin country
- Monitoring data from companies
- Linked with other data sources
- Dashboard: descriptive and AI predictions

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Case 5

Early warning food safety hazards, feed ingredients

PRORISKFEED DASHBOARD

OPEN PREDICTION TOOL

COUNTRY OF ORIGIN

Italy

PRODUCT

maize

DATE RANGE

Start Date → End Date

PERCENTAGE OF THE LEGAL LIMIT

0% 25% 50% 75% 100%

CONTAMINANT

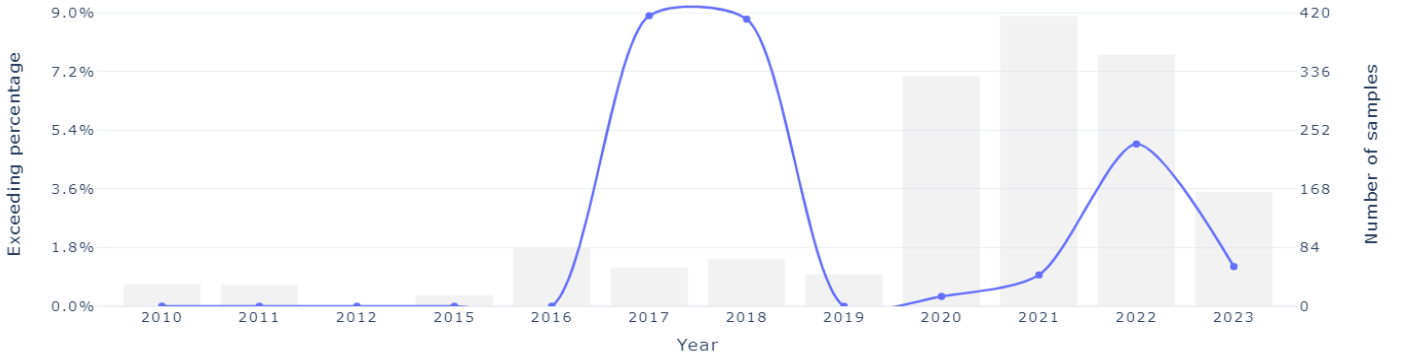
Select...

MINIMUM NUMBER OF SAMPLES FOR RANKING

0

APPLY FILTERS

General | Mycotoxins | Pesticides | Heavy Metals | Dioxins



CONTAMINANTS

CONTAMINANT	TOTAL SAMPLES	# EXCEEDING	% EXCEEDING
fumonisin b1 + b2	171	13	7.6
aflatoxin b1	569	23	4.04
deoxynivalenol (don)	423	0	0
t2 + ht2 toxin (sum)	23	0	0
zearalenone	302	0	0
ochratoxin a	117	0	0

PRODUCTS

PRODUCT	TOTAL SAMPLES	# EXCEEDING	% EXCEEDING
maize	1605	36	2.24

Case 5

Example output ML prediction tool

PRORISKFEED PREDICTION TOOL

Country ranking | Product ranking | Contaminant ranking

PRODUCT

wheat

CONTAMINANT

- (•) Mycotoxins
- ( ) Pesticides
- ( ) Heavy Metals
- ( ) Dioxins

deoxynivalenol (don)

COMPUTE PREDICTION

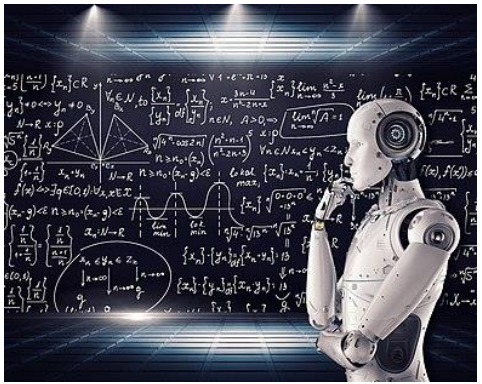
PROBABILITY OF EXCEEDING THE LEGAL LIMIT

Export

COUNTRY OF ORIGIN	PREDICTION MINIMUM (%)	PREDICTION AVERAGE (%)	PREDICTION MAXIMUM (%)
Italy	12.6	17.5	22.7
South Africa	6.1	16	38.1
France	9.6	15.3	20.4
Slovenia	9.2	15.1	26.5
Canada	9.9	13.4	19.8
Ecuador	5.4	10	15.4
Guatemala	5	9.6	16
United States	5.6	9.5	14.7
China	4.3	8.1	17.9
Latvia	2.4	7.7	20.8

Take home messages

- Use of big data and AI can help in moving towards pro-active tools in mycotoxin management
- Holistic and specific predictive models & tools
- Challenges remain
- Crucial are:
    - Data quality
    - Role of human knowledge and interaction



Relying on traditional methods for mycotoxin management is no longer enough— Using AI could greatly improve mycotoxin management

Thank you for your attention

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