Safety quality of grain maize

Mobilising all possible means of preserving safety quality

Fusariotoxins: When analysing the risk factors, some cropping techniques emerge as means of controlling ear fusarium.

The level of acceptable varietal susceptibility depends on which practices have been implemented and their risk factor, as well as on all the agronomical characteristics of the variety in question.

One of the main objectives of the maize sector in 2007, and beyond, is to meet the challenge of European safety quality standards. From July and October 2007, compulsory limits of mycotoxins will be extended to grain maize put on the market for human consumption (food). The maximum thresholds applying to maize will soon be confirmed, based on very restrictive proposals (UE 1881/2006), with maximum limits set at 1750 µg/kg for deoxynivalenol (DON), 200 µg/kg for zearalenon and 2000 µg/kg for fumonisins. The recommended thresholds (17th August 2006) for animal feed also require that everyone involved along the chain should strive to minimise risks.

It is the concern of everyone, at every level of activity in the maize sector:

- Storage facility organisations, cooperatives and merchants are going to be confronted with the market and the requirements imposed by their clients, i.e. downstream processors. They will have to provide a product meeting "food" and "feed" regulatory standards. They will have to take into account agronomical risk factors from the area from which they receive grain, risks from storage before and after drying and from the drying process itself, and will have to be sure of the quality of the grain. Their responsibility also extends to the influence they can exert on farmers' cropping practices.
- Farmers will have to modify some of their usual practices, being particularly careful with some agronomical practices (careful harvest residue management), modifying, if necessary, their cropping techniques and growing programmes (earliness, harvest date). Market access is at stake here.
- Upstream of the sector, and particularly seed companies, who will have to offer varieties adapted to new constraints, by removing the genetic material which is most susceptible to ear fusarium and fusariotoxins, and contributing to the choice of hybrids suited to the climate.
- ARVALIS – Institut du végétal, in partnership with economic and advisory organisations, by offering a preventative approach, with the possibility of earlier detection of risk factors, and by making information and decision-making tools available.
- Finally, French and European authorities, by helping farmers to protect their crops effectively against pests threatening the safety quality (seed treatments, Bt GMOs, targeted chemical treatments), managing crops with bearable levels of stress, limiting the exposure of plants to pathogens, and by prompting the Selection Technical Committee (CTPS) to qualify the level of susceptibility of varieties to ear fusarium and fusariotoxins.

Varietal study project

The varietal study project includes specific trials (three per year for each earliness category) and is based on the notes taken in post-registration trials presenting some symptoms. Around 287 grain maize varieties having been studied in post-registration since 2004, experimented on for a second year in 2003 and listed among the most commonly grown varieties, have been studied in their various cropping areas. The database includes 145 trials, with between 2 and 17 trials per variety, with varying intensity of infection from the two *Fusarium* families.

The summary below focuses on the 243 varieties with enough reference data (minimum of 3 trials), obtained in properly documented trials (confirmation of visual diagnosis carried out by trained technicians, minimum number of ears without borers, precise data, levels of infection allowing differentiation between behaviours). Data summaries were based on statistical analyses of the percentage of ears infected with fusarium (Bolton scale), using the SAS MIXED PROCEDURE which helps evaluate varietal effects with incomplete aggregation, taking differences between trials into account, and determine confidence interval for each average reference (at the 10% threshold).

The weather is the first risk factor of fusariotoxins being present.

Complex impact

We know which fungi are responsible for mycotoxins. Controlling toxins therefore implies controlling the pathogens which produce them. Maize is confronted with two main *Fusarium* families (*graminearum* and *moniliforme*), which produce regulated mycotoxins (zearalenon, trichothecens, including DON, and fumonisins). Even if the link between fusarium and fusariotoxins is undeniable, the complexity of competing species and strains, does not always allow precise prediction of the fusariotoxin content, based on the symptoms.

Symptom and fusariotoxin content variations noted from year to year confirm the substantial impact of climatic conditions: rain during female flowering and the days following it, hygrometry and temperatures during flowering and in autumn, length of exposure to pathogenic progression.

Determining which cropping techniques create risks

The 1600 field investigations set up to determine the causes of fusariotoxins and established by ARVALIS - Institut du végétal with several economic partners (cooperatives, merchants) since 2003, has helped assess mycotoxin contamination levels, to identify and hierarchically classify the main risk factors. They should result in the production of a model of all the interactions between climatic and agronomical factors. The weather always appears as the most significant factor. Borer insects on stem and ear (European corn borers, pink borers *Sesamia nonagrioides*, Heliothis) heavily influence the fumonisin content. The latter is also due to stress induced by lack of water, damage, cracks and pathogens on the ears, which encourage latent *Fusarium moniliforme,* extremely opportunistic and competitive, to enter the plant. This saprophyte behaviour, added to the crops being weakened by climatic stress specific to the year in question, could explain its presence in a large number of fields in 2006. The harvest date and maturity have a very significant impact on each type of mycotoxin. Varietal susceptibility is the second or third risk factor. The management of preceding maize residue is considered as a third level risk factor for DON and zearalenon, at the same level as varietal choice.

