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Agroscope

The 3rd MycoKey technological workshop

Prevention and integrated control of mycotoxins in wheat, barley and maize

June 18-19, 2019
Agroscope, Zurich, Switzerland

HORIZON 2020

Agroscope good food, healthy environment

The 3rd MycoKey technological workshop

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This workshop is organised within the framework of the Horizon 2020 – Research and Innovation Action – Societal Challenge – "Food security, sustainable agriculture and forestry, marine, maritime and inland water research and the bioeconomy challenge" – GA 678781 MycoKey "Integrated and innovative key actions for mycotoxin management in the food and feed chain.

Co-funded by the Horizon 2020 programme of the European Union

Introduction

On behalf of Agroscope and the organising committee, we would like to welcome you to the 3rd MycoKey technological workshop at Agroscope Reckenholz in Zürich, Switzerland.

Agroscope is the Swiss centre of excellence for agricultural research, and is affiliated with the Federal Office for Agriculture. Agroscope makes an important contribution to a sustainable agriculture and food sector as well as to an intact environment, and thereby, contributing to an improved quality of life. With sites in Avenches, Changins, Liebefeld, Posieux, Tänikon, Wädenswil and Zürich Reckenholz, Agroscope offers a decentralised infrastructure, which allows regional differences in the agro-environmental system to be taken into account.

The research goals of Agroscope are a competitive and multifunctional agriculture, high-quality food for a healthy diet and an intact environment. Mycotoxins represent a substantial threat to agriculture as well as to human and animal health. Furthermore, mycotoxin contaminated products hamper international trading, result in food and feed waste, and divert resources towards enforcement, regulation, and applications to alleviate mycotoxin problems. The FAO estimates that each year, about 25% of the world's harvested crops are contaminated by mycotoxins, leading to huge agricultural and industrial losses to the extent of billions of dollars.

This workshop is aiming to address and to share new knowledge and progress in the area of prevention and integrated control of mycotoxins in wheat, barley and maize. These two days will also provide excellent opportunities to scientists, researchers, industrial experts and students to present their research achievements and through cross-pollinations and sharing of ideas to develop new collaborations and partnerships with experts in this field.

We thank you for your participation and active contribution to 3rd MycoKey technological workshop and wish you a very successful and enjoyable experience.

Alain Gaume
Head Research Division Plant Protection, Agroscope

Susanne Vogelgsang
Head Research group Ecological Plant Protection in Arable Crops, Agroscope
MycoKey Partner and Principal Investigator at Agroscope

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Welcome from MycoKey

MycoKey aims at developing smart, integrated, sustainable solutions and innovative tool kits to reduce the major mycotoxins in economically important food and feed chains. MycoKey is providing scientifically sound, concrete, timely and cost-effective measures to producers, processing industry and markets to minimise mycotoxin contamination along the chain. Ongoing studies are investigating new methods to a) prevent mycotoxin contamination in the field, b) develop solutions for intervention to be applied during/after fungal infection of crops and c) apply remediation tools for post-harvest reduction of toxins. Thirty-two partners from Europe, China, Nigeria, Argentina, including research institutions, SMEs, industries and associations are working together for four years, focusing on the main EU regulated mycotoxins including, deoxynivalenol, zearalenone, ochratoxin A and fumonisins.

It is with great pleasure that I warmly welcome you to the 3rd MycoKey technological workshop on "Prevention and integrated control of mycotoxins in wheat, barley and maize" held at Agroscope in Zurich, Switzerland.

This technological workshop provides a unique opportunity for participants from all over the world to meet and discuss the issues on mycotoxin pre-harvest management of cereals, including the MycoKey public results. The workshop provides leaders in science and industry a forum for the exchange of ideas and perspectives in this strategic and significant field.

I would like to address my sincere gratitude to all honourable speakers, all participants and especially our colleagues from Agroscope, Susanne Vogelgsang and her team, for their enthusiasm and great efforts to organise this workshop.

I would like to wish you an interesting and enjoyable workshop and a wonderful stay in Zurich, a picturesque and cultural hub of Switzerland.

Looking forward to meeting all of you.

Antonio F. Logrieco
MycoKey Coordinator

MycoKey scientific committee

Paola Battilani (Università Cattolica del Sacro Cuore, Italy)
Nunzia Cito (CNR-ISPA, Italy)
Geert Haesaert (University of Gent, Belgium)
Alessandra Lanubile (Università Cattolica del Sacro Cuore, Italy)
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Theo van der Lee (Wageningen University & Research, the Netherlands)
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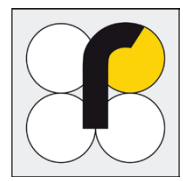

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Billions of people come into contact with Bühler technologies to cover their basic needs for food and mobility every day. Two billion people each day enjoy foods produced with Bühler equipment; and one billion people travel in vehicles manufactured with parts produced with our machinery. Countless people wear eyeglasses, use smart phones, and read newspapers and magazines, all of which depend on Bühler process technologies and solutions. Having this global relevance, we are in a unique position to turn today's global challenges into sustainable business. We want every human being to have access to healthy food. We want to do our part to protect the climate with energy-efficient cars, buildings and machinery. Our motto is creating "innovations for a better world".

Bühler invests up to 5% of its turnover into research and development. In 2018, over 13,000 employees generated a turnover of CHF 3.3 billion. As a Swiss family-owned company, Bühler is active in 140 countries around the world and operates a global network of 30 production sites.

Bühler can look back on 150 years of experience in transforming valuable raw materials into higher-grade end products. Over these years, the organisation has continuously refined the processes applied and thus left a strong imprint on the development of process technologies. The Group's core technologies are in the area of mechanical and thermal process technology. Processing technologies for reducing the risk of mycotoxins in cereal grains, nuts and other commodities are key elements of the portfolio. We focus on an integrated approach comprising post-harvest grain stabilisation by drying and mechanical cleaning, milling as well as feed and food processing. Optical sorting with SORTEX is the cornerstone of feed and food safety hazard reduction with precision sorting for detection and elimination of mouldy grains at high throughput. As members of the EU project MycoKey, we are actively contributing to build knowledge and transferring the scientific and technological advances into industrial scale applications. In R&D, we pursue a collaborative innovation approach that includes clients, suppliers, research institutions, analytical laboratories and policy makers.

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XEMA group

The XEMA group manufactures antigens, antibodies and immunoassay kits for medical and veterinary
in vitro diagnostics for more than 25 years.

We focus on immunoassays for detection of fungal antigens:

- *Fusarium* spp. ELISA and rapid tests
- *Alternaria* spp. ELISA
- *Aspergillus fumigatus* ELISA and rapid tests
- *Aspergillus niger* ELISA
- *Mucor* spp. ELISA
- *Ergot* ELISA

XEMA also develops a closed immunoassay analyser for food testing, including mycotoxins, antibiotics, adulteration markers and allergens.

swiss granum

Swiss granum is the Swiss organisation for the cereals, oil seeds and protein plants' industry, formed in 1999 as an association. It has 17 members from throughout the supply chain:

- Bread cereals
- Animal feed cereals and protein plants
- Oil seeds

Swiss granum

- brings together producers, collection points, retailers, millers, feed producers, producers of edible oils and fats, bakers and livestock keepers under one roof;
- is the point of contact for the Swiss cereal, oil seed and protein plant industry's concerns;
- promotes cooperation throughout the supply chain that it represents;
- coordinates and represents the interests of the industry as a whole vis-à-vis third parties;
- is committed to reliable framework conditions and devises consensual responses to current and future challenges that will allow the industry as a whole to develop successfully.

