Strategy for the fumonisin reduction in maize kernel in Italy

Stratégie pour la réduction des fumonisines dans le grain de maïs en Italie

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Abstract

Mycotoxins in cereals are an economic and health problem. The aim of this research is to evaluate the effect of combined agronomic techniques on mycotoxins contamination in maize kernels.

Three experimental fields were realised in 2005 and 2006. In each place, these treatments were compared: 2 hybrids (FAO class 400 and FAO class 600) and 4 combinations of agronomic techniques (seed time, seed density, N fertilization and ECB control): a) TAR1; b) TAR2; c) TAC; d) TAA.

The severity of ECB injury was higher in late planting than usual planting. The chemical treatment reduced on average the percentage of plants injured from ECB of the 55%. The thesis TAR2 and TAC reduced on average of the 60% the severity of mould of the ear than TAR1.

The results stressed a mean reduction of the fumonisin contamination of 2, 3 and 9 times respectively for TAR2, TAC and TAA than TAR1. A significant increased contamination of deoxynivalenol was pointed out for both hybrids only with late planting, while aflatoxins resulted low in all place.

Keywords: Maize, agronomic technique, mycotoxins, fumonisins, deoxynivalenol, aflatoxins

Résumé

La présence de mycotoxines dans les céréales est en train de devenir un véritable problème économique et sanitaire.
En 2005-2006 nous avons réalisées 3 parcelles expérimentales. Pour chacune les traitements suivant ont été combinés et confrontés: 2 hybrides et 4 techniques agronomiques (date des semaines, densité des plantes, engrais azoté, traitement contre la pyrale: a) TAR1; b) TAR2; c) TAC; d) TAA.

L’intensité des attaques des pyrales s’est montrée toujours plus élevée pour les semis tardifs par rapport aux ordinaires. Les traitements insecticides ont moyennement réduit de 55% les plantes attaquées. Par rapport au TAR1, les parcelles TAR2 et TAC ont mis en évidence une réduction moyenne de 60% de la surface des moisissures de l’épi. Toujours rapporté au TAR1, les résultats ont montré une diminution moyenne de la contamination par les fumonisines de 2, 3 et 9 fois, respectivement pour TAR2, TAC et TAA.

Seulement au cas des semis tardifs, l’augmentation significative de la contamination par le deoxynivalenol a été remarquée, tandis que les contaminations par les aflatoxines se sont révélées très limitées pour chaque année et lieux.

Mots clés : Maïs, technique agronomique, mycotoxines, fumonisines, deoxynivalenol, aflatoxines

Introduction

Mycotoxins in cereals are an economic and health problem (Shephard, 2006). Mycotoxins are secondary metabolites produced by plant fungal specie parasite or by foodstuff mouldiness agents which can produce acute or chronic pathologies known as mycotoxicosis, when they are ingested with feed or food. In temperate climate maize is the cereal that needs the highest level of attention, because it could be contaminated by more metabolites (AA.VV., 2004). Mycotoxins production became mainly in field, influenced by environmental conditions during ripening and by cultural choices that influence the length and the period (Reyneri et al., 2005). Despite the huge research work, useful detoxifying and reclaiming techniques for contaminated lots have not been found yet, because mycotoxins have a high molecular stability. Indeed, in order to get a good detoxification, very intensive treatments are required, although they could compromise product quality, or could result to be economically inconvenient (Sinha, 1998). At the moment, the best control strategy seems to be prevention, in order to reduce kernel toxins accumulation by realising unfavourable growing conditions to the toxigenic fungal species. The aim of this research, that is part of the national project MICOCER, is to evaluate the effect of combined agronomic techniques on mycotoxins contamination in maize kernels.
Materials and methods

In 2005 and 2006, two experimental fields were realised in Piedmont in Carmagnola (TO) and Vigone (TO) and one in Mantova (MN). In each place, with a common protocol, these treatments were compared: 2 hybrids (PR35Y65 of FAO class 400 and Kermess of FAO class 600) and 4 combinations of agronomic techniques (seed time, seed density, N fertilization and European Corn Corer - ECB control, *Ostrinia nubilalis* Hb.) following this schedule:

- TAR1: high risk agronomic technique, characterized by late planting and high seed density and N fertilization;
- TAR2: medium risk agronomic technique, characterized by usual planting and high seed density and N fertilization;
- TAC: right agronomic technique, characterized by early planting, low seed density and balanced N fertilization;
- TAA: careful agronomic technique, characterized by the same agronomic techniques of TAC and by ECB control with chemical treatment.

At harvest, 3 repetition of 200 ears were collected by hand in each plot. These samples were: i) visually evaluated for the quantification of the European corn borer damage and for the toxigenic fungi development; ii) analyzed for fumonisin B1+B2 (Fu), aflatoxin B1, B2, G1 and G2 (Afla) and, only for 2005, Deoxynivalenol (DON) content with HPLC technique.

Results

The severity of ECB injury was higher in late planting (May) than usual planting for Po Plain (end of March, beginning of April). The chemical treatment reduced on average the percentage of plants injured from ECB of the 55%. TAR2 and TAC reduced on average of the 60% the severity of mould of the ear than TAR1. The application of TAA protocol allowed to reduce of the 87% the mean area of mould ear than TAR1.

The results stressed a mean reduction of the fumonisin contamination of 2, 3 and 9 times respectively for TAR2, TAC and TAA compared to TAR1, that in each place and year was the most contaminated for this toxin (Table 1) There were no significant differences for fumonisin contamination between hybrids with different precocity.