Fusariotoxin risk assessment matrix (table 1)

WITHOUT BORERS				WITH BORERS			
Harvest date	Varietal susceptibility to F. moniliforme /F. graminearum	Residue management	Risk category	Harvest date	Varietal susceptibility to F. moniliforme /F. graminearum	Residue management	Risk category
> 15/10	other varieties	satisfactory	A	> 15/10	other varieties	satisfactory	B
		unsatisfactory	A			unsatisfactory	C
	Most susceptible	satisfactory	B		Most susceptible	satisfactory	C
		unsatisfactory	B			unsatisfactory	D
15/10 to 31/10	other varieties	satisfactory	B	15/10 to 31/10	other varieties	satisfactory	B
		unsatisfactory	B			unsatisfactory	C
	Most susceptible	satisfactory	C		Most susceptible	satisfactory	C
		unsatisfactory	C			unsatisfactory	D
1 to 15/11	other varieties	satisfactory	B	1 to 15/11	other varieties	satisfactory	C
		unsatisfactory	B			unsatisfactory	C
	Most susceptible	satisfactory	C		Most susceptible	satisfactory	D
		unsatisfactory	C			unsatisfactory	E
< 15/11	other varieties	satisfactory	B	< 15/11	other varieties	satisfactory	D
		unsatisfactory	C			unsatisfactory	E
	Most susceptible	satisfactory	C		Most susceptible	satisfactory	E
		unsatisfactory	D			unsatisfactory	E

**Risk: from A, lowest risk, to E, highest risk*

Towards a fusariotoxin risk assessment matrix

ARVALIS - Institut du végétal offers an assessment matrix to identify and classify cropping techniques according to an increasing risk of mycotoxins appearing (table 1).

This matrix assesses the overall risk of fusariotoxins and includes the three types of mycotoxins which are subject to regulation: DON, zearalenon and fumonisins. It is based on the combination of four main factors: presence of borer insects, harvest date, harvest residue management, and varietal choice. Five groups of cropping techniques have been defined, to help identify the fields least at risk (A) and progress up to those facing the highest risk (E), depending on the accumulation of factors. However, the absolute value given to the risk level can be adjusted depending on climatic conditions.

A few prevention principles to lower the risk

The accumulation of risk factors compounds the problem. Those interactions require the choice and simultaneous implementation of several technical levers, in order to limit the risk of fusariotoxins.

- Protecting fields against European corn borers and pink borers (*Sesamia nonagrioides)* in order to reduce fumonisin levels, when the infestation reaches a level which justifies it.
- Optimum maize sowing and harvest dates, choosing varieties with the appropriate levels of earliness and maturity at harvest. Harvest after 1st November must be ruled out. Once the symptoms are well established, harvest must not be postponed for too long after maturity, in order to limit the progression of fusarium and the accumulation of toxins. Therefore, the temperatures required by a variety to reach physiological maturity must be compatible with the temperatures available in the area at the sowing date. After 10th/15th May, an earlier variety must be chosen.
- The choice of variety. Choosing a variety with the right level of earliness and offering an early harvest date in the area where it will be grown is a prerequisite. The acceptable level of susceptibility depends on which practices are implemented to tackle the other risk factors, as well as on all the agronomical characteristics of the variety in question. The most susceptible varieties should be avoided and the varieties chosen should be matched with appropriate cropping techniques which suit them.
- Maize residue management after harvest, and soil cultivation. Plant residue on the ground constitutes a potential risk of infection for the following crop of maize, both from fusarium and borers. Chopping the canes very finely immediately after harvest, combined with early shallow incorporation of this mulch by stubble cultivation, has several advantages: it encourages organic matter to decompose and facilitates its later incorporation during deeper soil cultivation work, and it helps reduce European corn borer and pink borer populations. The implementation of those recommendations is indeed dependent on autumn rainfall and soil conditions. It implies certain adjustments in terms of harvest dates and of the application calendar. Deep cultivation work, which helps incorporate residue, reduces the infection potential.

To know the varieties behaviour vis-à-vis the graminearum and the moniliforme Fusarium, thanks to contact ARVALIS' specialists

Varietal impact

In parallel with the field investigation project, which confirms the interaction between risk factors, ARVALIS – Institut du végétal conducted experiments on the impact of various factors. The study into the way different maize varieties behave has been the subject of particularly heavy investment. Differences in the way symptoms are expressed have been verified, identifying specific behaviours with regards to susceptibility to the two *Fusarium* families. The varietal impact only becomes outwardly noticeable when there is a potential for infection, and more so if it is virulent.
Genetic variability when the plant is threatened by *Fusarium graminearum* is more significant than for Fusarium moniliforme, which is even more influenced by interactions. The varieties which are most often affected by graminearum are not necessarily those most often affected by moniliforme and vice versa.
However, *F. graminearum* infection can create entry channels for moniliforme, as this was observed on cephalosporium necrosis, grain cracks and borer tunnels.

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