Swiss granum's main tasks comprise:

- Creation of market transparency

  - Conducting harvest estimates and harvest surveys,
  - Establishing guideline prices for bread and feed cereals,
  - Investigating the quality of the bread wheat harvest,

- Quality improvement/assurance

  - Defining conditions for acquisition of cereals, oil seeds and protein plants,
  - Quality assurance and food safety recommendations (risk management of mycotoxins),
  - Preparation and publication of lists of recommended varieties,

- Representation of common interests

  - Comments, negotiations, contact with government and partners,
  - Internal and external communications.

In addition, swiss granum collects product-related membership contributions on behalf of various member organisations and, as part of its mandate, is responsible for running the administrative offices of the 'Verein Schweizer Brot' (Swiss Bread Association) and the 'Verein Schweizer Rapsöl' (Swiss Canola Oil Association).

R-Biopharm

R-Biopharm – dedicated to food safety

R-Biopharm AG – innovative, reliable and proven solutions from a single source

We have developed innovative products in the field of food and animal feed analysis as well as for clinical diagnostics since 1988. Food producers, laboratories and hospitals throughout the world appreciate our high quality and customer-oriented solutions. Starting from a business with 6 employees, R-Biopharm quickly developed into an international biotechnology company. R-Biopharm is family-owned in second generation and combines development, production and sales under a single roof.

Test systems for food & animal feed analysis

As a competent partner of the food industry, we offer test systems for a wide range of requirements:

- Detection of food allergens and mycotoxins with a leading product portfolio
- Tests for the identification of substances, prohibited residues and adulteration of products
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We invest continuously in the development of modern diagnostic methods, as well as in the further development of traditional solutions such as our proven ELISA test kits. Our qualitative rapid tests set new standards in the area of on-site analysis. Our focus is also in automation solutions for the convenient, standardized and efficient processing of tests – not just for large sample quantities. All of our tests are validated.

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- Several awards for sustained strong growth

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MycoKey: A European project for mycotoxin management along various food and feed chains

Antonio F. Logrieco[1], Paola Battilani[2], Sarah De Saeger[3], Cees Waalwijk[4], Theo van der Lee[4], Susanne Vogelgsang[5], Giuseppe Meca[6], Michelangelo Pascale[1], Antonio Moretti[1], Nunzia M. Cito[1], Giuseppina Avantaggiato[1]

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The use of good agricultural practices is a key issue to minimise the risk of mycotoxin accumulation in crops before harvest. Such practices include crop rotation, tillage, less susceptible varieties, appropriate fertilisation, fungicides or biological control as well as timely harvests and control of insects, which often facilitate infection through toxigenic fungi. On the other hand, the reduction of mycotoxins along agro-food chains depends also on post-harvest management, which aims at the separation of contaminated crop products from healthy material. Therefore, the use of different tools such as manual sorting or optical sensors is of crucial importance for reducing the level of mycotoxin contamination. Moreover, it is essential to prevent post-harvest contamination and to develop practical and effective procedures for mycotoxin reduction in food and feed supply chains and to provide alternative and safe use options for contaminated batches.

A review will be given on integrated pre-and post-harvest practices to minimise the risk of mycotoxin contamination of various important crops and the search for effective solutions, including the MycoKey app, proposed and developed within the EU project MycoKey (http://www.mycokey.eu/).

As part of this project, a Mycotoxin Charter (charter.mycokey.eu) (1) was launched to share information required for global harmonisation of mycotoxin legislation and policies and to minimise human and animal exposure worldwide, with special focus on less developed countries that lack effective legislation.

Acknowledgment
This work was funded by the EU project MycoKey [grant number N. 678781].

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Mycotoxin contamination of cereals and "Good Agricultural Practice" to reduce *Fusarium* mycotoxins in cereals

Simon Edwards[1] and Ingerd Hofgaard[2]

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Maize and small grain cereals are routinely contaminated with mycotoxins. In Europe, the predominant mycotoxins on these crops are *Fusarium* mycotoxins, in particular deoxynivalenol (DON), as a result of pink ear rot in maize and fusarium head blight (FHB) in small grain cereals. European legislation was introduced in 2006, setting maximum limits for DON in unprocessed cereals, intermediate products (e.g. flour) and finished products (e.g. bread). The legislation also stipulates that growers should use "Good Agriculture Practice" (GAP) to minimise mycotoxin contamination in harvested grains. Numerous studies, either as replicated field experiments or observational surveys have been conducted to identify the risk factors associated with DON contamination in small grain cereals. These studies have identified rotation, inversion tillage, use of resistant cultivars, appropriate nutrient management, timely harvesting and the use of *Fusarium* active fungicides can all contribute to reduced mycotoxin contamination and as such contribute to GAP to reduce mycotoxins.

Fungicide control of FHB is currently limited to a few chemicals in the triazole group. This is problematic as members of this group are known to be endocrine disruptors and as such maybe removed from use within the EU and, as a single fungicide group, there is large selection pressure for the *Fusarium* pathogens to develop fungicide resistance. The term biopesticide covers a wide spectrum of potential products used within plant protection and in general can be considered as any product, except conventional synthetic pesticides, used to control pests. Biopesticides include salts, plant defence elicitors, biological control agents and botanical extracts.

As part of the MyToolBox project, several biopesticides as well as alternative, non-triazole fungicides were evaluated to control FHB and DON in wheat and oats in replicated field studies. To date, no biopesticide has proved to be effective at reducing FHB or DON. Old fungicide chemistry has had limited ability to reduce FHB and DON and a new fungicide has shown good efficacy against FHB and DON.

Acknowledgment
This work was funded by the MyToolBox project, which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 678012.