Aflatoxins were very low and present mainly in Mantova. For these toxins the combinations of agronomic techniques shown no clear differences. The early maturing hybrid (FAO class 400) shown a mean contamination of aflatoxin B1 higher than late maturing hybrid (FAO class 600).
Tab. 1. Comparison between different combined agronomic techniques of maize for kernel on the severity of mould of the ear and on the fumonisin B1+B2 (Fu) and total aflatoxins (Afla)

<table>
<thead>
<tr>
<th>Place</th>
<th>Treatments</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Severity fus. (%)</td>
<td>Fu (µg kg⁻¹)</td>
<td>Afla (µg kg⁻¹)</td>
</tr>
<tr>
<td>Carmagnola</td>
<td>TAR1</td>
<td>9.9 a</td>
<td>3250 a</td>
</tr>
<tr>
<td></td>
<td>TAR2</td>
<td>10.6 a</td>
<td>2478 a</td>
</tr>
<tr>
<td></td>
<td>TAC</td>
<td>6.3 b</td>
<td>2690 b</td>
</tr>
<tr>
<td></td>
<td>TAA</td>
<td>5.2 b</td>
<td>2766 b</td>
</tr>
<tr>
<td>Vigone</td>
<td>TAR1</td>
<td>17.1 a</td>
<td>2759 a</td>
</tr>
<tr>
<td></td>
<td>TAR2</td>
<td>14.4 a</td>
<td>24281 a</td>
</tr>
<tr>
<td></td>
<td>TAC</td>
<td>4.3 b</td>
<td>1538 b</td>
</tr>
<tr>
<td></td>
<td>TAA</td>
<td>2.2 b</td>
<td>5484 c</td>
</tr>
</tbody>
</table>

NR: value under the limit of quantification (0.2 µg kg⁻¹ for aflatoxin, 10 µg kg⁻¹ for fumonisin B1 + B2)

(*) Measured as mean percentage of the ear surface with symptoms of the attack by species of Fusarium and other fungi, mean value of the 3 replications of 30 ears each.

Analysis of 200 ears of maize drawn in a representative way from each experimental plot. The values reported in table are the mean of PR35Y6 and Kermess hybrids. The same letter shows no significative differences.

In 2005 a significant increased contamination of deoxynivalenol was pointed out for both hybrids with late planting and also with the combination of high plant density and N fertilization. The chemical treatment against ECB showed no effect on the content of this mycotoxin (Table 2).

Tab. 2. Comparison between different combined agronomic techniques of maize for kernel on the content of deoxynivalenol (DON)

<table>
<thead>
<tr>
<th>Place</th>
<th>Treatments</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DON (µg kg⁻¹)</td>
<td></td>
</tr>
<tr>
<td>Carmagnola</td>
<td>TAR1</td>
<td>753 a</td>
</tr>
<tr>
<td></td>
<td>TAR2</td>
<td>558 a</td>
</tr>
<tr>
<td></td>
<td>TAC</td>
<td>283 b</td>
</tr>
<tr>
<td></td>
<td>TAA</td>
<td>121 b</td>
</tr>
<tr>
<td>Vigone</td>
<td>TAR1</td>
<td>649 a</td>
</tr>
<tr>
<td></td>
<td>TAR2</td>
<td>595 a</td>
</tr>
<tr>
<td></td>
<td>TAC</td>
<td>267 b</td>
</tr>
<tr>
<td></td>
<td>TAA</td>
<td>332 b</td>
</tr>
</tbody>
</table>

Analysis of 200 ears of maize drawn in a representative way from each experimental plot. The values reported in table are the mean of PR35Y6 and Kermess hybrids. The same letter shows no significative differences.

The late planting (TAR1), during the month of May, caused a mean yield loss of the 24% respect to the planting date of March and April. There were no significant productive differences between TAR2, TAC and TAA.

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Discussion

The results of this study confirm that the climatic factors throughout the season determine the presence of fungal species in maize kernels and the type of mycotoxins found in grains. Moreover this research has confirm that crop techniques have a clear effect on fungal infection and this could stress the differences on mycotoxin concentrations. Therefore, data clearly underline the possibility to improve management in order to control mycotoxins in the corn kernel, and to guarantee a better sanitary and quality of the product.

Fumonisins, but not aflatoxin, appear to be highly correlated with ECB infection. Chemical control, against this phytophagous, was successful to control these mycotoxins; moreover early time of sowing has been another key to control ECB and therefore the contamination of this mycotoxins.

The presence of deoxinivalenol is more related to all the crop techniques (late planting, high nitrogen fertilization and plant density) that lead to a larger development of green tissue in plants and prolonged vegetative growth, which delay kernel dry-down and physiological maturity and make the microclimatic conditions inside the crop more humid. These results agree with the conditions that are known to be favorable for \textit{F. graminearum} development (Munkvold, 2003).

The contamination of aflatoxins observed was low and limited at the site more warm and at the early hybrid. The presence of this mycotoxin seems to be more related to stress conditions for the crop, such as drought and lack of nitrogen.

Conclusion

Toxins produced by the species of genus Fusarium are always present in maize productions of the North Italy. The choice of early planting, low plant density and balanced nitrogen fertilization, allowed to control always in a significative way the presence of these toxins. Furthermore, the chemical treatment against ECB was a factor always determinative in the reduction of fumonisins.

Acknowledgements

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References


