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Improving risk assessment to minimise fusarium mycotoxins in harvested oats and malting barley

by

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This is the final report of three projects (RD-2007-3332, RD-2007-3401 and RD-2008-3574) which started in April 2007, January 2008 and July 2009. The work was funded by contracts totalling £258,898 from HGCA.

1. ABSTRACT

This report details HGCA-funded research to further identify the effects of agronomic practices on the concentration of fusarium mycotoxins in UK barley and oats over a number of seasons. One hundred samples both of barley and oats were collected each year at harvest, together with agronomic details, and analysed for ten fusarium mycotoxins including deoxynivalenol (DON), nivalenol, HT2, T2 and zearalenone (ZON). The European Commission (EC) set legislative limits for the fusarium mycotoxins, DON and ZON in cereals and cereal products intended for human consumption in July 2006. New investigative limits for HT2 and T2 in cereals and cereal products were proposed in May 2012. The investigative limits for unprocessed barley and oats for human consumption are 100-200 and 1000-1500 parts per billion (ppb), respectively. Further legislative measures for HT2 toxin and T2 toxin (HT2+T2) will be considered in 2015.

The incidence and concentration of most fusarium mycotoxins, including DON and ZON, have remained relatively low in both barley and oats compared to values for wheat. Concentrations of DON and ZON exceeded legislative limits in a low percentage of both barley and oats over the three years sampled. These high levels were associated with the wet summers of 2007-2009. Concentrations of HT2 and T2 in barley have only exceeded 100 ppb seven times in seven years (0.9% of samples).

HT2 and T2 levels continued to be relatively high in UK oats with an overall mean of 450 ppb for 2006-2008. From 2002-2008, between 1 and 30% of samples exceeded 1000 ppb HT2+T2 each year (annual mean was 16%). There was a negative relationship with late summer rainfall, indicating that drier conditions in July and August result in increased HT2 and T2 in UK oats. Agronomic factors that impacted upon HT2 and T2 in harvested oats were previous crop, cultivation and variety. Analysis of the previous cropping history showed there was a stepwise increase in HT2+T2 as the cereal intensity of the rotation increased. Variety was an important factor with higher levels and a wider range detected on winter compared to spring varieties. Analysis of oat samples from HGCA Recommended List trials confirmed the differences observed in the survey data and provided clear comparisons between all RL varieties under controlled field conditions.

The introduction of European legislation on HT2 and T2 mycotoxins could have serious implications for UK oat production and oat processing industries based on current levels.

2. SUMMARY

2.1. Introduction

Fusarium mycotoxins are toxic compounds that are produced as a result of the disease fusarium head blight, caused by *Fusarium* species. The most important head blight pathogens, worldwide, are *F. graminearum* and *F. culmorum*, which produce deoxynivalenol (DON) and zearalenone (ZON). The mycotoxins are present in both grain and straw at harvest and are hazardous to human and animal health at high concentrations. European Commission (EC) legislative limits for the fusarium mycotoxins, DON and ZON were introduced in 2006 for cereals and cereal products intended for human consumption. Guideline limits were also set for animal feed in the same year. Two other Fusarium mycotoxins related to DON are HT2 toxin and T2 toxin. There is no current legislation for these mycotoxins but investigative limits were proposed recently (May 2012) further legislative measures will be considered in 2015. Proposed investigative limits for unprocessed cereals intended for human consumption are as follows; for barley 100-200 ppb, for oats 1000-1500 ppb and for wheat 50-75 ppb HT2+T2. The EC recommendation is expected to request that member states in conjunction with food operators monitor HT2 and T2 in a wide range of cereals and cereal products and where investigative limits are exceeded then the factors resulting in the occurrence of the high concentrations and measures to avoid or reduce such high levels should be determined.

Based on a previous FSA/HGCA funded project (Edwards, 2007b), it was identified that both barley and oats tended to have low levels of fusarium mycotoxins DON and ZON compared to wheat, but oats had high concentrations of HT2 and T2 and there was an indication that levels of HT2 and T2 may be increasing in UK malting barley.

The aims of the projects detailed in this report were:

- To monitor fusarium mycotoxins in UK barley and oats over three years
- To determine the impact of additional agronomic factors, such as cereal intensity within rotations and crop debris management, on the fusarium mycotoxin contamination of UK barley and oats
- To monitor the HT2+T2 content of oat varieties from HGCA Recommended List trials
- To improve mycotoxin risk assessments for UK barley and oats

2.2. Materials and methods

Each year ca. 100 samples of oats (2006-2008) and malting barley (2007-2009) were collected at harvest from fields of known agronomy. Samples were collected by crop consultants (AICC, Agrovista, DARD and Scottish Agronomy). Samples were milled and then analysed for fusarium

mycotoxins; DON, ZON and another eight trichothecenes (relatives of DON including HT2 and T2) by liquid chromatography with tandem mass spectrometry (LC/MS/MS) at Campden BRI.