Cropping factors: the key to reduce the risk of *Fusarium* infection and mycotoxins in cereals

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Over an eight-year period, 686 winter wheat grain samples and information on their cropping history were obtained from Swiss growers. To estimate the risk of Fusarium head blight (FHB), grains were examined for *Fusarium* species incidence, mycotoxin content as well as the abundance of *F. graminearum* (FG) and *F. poae* (FP) DNA and three chemotypes, 15-acetyl-deoxynivalenol (15ADON), 3-acetyl-deoxynivalenol (3ADON) and nivalenol (NIV). Of all *Fusarium* species, FG and FP were predominant, and the average abundance of the FG DNA was three times higher compared with that of FP. Deoxynivalenol (DON), zearalenone (ZEN) and nivalenol (NIV) were the most frequently detected toxins. The average detection of the 15ADON chemotype was twice as high as those of 3ADON and NIV, respectively. For DON, 11% and for ZEN, 7% of all samples exceeded the European maximum limits for unprocessed cereals (1). Furthermore, NIV was most likely produced by four different *Fusarium* species. A multiple correspondence analysis revealed that high levels of FG and DON were mainly observed in grain samples from fields with the previous crop maize, reduced tillage, cultivars with poor FHB resistance and strobilurin-based fungicides. Other previous crops and/or ploughing resulted in DON reductions between 78 to 95%. ZEN showed a similar pattern. In contrast, high levels of FP and NIV were associated with samples from ploughed fields and the previous crop canola (2). These findings and the fact that FP DNA was negatively correlated with FG incidence, ZEN and DON, suggest a different ecological niche for FP or diverging requirements for infection. The effect of cropping factors on FG infection and DON contamination in wheat was quantified to develop the forecasting system FusaProg. This internet-based system employs plot-specific cropping, growth stage and regional weather data (3) and was successfully validated with more than 600 wheat samples. FusaProg showed to be a highly valuable tool for targeted fungicide application and production of safe wheat.

The barley survey (2013-2014 and ongoing) showed similar patterns as those in wheat except that tillage did not have a significant effect on the DON content (4). In oats (2013-2015), T-2/HT-2 toxins were detected in 91% of all samples. Samples of the winter oat variety 'Wiland' or from fields with pre-crop cereals contained significantly higher T2-/HT-2 contents compared with other varieties or other pre-crops (5).

Our cereal surveys demonstrated that cropping factors have distinct effects on mycotoxin contamination, depending on the cereal type and the respective dominant *Fusarium* species.

Acknowledgment
This work was funded by the Swiss federal research institution Agroscope, project 'Fusaria and mycotoxins in maize and cereals' and the Swiss National Science Foundation, national research programme 'Healthy Nutrition and Sustainable Food Production' (NRP 69) [grant number 406940_145210].

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How to reduce mycotoxins in cereal-based crop rotations?

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Mycotoxins of *Fusarium* species are often found in grains and grain products coming from cereal-based crop rotations. However, depending on weather conditions and crop husbandry, mycotoxin contamination levels vary strongly from year to year and even from location to location. Since 2002, Ghent University collects data on Fusarium Head Blight (FHB) and deoxynivalenol (DON) content in winter wheat in Flanders, Belgium. These data include FHB disease indexes, distribution of *Fusarium* species in the FHB-complex as well as local weather parameters and crop management measures. In addition, experiments that studied the effect of soil management, cover crops, wheat genotypes, fungicide treatments, etc. on FHB infection and DON accumulation were also carried out. Based on our dataset with over 10'000 data points, we were able to quantify the impact of several factors on FHB disease indexes and DON content and to develop mitigation measures to reduce DON levels in winter wheat. During the presentation, the impact of crop rotations, soil management, antagonistic cover crops, wheat genotype and fungicide treatments will be discussed.

Reducing mycotoxin risks in cereal grain through introducing resistance and eliminating susceptibility

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Breeding for resistance to Fusarium head blight (FHB) is challenging because of the polygenic nature of resistance and interactions with environmental and host morphological factors such as plant height. While most research into FHB is understandably focussed on increasing resistance through introducing beneficial genes, it is becoming clear that removing deleterious ones may provide an alternative approach. Despite years of effort by many groups it has proven extremely difficult to clone FHB resistance genes. The best studied resistance is Fhb1 but the identity of even this gene has proved contentious.

Investigations of wheat and barley have highlighted the potential involvement of phytohormone signalling in both susceptibility and resistance to FHB. The relationships between particular pathways and susceptibility are not always clear-cut because of the hemi-biotrophic nature of the interaction between *Fusarium graminearum* and wheat. It appears that *F. graminearum* may be exploiting certain pathways to prevent the plant from mounting an effective defence. This view is supported by the finding that isolates of *F. graminearum* are capable of producing some of the core phytohormones and these may be used by the pathogen to force/persuade the plant to maintain growth at the cost of defence.

While the majority of wheat varieties lack the ability to prevent the spread of the fungus once it enters the spike, barley varieties have high levels of this so-called Type 2 resistance. We examined wheat barley chromosome addition/substitution lines to determine whether barley chromosomes could provide Type 2 resistance to wheat. While addition of 5H increased Type 2 resistance, the most potent effect derived from the substitution of chromosome 4D with 4H suggesting that the susceptibility of wheat is due to the presence of a susceptibility factor(s) rather than the absence of resistance factor(s).

Conventional bi-parental QTL mapping has revealed regions associated with resistance to FHB in wheat and barley as well as regions associated with mycotoxin accumulation. While resistance to FHB and DON mycotoxin accumulation in agronomically adapted varieties can undoubtedly be enhanced by the introduction of resistance from various sources it is also possible that resistance can be increased through the elimination of susceptibility factors. The challenge in both cases is to provide robust FHB resistance without compromising other important agronomic characteristics required by breeders and growers.

Acknowledgment
We would like to acknowledge the horticultural and field trials teams of JIC for their invaluable contributions to this work. This work was funded by the BBSRC [grant number BB/J004588/1], AHDB [RD-2007-3453] and Newton Fund [BB/N019113/1].

Breeding for resistance to *Fusarium* infection in maize

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Fungal infection by *Fusarium verticillioides* causes substantial reductions in maize yield and grain quality worldwide. Developing natural resistance in maize genotypes is an effective way to achieve sustainable control of *F. verticillioides* in the field, and breeding for resistance may be accelerated by identifying genes and loci responsible for natural disease resistance. Significant advances have been made in the development of transcriptomic, genetic and genomic information for maize, *F. verticillioides* moulds, and their interactions over recent years. Several quantitative trait loci (QTL) and single-nucleotide polymorphism markers for resistance to *Fusarium* deriving from QTL mapping and genome-wide association studies have been described in three different maize populations: 1. Bi-parental population; 2. Association mapping panel; 3. Multi-parent Advanced Generation Inter Crosses (MAGIC). To guide the identification of candidate genes within the identified QTL, transcriptomic and sequencing information have been exploited. Promising candidate genes associated with disease resistance and pathogen related-mechanisms at the *Fusarium* resistant loci have been identified on maize chromosomes 4, 5 and 7. Many of the identified candidates' genes offer hints to key metabolic pathways that may have a significant effect on reducing *Fusarium* infection. Measuring *Fusarium* resistance in open field could confirm and support their direct use in maize breeding either through crosses or genome editing approaches.

Acknowledgment
This work was funded by the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 678781 (MycoKey).

Multi-mycotoxin screening methods: current trends and innovative solutions

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According to the General Food Law (EC) No. 178/2002, which sets the legal basis of the European Union food controls, the food and feed business operators have the primary responsibility for the safety of their products. Their demand for simplified and rapid test methods at critical control points in the entire chain has never been greater.

Validated rapid screening methods are nowadays recognised as a strategic tool to tackle this issue, and, by analogy with chromatographic methods, mainly based on liquid chromatography-mass spectrometry, the new trend in this field is multiplexing.

