Latest progress

For maize, the situation is becoming more complex. Three mycotoxins produced by two families of Fusarium determine access to the human food market. Reference data acquired in the last two years reveals unexpected interactions.

Weather conditions at the end of the maize cycle (ripening phase) have a determining impact on final mycotoxin contents.

For maize destined for the human food market, maximum limits have been fixed for three fusariotoxins: DON (1,750 µg/kg), zearalenone (350 µg/kg) and fumonisins (4,000 µg/kg). They are produced by two fungi *(insert 1)* which give different visual symptoms: *Fusarium graminearum* and *Fusarium moniliforme*.

A reliable risk assessment grid

As it is essential to be able to assess the safety quality of a field for those three toxins, the global risk assessment grid *(table 1)* helps to position fields in relation to the main agronomical factors:

- presence of borers,
- harvest date,
- varietal sensitivity to each of those two Fusarium,
- residues management.

The fusariotoxin risk assessment grid for maize is reliable and sorts fields into appropriate categories, even in difficult years like 2006.

Assessment grid of fusariotoxins on maize *(tab 1)*

Whithout borer				Borers			
Harvest date	Varietal susceptibility	Residue management	Risk category	Harvest date	Varietal susceptibility	Residue management	Risk category
Before 15/10	Other varieties	Sufficient	A	Before 15/10	Other varieties	Sufficient	B
		Poor	A			Poor	C
	Most susceptible varieties	Sufficient	B		Most susceptible varieties	Sufficient	C
		Poor	B			Poor	D
Between 15 and 31/10	Other varieties	Sufficient	B	Between 15 and 31/10	Other varieties	Sufficient	B
		Poor	B			Poor	C
	Most susceptible varieties	Sufficient	C		Most susceptible varieties	Sufficient	C
		Poor	C			Poor	D
Between and 15/11	Other varieties	Sufficient	B	Between and 15/11	Other varieties	Sufficient	C
		Poor	B			Poor	C
	Most susceptible varieties	Sufficient	C		Most susceptible varieties	Sufficient	D
		Poor	C			Poor	E
After 15/11	Other varieties	Sufficient	B	After 15/11	Other varieties	Sufficient	D
		Poor	C			Poor	E
	Most susceptible varieties	Sufficient	C		Most susceptible varieties	Sufficient	E
		Poor	D			Poor	E

The combination of the four agronomical factors helps to position each cropping technique from the lowest "A" risk category to the highest, which is "E". However, this risk must be adjusted depending on actual weather conditions during the cropping season. It is then important to limit the number of agronomical factors

Fusarium: contamination channels *(insert 1)*

Fusarium graminearum - produces DON and zearalenone - likes mild and damp conditions. Maize is particularly susceptible to this pathogen at the female flowering stage, just after the silks come out. It penetrates the ear through the silk canal. The other *Fusarium*, called "*moniliforme*", includes two species, *Fusarium verticilliodes* and *F. proliferatum*, that are difficult to differentiate and both produce fumonisins. *F. moniliforme* may also contaminate the ear through the stylar canal. But its main "entry point" is usually through a damaged area caused by a borer. It will get established more easily if the plant is under stress. Unlike *F. graminearum*, it likes hot and dry conditions and is mainly found in a Mediterranean climate.
This would explain low fumonisin contents in 2007. The absence of borers and the cool summer season did not encourage this fungus to develop.

Fusarium graminearum penetrates the ear through the silk canal just after the female flowering stage.

Created from the results of field surveys carried out between 2003 and 2005, this assessment grid demonstrated its reliability in 2006 and 2007, two years with extreme and opposite characteristics. 2006 saw record mycotoxin contamination levels whereas 2007 saw a departure from the previous four years as regards fumonisins. As well as this grid, a first characterization of varietal susceptibility to fusarium has been available since January 2007. The classification, updated in 2008, is based on the outcome of passed agronomical trials combined with a special experiment to complete the existing results. It is expressed as a percentage of affected ears in the field, which helps, among other things, to identify which hybrids are most sensitive (for more information, download ARVALIS INFOS Maïs January 2008 from our website www.arvalisinstitutduvegetal.fr).

Pre-harvest preliminary diagnosis: an indispensable stage

To assess risks more precisely during the cropping season, the impact of the weather, which is a prime factor in the production of fumonisins, must be taken into account. Unlike wheat, where everything seems to be determined around the flowering stage, the month preceding the maize harvest is decisive for final mycotoxin content of the grain. The conditions at that time often encourage the development of fungi. The harvest date is the corner stone of maize safety quality.

ARVALIS – Institut du végétal is proposing to support grain stores by taking samples from mid-September, in order to bring the harvest forward if necessary.