This topic also falls within the scopes of the MycoKey project, which explored different technologies for rapid multi-mycotoxin screening, including: multiplex strip test immunoassays for the semi-quantitative determination of *Fusarium* toxins and fluorescence polarization immunoassays for the quantitative simultaneous determination of trichothecenes and their modified forms. The process of evaluating methods fitness-for-purposes according to EC official guidelines and performance criteria (Regulation 519/2014/EU) will be presented and discussed. Validation according to harmonised protocols is critical to establish credibility of results across both scientific and regulatory boundaries. However, besides methods' performances, practicality of the different approaches for mycotoxin screening needs to be considered. These aspects will be discussed in comparison with liquid chromatography-mass spectrometry based methods when applied for mycotoxin screening purposes.

Moreover, a MycoKey survey was performed among scientists and stakeholders for the collection and sharing of current knowledge and experience on rapid methods for mycotoxin screening. This, together with some lessons learned during the MycoKey round table discussion on mycotoxin detection methods, enabled a better understanding of trends in research and development areas in this field. The results from these discussions and their significance will be summarised to highlight priorities and critical issues to be addressed to provide multi-mycotoxin rapid methods that fit stakeholders' needs and expectations.

Acknowledgment
This work was supported by the MycoKey project "Integrated and innovative key actions for mycotoxin management in the food and feed chain" (Horizon 2020 - Grant Agreement No 678781).

Measures to protect consumers from mycotoxins

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Mycotoxins are a risk for consumers since humans eat cereals and maize. However, they have only been identified and toxicologically evaluated during the last 50 years. Besides effects such as liver impairments, the carcinogenic and genotoxic properties of several mycotoxins are in the focus of regulators. In particular, genotoxicity is significant for consumer protection, as a single molecule can potentially be harmful. For this reason, such substances should not be present in foods although its occurrence cannot be completely avoided.

To limit the content of mycotoxins in food, regulators implement different measures. As a first step, they frequently describe the best practices to avoid and reduce contamination of food during production, storage and processing. This strengthens the responsibility of food business operators and makes information on good manufacturing practices broadly available. To put more importance on the implementation of these good practices, reference values, indicating which level should be achievable, are sometimes set. Further, a very frequent measure is setting maximum levels (ML) in food to exclude products from the market, which contain too high concentrations of contaminants. Finally, other measures, such as consumption advices, can be implemented to protect consumers from contaminants.

In Switzerland, as in the European Union, several ML for mycotoxins were established based on the ALARA-principle ("as low as reasonably achievable"): because of the toxicity of these substances, any level would formally be too high to protect consumers, therefore this principle is applied. At the international level, the Codex Alimentarius of the WHO and FAO has set ML and developed several codes of practice for the prevention and reduction of specific mycotoxins in food, which shall be implemented by the member countries. Commonly, the codes of practice and ML are regularly revised based on improvement of manufacturing practices or new research findings.

Advanced grain cleaning solutions for mycotoxin reduction

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A value chain approach is needed for an efficient mycotoxin reduction in the food and feed chain: starting from measures to prevent contamination in the field, to control measures to avoid mycotoxin production during storage and over the process line, until final consumption. Grain cleaning is the most effective post-harvest mitigation strategy to reduce high levels of mycotoxins due to the efficient removal of mould-infected grains and grain fractions with high mycotoxin content. Several studies have been performed during the last years to investigate the reduction of deoxynivalenol in wheat and barley, ergot in rye, and total aflatoxins in peanuts and maize. Typical cleaning steps include (i) mechanical size separation and dust removal by aspiration, (ii) separation based on density differences, and finally (iii) optical sorting. Within grain milling, often a fourth cleaning step is included, (iv) "debranning", i.e. removal of the outer layers of the pericarp, and for wet processing as in malting, (v) washing can be introduced. Recently, a completely new technology was developed for grain cleaning and monitoring based on the spectral properties of fluorescence. These well-proven and recent innovations for mycotoxin reduction will be described further in the talk, taking a whole value chain approach.

Acknowledgment
This work was supported by the MycoKey project, which has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 678781.

Biological control of *Aspergillus flavus* in maize with atoxigenic strains in Europe

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The worldwide experience suggests that the prevention of aflatoxin contamination can count on few tools and the only effective preventive intervention is biocontrol with *Aspergillus flavus* non-toxigenic strains. The objective of this technique is to replace the aflatoxin-producing fungi with fungi of the same species that do not produce these metabolites. The natural population of *A. flavus* is composed of toxin producing and non-producing strains. The inundative distribution of an atoxigenic strain as a "biocontrol agent" increases its presence in the maize crop environment and makes it effective in preventing aflatoxin contamination. It is not realistic to achieve 100% non-producers, but with a proper selection for the most competitive strain and the best adapted to the environment, a high exclusion level of toxigenic strains by competition can be obtained. Interestingly, the effectiveness of this approach is highest in years with greater risk of contamination.

US-Americans, who have been dealing with the aflatoxin problem for a long time, have come up with this tool and have developed two commercial products. Subsequently, also in Africa, several countries have selected native fungal strains and they are now registered and used under the name "AFLASAFE".

The same approach was considered in Europe, after the first aflatoxin outbreak in Italy in 2003. AF-X1 is the result of about 10 years of research to characterise the best strain for biocontrol of *A. flavus.* The product is present on the market since 2015 with temporary application authorisation, renewed annually, but hopefully close to definitive authorisation. It is therefore a biological plant protection product whose active ingredient is a native strain of *A. flavus*, rigorously selected and characterised as atoxigenic and highly competitive. The commercial formulation consists of heat-treated sorghum grains, to prevent germination, which are inoculated with the active ingredient, the deposited MUCL strain 54911. The distribution is provided with standard fertiliser spreaders, with maize plants at the 5-true leaves stage. Field applications on around 15'000 ha in 2016-2018 resulted in highly promising results, with around 90% aflatoxin reduction in grain contamination and a relevant shift from grain uncompliant with European legislation and product without any restriction.

The work is now continuing with the selection of candidate biocontrol agents in Romania and Serbia, with a good candidate strain selected in the former country, entering the field trial step in the current year.

Acknowledgment
This work was partially funded by Emilia Romagna local government, Ministry of Agricultural, Food, Forestry and Tourism Policies and the EU Project MycoKey N. 678781.

Prevention and intervention strategies to control *Fusarium graminearum* with the fungal antagonist *Clonostachys rosea*

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Mycotoxins produced by members of the Fusarium Head Blight (FHB) disease complex are jeopardising the quality and safety of food and feed. Since 2016, the European Horizon 2020 project MycoKey has made a united effort to investigate alternative strategies to mitigate risks of mycotoxins as part of a sustainable approach. One of the goals is to develop new control strategies against the predominant species *Fusarium graminearum* (teleomorph *Gibberella zeae*) by using microbial biological control agents (BCA).

We present findings from three years (2016-2018) of experiments to investigate the ability of the antagonist *Clonostachys rosea* to protect wheat against *F. graminearum*. Within the project, we developed strategies to improve the inoculum production, the survival and the UV-stability of the BCA.

In vitro, our reference isolate, *C. rosea* strain 016 outcompeted *F. graminearum* by direct hyphal interaction (mycoparasitism) and showed a complete inhibition of perithecia development and ascospore discharge from artificially infected maize residues. This strain was further evaluated under field conditions using infected and subsequently treated maize residues that were placed in winter wheat plots in late autumn. The treatments with *C. rosea* strain 016 resulted in significantly lower incidences of FHB symptoms during the following season and reduced the content of deoxynivalenol (DON) in the harvested grain by up to 82% in 2016/2017 and by 90% in 2017/2018. In parallel, the zearalenone content was reduced by up to 80% in 2016/2017 and by 90% in 2017/2018.

Furthermore, in solid-state fermentation, a wettable powder formulation was developed, leading to an average *C. rosea* content of 1 x 10^9 CFU per g. The accompanying shelf-life study at different temperatures showed unchanged viability for 24 months at 5°C. To protect *C. rosea* from harmful UVB radiation, different natural and synthetic oil formulas were screened under controlled conditions. The addition (5% oil in water) of a mixture of sunscreen (methoxycinnamate; 10%vol), sunflower oil (70%vol) and emulsifiers (20%vol) significantly improved the mean germination rate of irradiated spores (17.4 kJ m^{-2}) from 7% in the untreated control up to 92% in emulsion. The spray-application of this oil-in water formulation of *C. rosea* conidia to flowering wheat heads significantly reduced the mean levels of DON in the harvested grain by up to 50% over two consecutive years in the field. This reduction was significantly higher, compared with an application of unformulated conidia. The conclusions will be presented and discussed.

Acknowledgment
This work was funded by the European Horizon 2020 Program MycoKey "Integrated and innovative key actions for mycotoxin management in the food and feed chain", grant no. 678781. We further want to thank the people involved in the preparation and analysis of the field experiments at Agroscope and our collaborators in the MycoKey Project. We thank Dr. Jürgen Köhl from Wageningen University for providing the *C. rosea* strain 016.

Prevention of Fusarium head blight in wheat with intercrops, biofumigation and botanicals

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Fusarium head blight (FHB) is a devastating fungal disease of wheat worldwide causing yield reductions and grain contaminations with mycotoxins, such as deoxynivalenol (DON) and zearalenone (ZEN), which jeopardise food and feed safety. The predominant species of the FHB disease complex is commonly *Fusarium graminearum* (FG). In maize-wheat rotations with reduced or no-till systems, the remaining maize crop residues on the soil surface represent an important inoculum source for FG infection of the subsequent cereal crop. Field experiments were conducted to investigate the potential to suppress FHB and prevent mycotoxin accumulation in wheat grain with (a) maize-intercropping systems under reduced tillage (RT) or no-till (NT); (b) applications of mulch layers and botanicals onto maize residues artificially inoculated with FG.

For (a), sorghum, red clover, phacelia, Indian mustard and white mustard were used as intercrops in maize. Under NT, the use of red clover, Indian mustard and white mustard decreased DON content in wheat grain by 39%, 47% and 63%, respectively, compared with maize as a sole crop (average of 578 µg kg^{-1}). Under RT, only the use of white mustard resulted in lower DON content (by 53%) compared with maize as a sole crop (596 µg kg^{-1}). ZEN content was reduced in phacelia- and white mustard-maize intercropping by 34% and 47%, respectively, compared with maize sole cropping (237 µg kg^{-1}). The results suggest that various maize-intercropping systems have the potential to suppress FHB in the subsequent wheat crop under RT or NT practices without decreasing the crop yields of maize or wheat.

For (b), fresh aboveground biomass was collected from white mustard, Indian mustard or berseem clover crops, while botanicals included aqueous extracts of white mustard seed flours or milled Chinese galls. Mulch layers and botanicals were applied onto maize residues artificially inoculated with FG. Mulch layers consistently suppressed FG infection in both years of experiments as well as decreased DON and ZEN content in wheat grain by up to 58% and 87%, respectively. Botanicals were more effective in the second year of field experiments reducing DON and ZEN content in grain by up to 42% and 78%, respectively.

Within the context of sustainable crop protection, cereal growers could benefit from the suggested prevention strategies against FHB by decreasing the risk of mycotoxin contamination in harvest products and sustaining or even improving grain yield and quality.

Acknowledgment
This work was funded by the MycoKey project "Integrated and innovative key actions for mycotoxin management in the food and feed chain", Horizon 2020, grant no. 678781.

MycoKey app: an ICT solution to facilitate mitigation of mycotoxin risks

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The MycoKey app is developed as an ICT solution to facilitate mycotoxin risks mitigation by various stakeholders in the chain. Different work packages of MycoKey generate, validate and integrate knowledge that provide useful information for risk assessment and help to raise awareness, alert and specifically notify stakeholders and provide options for mitigation of mycotoxin risks. This knowledge needs to be customised in order to effectively assist stakeholders. The MycoKey app, a mobile accessible platform, will deliver this customised information on a smartphone, tablet or computer. This app will generate a dashboard experience for accessing all relevant information for growers, advisors, grower associations, stakeholders in the production chain as well as policy-makers. It provides information on the risk of mycotoxins and, if required, will suggest management activities to mitigate and reduce risks. The app is user protected by a personal password and data can be private, shared with friends and advisors or anonymised and shared to other stakeholders. Governmental planners and policy makers will have access to shared, public databases and satellite data, as such biomass indices, land-use and mycotoxin risks can be estimated per region. The MycoKey app has different functionalities for smart phone (data entry and retrieval) and computer platforms (data entry and retrieval and analysis). Recalculation using different intervention strategies allows integration of management strategies in the risk model and calculations of "what if" scenarios. We will demonstrate the MycoKey app for worldwide mycotoxin risk prediction.

Acknowledgment
This work is supported by the Horizon 2020-project MycoKey (grant no. 678781).