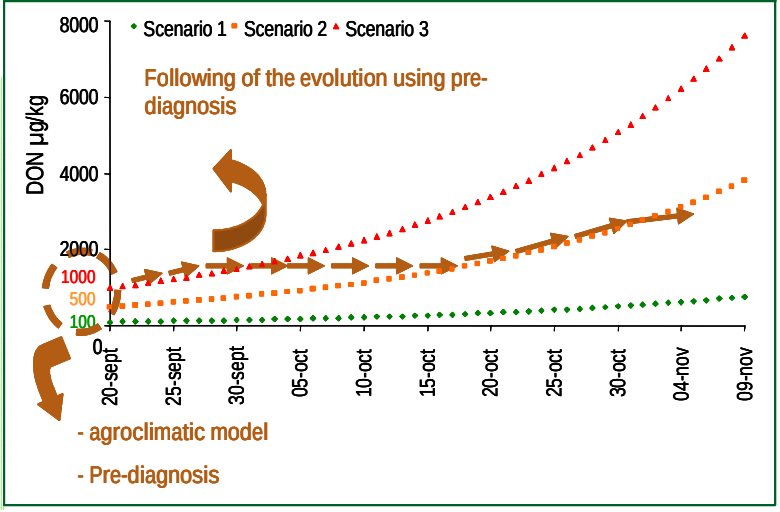
Forecasts carried out as early as September help to bring harvest forward if necessary. But additional reference data is needed to create models of contamination dynamics for the different mycotoxin carrying pathogens. Variation curves show that in "favourable" conditions, levels increase exponentially during the last cropping weeks *(figure 1)*.

ARVALIS – Institut du végétal is proposing to support grain stores by taking samples from mid-September. First implemented for the 2007 southwestern harvest, this approach proved successful. It was possible, as early as September, to highlight the good level of safety quality of maize crops, including with regards to fumonisins.

The implementation of this strategy is fairly cumbersome (sampling, sorting, drying, analysing...), but it helps adjust recommendations at regional or production basin level and therefore to optimise the harvest date.

If weather conditions are likely to encourage the development of fungi, theoretical variation curves of DON content (dotted lines) are calculated for different contamination levels on 20/09 (100, 500 and 1,000 µg/kg). Those theoretical variations at the end of the cycle were derived from data produced by the field network, on the basis of harvests 2003 to 2006.
In 2007, which saw cool autumnal weather conditions, safety quality did not decrease much. Monitoring of fields through preliminary diagnoses (dart lines) helped to obtain an accurate assessment of the situation as early as September. In order to adjust the harvest date as accurately as possible, an initial preliminary diagnosis must be carried out in mid-September. Monitoring of the way in which the situation is evolving can then be based on the theoretical curves or repeated preliminary diagnoses.

Pre-harvest diagnosis : determining of initial risk level and evolution *(fig. 1)*



Competition or opportunism? *(Insert 2)*

ARVALIS – Institut du végétal carried out field trials, inoculating ears with *F. graminearum* only, or a combination of both but in different proportions.
In the inoculation tests, DON, heavily present on the ears which were inoculated with *F. graminearum* only, was inhibited by the presence of *F. moniliforme*. *F. moniliforme* includes different species, the characteristics of which are still to be discovered.

F. moniliforme, which produces fumonisins, adds opportunism to its parasitic conquering channels. Early *F. graminearum* contamination or borer attacks prepare the way for it.

The presence of fumonisins is greater when *F. moniliforme* inoculation was combined with large proportions of *F. graminearum*. In addition, the more susceptible to *F. graminearum* the variety is, the higher the fumonisin contents are. Those results suggest that *F. graminearum* prepares the ground for the subsequent establishment of *F. moniliforme*. In other words, early *F. graminearum* contamination seems to encourage late *F. moniliforme* contamination. The latter would use the opportunity created by the stress resulting from the *F. graminearum* attack to gain entry!

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The use of pyrethroid-based insecticides to control European corn borers is effective and also has an impact on fumonisin content.

Fumonisins : the Italian experience *(insert 3)*

95% of Italian maize is grown in the north of the country, in the plain of the Pô river, and 90% of the maize area is irrigated. European corn borer attacks are common and 2003, 2005 and 2006 were characterised by average fumonisin contents exceeding 6,000 µg/kg.

Italians have demonstrated that appropriate cropping techniques help to reduce fumonisin content. They recommend early sowing, in March, to reduce the window of exposure to drought and European corn borers, and therefore the accumulation of fumonisins.

Early sowing, combined with reasoned nitrogen fertilisation and efficient European corn borer control with insecticides, help to lower final content down to very low levels. This evasion strategy is possible in Italy because the weather in March is milder than in France. It is also worth mentioning that, in France, early sown crops are open to attacks from ground pests, against which chemical treatments are not very effective.

Italians sow early to evade some of the European corn borer attacks and limit final fumonisin content levels.