Prevention strategies - a cereal stakeholders' perspective

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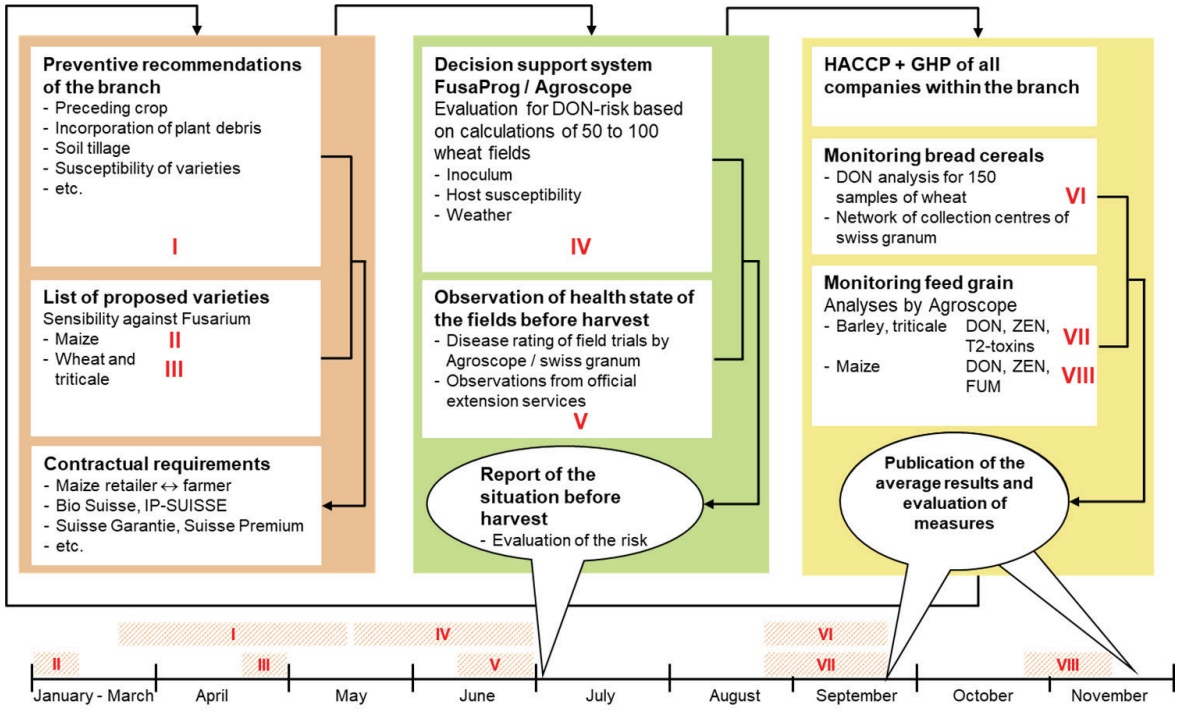
Swiss granum, the Swiss organisation that represents the cereal, oil seed and protein plant industry, annually stipulates the conditions for acceptance of bread and feed cereals (1) and oil seeds (2). In addition to the applicable maximum content of and guideline values for mycotoxins, these include recommendations for preventing mycotoxins in cereals, based on the applicable legal provisions in Switzerland and the EU respectively.

On the basis of these regulations, the industry has drawn up a three-stage concept for managing the risk of mycotoxins (Figure 1). This consists of

- preventive recommendations at production and acceptance stage, as well as a description of susceptibility in the list of recommended varieties to the most common *Fusarium* species, *F. graminearum*,
- assessment of the pre-harvest risk (Agroscope FusaProg prediction model, results of field observations by swiss granum and Agroscope),
- monitoring of the deoxynivalenol (DON) content after harvest based on analyses of collection points and mill samples.

Figure 1: swiss granum's three-stage concept for mycotoxin risk management



The aim is to keep the risk of infection with *F. graminearum* as low as possible with preventative measures, defining situation-appropriate measures using pre-harvest predictions and making these available to the cereal collection points, and to record the new harvest's current DON load as quickly as possible in order to determine locations and further optimise risk management.

Swiss granum's Food Safety working group has been entrusted with implementing the concept, which is published annually in a situation report (3) before harvest. The situation in Switzerland is under control thanks to the joint efforts of industry partners. The entire supply chain in Switzerland is called upon to face the future challenges. With this collaboration, we can produce safe food and safe animal feed not only today, but also tomorrow.

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Alain Gaume

Speaker

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Swiss Confederation

Federal Department of Economic Affairs,
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Alain Gaume obtained a diploma in Agronomy (crop production) in 1995 and a PhD in Plant Nutrition and Soil Science in 2000 from ETH in Zurich, Switzerland. He was a postdoctoral fellow at Rutgers University, USA between 2000 and 2002, and at the University of Pretoria, South Africa from 2002 until 2003. Between 2003 and 2005, he had his own research team at the ETH in Zürich before joining Agroscope, Switzerland (Team leader Plant Nutrition) in 2005. Between 2009 and 2017, he was leading the Research Group for Seed Treatment (Seedcare) by Syngenta in Stein (Switzerland).

Since 2017, he is Head of the Research Department Plant Protection at Agroscope and member of the Directory Board.

His major professional interests are:

- The research fields of crop production and plant protection
- Supporting the development of innovation in Agriculture

Antonio F. Logrieco

Speaker and session chair

Consiglio Nazionale delle Ricerche
ISPA
ISTITUTO DI SCIENZE DELLE PRODUZIONI ALIMENTARI

Antonio Logrieco obtained his PhD in Agricultural Sciences in 1981 from the University of Bari, Italy. He is Director of CNR-ISPA (http://www.ispacnr.it/) and was the coordinator of various national and international projects dealing with plant pathology and food safety, with particular attention to mycotoxin problems. These include for example the COST action 835 "Agriculturally important toxigenic fungi"; DeTox-Fungi-1999-01380 in FP 5; WP3 "Microsystems technology solutions for rapid detection of toxigenic fungi and mycotoxins in Good Food" -IST-1-508774-IP in FP 6; "Novel integrated strategies for worldwide mycotoxin reduction in food and feed chains"- MycoRed-KBBE-2007-2-5-05 in FP 7; and currently, MycoKey "Integrated and innovative key action for mycotoxin management in the food and feed chain" (www.mycokey.eu) in Horizon 2020.

He is the founder and director of the Agro-Food Microbial Culture Collection "ITEM" (http://server.ispa.cnr.it/ITEM/Collection/). In addition, he is the co-founder and former Past-President of the International Society for Mycotoxicology (www.mycotox-society.org), acting President of Mediterranean Phytopathological Union (www.mpunion.eu/) and was President of the ISPP "*Fusarium* Committee".

Antonio Logrieco is elected as member of the Hungarian Academy of Sciences, was nominated as Distinguished International Supervisor of the Institute of Food Science and Technology, Chinese Academy of Agricultural Sciences and is honorary instructor of the annual *Fusarium* training workshop at Kansas State University, USA.

Simon Edwards

Speaker and session chair

Harper Adams University

Professor Simon Edwards was awarded a BSc(Hons) in Applied Biology at Manchester Polytechnic in 1988 and a PhD in Plant Pathology from Aberdeen University in 1993. He worked as a post-doctoral research fellow at the University of York and Harper Adams University. He was awarded the title of Reader in Molecular Diagnostics in 2003 and Professor of Plant Pathology in 2010.

Simon has worked extensively on the epidemiology, mycotoxin production, diagnostics and control of *Fusarium* pathogens on cereals. Over the last twenty years, he has led numerous research projects with funding from national funding bodies, the European Union and industry. These studies informed the UK "Codes of Practice to reduce mycotoxins in cereals" and the UK cereal industry "Guidelines to minimise risk of *Fusarium* mycotoxins in cereals".

Simon is a member of JECFA (UN/WHO Joint Expert Committee on Food Additives and natural contaminants).

Susanne Vogelgsang

Speaker and session chair

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Susanne Vogelgsang obtained a Diploma in Agrobiology (Plant Protection, Physiology, Ecology, Horticulture) from the University of Hohenheim, Germany in 1994, and a PhD in Plant Science (Weed Biology/Plant Pathology) from McGill University, Canada in 1998. Between 1998 and 1999, she worked as a postdoctoral fellow at the Université de Fribourg (Switzerland) and between 2000 and 2001 as a visiting scientist at the Pacific Forestry in British Columbia (Canada). Between 2001 and 2003, Susanne worked as a Technology Transfer Officer for the NCCR Plant Survival in Neuchâtel (Switzerland).
Since 2011, she is head of the research group "Ecological Plant Protection in Arable Crops" at Agroscope in Zurich (Switzerland). In 2014, Susanne was nominated as member of AcademiaNet, a database with profiles of Leading Women Scientists (www.academia-net.org/profil/dr-susanne-vogelgsang/1289453).

Susanne's major research interests are:

- Development of sustainable cropping systems to control plant diseases in arable crops;
- Utilisation of surveys and forecasting systems to develop strategies to avoid pests and diseases;
- Biological control and use of botanicals or thermal treatments to limit plant diseases in cereals and potatoes.

Geert Haesaert

Speaker and session chair

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FACULTY OF
BIOSCIENCE ENGINEERING

Geert Haesaert obtained his PhD in Applied Agronomical Science in 1991 from the University of Ghent. He is an agronomist and plant breeder involved in more than 40 national and international research projects. Since 2013, he is full professor at the faculty of Bioscience Engineering of Ghent University. His research focusses on sustainable crop production and crop protection in moderate as well as in tropical agro-ecological zones. Recent interests are biostimulants, growth promoting and biocontrol microorganisms. Since 2002, research programmes on toxigenic fungi (especially *Fusarium* spp.) and their associated mycotoxins are conducted. These projects focus on pre-harvest control of mycotoxins including fungal population diversity, control measures, development of prediction models, etc.). His research in the field of breeding is focused on triticale and malting barley. He is internationally recognised as a leading expert in triticale breeding for which he has managed a dedicated breeding programme for many years.

Geert Haesaert is co-founder of the MYTOX research platform (www.mytox.be) and of the consortium CropFit (www.cropfit.be). He is president of the International Triticale Association (ITA) and external expert for national and international agencies. He is also co-founder of the Ghent University spin-off company Progeno that provides data-driven breeding advice to plant breeders companies. Progeno is the results of a long-term scientific symbiosis between the department plants and crops and the department of data analysis and mathematical modelling.

Geert Haesaert is (co)-author of more than 100 international peer-reviewed and more than 200 technical publications (https://biblio.ugent.be/person/802000168067).

Paul Nicholson

Speaker

John Innes Centre

Professor Paul Nicholson obtained a degree in Biological Sciences at the University of East Anglia in 1981 and a PhD from the University of Cambridge in 1985. He joined the John Innes Centre in 1989 as a project leader.

Research in his group focusses on investigating the genetic basis of resistance diseases of cereal heads. Fusarium head blight (FHB) reduces yield and contaminates grain with harmful mycotoxins. Resistance is quantitatively inherited and to date no gene for resistance to FHB has been isolated.

His group has demonstrated that the host plant assists the fungus through the presence of genes that increase susceptibility (so-called 'susceptibility' factors). We have identified a number of these and are working to increase resistance by eliminating these genes while retaining yield potential in varieties.

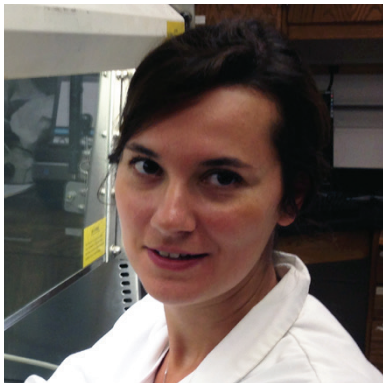
The second major disease is 'wheat blast' which has recently spread from South America into Bangladesh and India.

Conventional major genes (R-genes) for resistance are involved in wheat blast (in contrast to FHB) although none has been reported to date.

His group identified the first wheat blast resistance genes and are developing molecular markers for plant breeders to produce varieties containing multiple resistance genes to provide durability of resistance.

Alessandra Lanubile

Speaker and session chair



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Alessandra Lanubile obtained her Master Degree in 2006 in Biotechnology from the University of Parma, and her PhD in 2011 (Agrisystem XXIII cycle - Title of experimental thesis: Maize transcriptome analysis upon *Fusarium* infection in relation with host and pathogen genotypes). She spent six months as a visiting scientist at the Department of Biology, Biotechnical Faculty, University of Ljubljana, Slovenia, and 12 months at the Department of Plant Pathology and Microbiology, Iowa State University, USA.

Alessandra is Assistant Professor in Agricultural Genetics (07E1) at DI.PRO.VE.S. (Department of Sustainable Crop Production), Università Cattolica del Sacro Cuore in Piacenza, Italy.

During her career, she participated in several projects funded by Italian Agencies and the European Union establishing scientific collaborations with several national and international groups. Her research activity concerns plant breeding of field crops, with particular emphasis on the integration between conventional classical selection methods and the application of biotechnological tools. The purpose of her research activity is to determine genetic bases of traits, which can be useful in the frame of a sustainable agriculture. Presently, these investigations mainly address the study of resistance to biotic stress and of physiology and genetics of seed development in plants of agronomic importance, such as maize and soybean.

Veronica Maria Teresa Lattanzio

Speaker

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Veronica M.T. Lattanzio graduated in Chemistry at the Chemistry Department, University of Bari, Italy, in 1999. She is currently a researcher at the Institute of Sciences of Food Production (ISPA) of the National Research Council of Italy (CNR).

Her main research topic is the development and validation of analytical methods for mycotoxin detection either based on mass spectrometry techniques and immunoassays, including the organisation of collaborative trials and preparation of reference materials. Veronica is a member of the Working Group "Biotoxins" (CEN/TC 275 WG5 "Food Analysis – Horizontal Methods – Biotoxins) of the European Committee for Standardisation. Since 2008, she is also deeply involved in the validation of rapid methods for (multi)-mycotoxin detection, in the framework of National and EU funded projects. Since 2017, she is appointed by the International Atomic Energy Agency (IAEA) as an expert to provide individual and collective training related to testing chemical contamination for food safety in the framework of IAEA funded projects. Veronica has also specific expertise in identification, structural characterisation and determination of mycotoxin metabolites and modified mycotoxins, study of fate of mycotoxins during food processing as well as the identification and characterisation of biomarkers for the evaluation of animal and human exposure to mycotoxins.

Lucia Klauser

Speaker

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Federal Department of Home Affairs FDHA
Federal Food Safety and
Veterinary Office FSVO

Lucia Klauser obtained a Diploma in Chemistry from the University of Basel, Switzerland in 2002 and a PhD in Environmental Science from ETH Zurich in 2007. In 2007-2008, she worked as a consultant for chemical regulation REACH in Germany. From 2008 to 2015, she was responsible for the regulation on pesticide residues in food at the Federal Office of Public Health and at the Federal Food Safety Office (FSVO).

Since 2015, Lucia Klauser is in charge of the regulation of contaminants in food at the FSVO. Her main task is to define measures to protect consumers from contaminants in food, for instance setting maximum levels for substances in food. For the coordination at an international level, she is head of the Swiss delegation of the WHO/FAO Codex Committee on Contaminants in Food.

Katarina Slettengren

Speaker and session chair

Katarina Slettengren obtained her PhD in Food Process Engineering at the Swiss Federal Institute of Technology in Zurich (ETHZ) and her MSc in Biotechnology with specialisation in Food and Health at Chalmers University of Technology.

At Bühler AG, she is currently working as Scientific Head of the Analytics Laboratory. She is an expert on mycotoxins in cereal grains with subsequent control measures, including advanced grain cleaning technologies. Within MycoKey, she coordinates the project from Bühler's side. She works in a customer-facing role, adding value to innovation projects by combining expertise in technology and laboratory analytics.

Paola Battilani

Speaker and session chair

UNIVERSITÀ CATTOLICA del Sacro Cuore

Professor Paola Battilani graduated in Agriculture at the Università Cattolica del Sacro Cuore (UCSC), Italy. At UCSC, Piacenza, she is full professor in Plant Pathology and leads a research group on food safety with focus on mycotoxins.

Her major professional interests are:

- Ecology and epidemiology of mycotoxin producing fungi
- Modelling to predict the risk of mycotoxin contamination in different crops
- Development of Decision Support Systems to mitigate mycotoxin contamination in maize, wheat and grapes
- Impact of climate change on mycotoxin producing fungi
- Biocontrol of *Aspergillus flavus* with field application of atoxigenic strains
- Risk assessment modelling approach for mycotoxin mixtures in food and feed

Alejandro Gimeno

Speaker

University of Zurich[UZH]

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER
Agroscope

Alejandro Gimeno obtained his Bachelor's degree in Agronomy from the University of Natural Resources and Life Sciences Vienna (BOKU), Austria. In 2016, he obtained his Master's degree in a double degree study programme on Agricultural and Environmental Sciences in Europe, between the University of Copenhagen, Denmark, and the University of Hohenheim, Germany. Before joining Agroscope, he gathered professional experience in agricultural industry, working with registration and production of plant protection products.

Since 2016, he is a doctoral candidate at Agroscope in the research group "Ecological Plant Protection in Arable Crops" under the supervision of Dr. Susanne Vogelgsang, Agroscope, and is inscribed at the University of Zürich in the lab of Prof. Beat Keller.

The objective of his PhD project is the biological control of Fusarium Head Blight with the antagonistic fungus *Clonostachys rosea*. The project is funded by the European Horizon 2020 Programme MycoKey "Integrated and innovative key actions for mycotoxin management in the food and feed chain".

Dimitrios Drakopoulos

Speaker

ETH zürich

Schweizerische Eidgenossenschaft
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Dimitrios Drakopoulos obtained his BSc and MSc degrees in `Crop Science` from the Agricultural University of Athens, Greece, and his second MSc degree in 2014 in `Agroecology` from Wageningen University, the Netherlands. Moreover, he conducted research in the seed sector at Syngenta Seeds and Enza Zaden in the Netherlands, investigating seed treatments to enhance seed quality of field crops and vegetables. Currently, he is a PhD student at Agroscope-Reckenholz in Switzerland under the supervision of Dr. Susanne Vogelgsang. He is also enrolled in the Sustainable Agroecosystems group (Prof. Johan Six) of ETH Zurich.

The main objective of his research is to develop prevention and intervention strategies against Fusarium Head Blight in wheat and barley, and to reduce the risk of mycotoxin accumulation in grain.

Prevention projects:

- Maize-intercropping and cover cropping systems
- Botanicals and `cut-and-carry` biofumigation with antifungal mulch layers
- *Fusarium* and mycotoxin survey on barley across Switzerland

Intervention project:

- Control of *F. graminearum* with mustard-based botanicals i*n vitro* and *in planta*

His research is funded by the European Horizon 2020 Programme MycoKey "Integrated and innovative key actions for mycotoxin management in the food and feed chain".

Theo van der Lee

Speaker and session chair

Theo van der Lee obtained his PhD in 2000 from Wageningen University (the Netherlands), in the Department of Phytopathology. Since 2007, he is a Senior Scientist at Plant Research International, Wageningen.

Theo played an active role in several research projects, including EU projects such as MycoRed, Bioexploit, Detox, TESTA and currently, MycoKey. He co-authored over 90 articles in peer reviewed journals in the field of molecular biology, genetics, plant resistance and plant pathology which collected over 21.000 citations (source: google scholar).

The resistance and resilience of plants to pathogens has been his focus for over 25 years. He was involved in cloning of plant resistance genes, detection, identification and characterisation of plant pathogens including population studies of plant pathogens (fungi, oomycetes, viruses, nematodes and bacteria). Furthermore, Theo exploited advanced technology including single molecule sequencing, digital phenotyping and satellite images as well as state of the art analysis and data visualisation tools. Together with his colleagues at Plant Research International, he designs and validates molecular assays, monitors populations and develops apps for governmental agencies, private partners and the public.

Stephan Scheuner

Speaker

Stephan Scheuner obtained his Master of Science from ETH Zürich in 2006 (Diploma in Agricultural Engineering), supplementing this in 2018 with an EMBA in General Management.

From 2006 to 2012, he filled various positions with Proviande, the Swiss meat industry organisation, where he had particular responsibility for developing and implementing "Swiss Meat" marketing communications outside Switzerland.

Since 2012, he is the director of swiss granum, the Swiss branch organisation for cereals, oil seeds and protein plants. His role includes the managing directorship of the "Verein Schweizer Brot" (Swiss Bread Association) and the "Verein Schweizer Rapsöl" (Swiss Canola Oil Association), managed on behalf of swissgranum.

Max Schulman

Session chair and moderator panel discussion

Max Schulman grew up on his family's farm, which he took over in 1986. Stor-Tötar Gård is an old farm that combines arable land and forestry in South Western Finland that has been in the family for around 300 years.

Before taking over the full responsibility of running the farm and having taken a degree in Agricultural Economics, he became a grain trader for the Finnish Grain Board. After that, Max worked in the agricultural machinery sector from 2003 until 2008. This job took him all over the world from America to China.

For the last 10 years, he has been working in the Central Union of Agricultural Producers and Forest Owners (MTK) as the Advisor for cereals, oilseeds and protein crops.

From 2013 to 2019, Max was Chairman of the Cereals Working Group in Copa-Cogeca based in Brussels, member of the EU Arable Crops Market Observatory. Since 2018, he is Chairman of the Civil Dialogue Group, Arable Crops. He is also the owner of Farm-XPort Ltd, grain trading company, co-founder and member of the board of Grain Sense Ltd, a portable protein and quality analyser for grain. Furthermore, Max is Chairman of VYR, the Finnish Grain Chain.

Practical information

Map of Zürich

SBB (train, bus)

Tourist information

MycoKey