Summary statistics (percentage incidence and percentage above legal limits for cereals intended for human consumption, mean and median) of mycotoxin concentrations were produced and had been reported on the HGCA website Concentrations of fusarium mycotoxins were modelled against the agronomy factors to identify the importance of various agronomic factors. Where possible, data from the previous project (HGCA Project Report No. 415) were included.

Each year (2006-2011) oat variety samples from HGCA Recommended List fungicide treated trials were analysed for HT2+T2.

2.3. Results

For barley, mycotoxin levels remained low in all years except for DON and ZON. DON was above the legal limit (1250 ppb) in a single sample (0.7%) after the wet, delayed harvest of 2008. Of greater concern was ZON which was above the legal limit of 100 ppb in a low percentage of samples (ca. 5%) in all three years (2007-2009). This is markedly higher than experienced in the previous project (2002-2005) and was associated with wet weather in July and August in those years.

There were significant differences in DON and ZON concentrations for barley following different previous crops, with barley grown after maize as previous crops have been significantly more at risk from DON and ZON than other crops. There were significant differences between DON and ZON concentrations in different varieties of barley, although some of these differences may in part be due to when and where these varieties were grown.

The incidence and concentration of the HT2 and T2 continued to be high in UK oats with quantifiable concentrations in most samples and a combined mean concentration (HT2+T2) of 450 ppb for all samples from 2006-2008. This is a slight drop from the previous study which had a mean of 682 ppb for all conventional oat samples analysed from 2002 to 2005. The concentration of HT2+T2 was modelled against agronomic practices applied to each field.

There was a significant interaction between year and region, which is probably due to fluctuation in weather between years and regions. There was a strong negative relationship between harvest rainfall and HT2+T2, indicating that concentrations are higher when weather is drier in July and August. This is the opposite trend to ZON concentration in wheat and barley, which is higher after wet weather in late summer. There was no trend from North to South, as seen for DON and ZON in wheat and barley, which would indicate that the temperature difference across the UK does not

limit HT2 and T2 production in oats. Oat samples with more than 500 ppb HT2+T2 were detected in all regions of the UK.

The impact of previous crop and cultivation was studied using various datasets and categories. Analysis of previous crops showed no differences between HT2+T2 in oats after different cereal crops so the categories of cereal and non-cereal were used to look at the interaction of previous crop (cereal or non-cereal), crop debris management (baled or chopped) and cultivation (plough or min-till). Crop debris management and all interactions involving crop debris management were not significant. There was a significant interaction between cultivation and the last two previous crops with results indicating that cereal debris either left on the soil surface from the previous crop or ploughed back to the surface from two years previous, increased the risk of HT2+T2 in oats. There was a stepwise increase in HT2+T2 concentration as the cereal intensity within the rotation increased. This suggests that cereal debris is important in the epidemiology of HT2+T2 producing *Fusarium* species and the level of inoculum of these *Fusarium* species can build up over time.

There were significant differences in the HT2+T2 content of different UK varieties. HT2+T2 content of spring oat variety trial samples were consistently lower than winter oat samples. Naked oat varieties tended to have a lower HT2+T2 content compared to conventional husked oat varieties. Naked oats have a loose husk which is removed during harvesting. Short-strawed varieties tended to have a high HT2+T2 content.

2.4. Discussion

Legislative limits for fusarium mycotoxins, DON and ZON, in unprocessed cereals and cereal products intended for human consumption were set in 2006. Based on project results collated since 2002, there is a low risk of UK barley and oats exceeding these legal limits. UK barley and oats are less prone to Fusarium infection by DON and ZON-producing species, *Fusarium graminearum* and *F. culmorum*, compared to wheat. The main issue identified for barley is the impact of delayed wet harvests on ZON, resulting in 5% of samples exceeding the legal limit for ZON (100 ppb) within the current project (2007-2009).

For UK oats, DON and ZON levels were consistently low except after the delayed wet harvest of 2008 when 1 and 6% of samples exceeded the legal limits for DON (1750 ppb) and ZON (100 ppb), respectively. It is of concern, that there has been a dramatic increase in DON levels in Nordic oats in recent years, the cause of which has not yet been determined.

Investigative limits for fusarium mycotoxins, HT2 and T2 are currently under discussion within the European Commission. These mycotoxins have equivalent toxicity and any limit set will be based on a combined concentration (HT2+T2). Recently proposed investigative limits (May 2012) of

1000-1500 ppb for unprocessed oats and 100-200 ppb HT2+T2 for unprocessed barley for human consumption. The concentration of HT2 and T2 has remained consistently low in malting barley during 2007-2009; this is likely to be associated with the wet late summers experienced in these years. For UK oats, HT2 and T2 concentrations have remained relatively high although they were lower in 2008 after the delayed wet harvest. For UK oats there was a negative relationship between harvest rainfall and HT2+T2 concentration in oats. As the harvest rainfall increased, the level of HT2+T2 decreased. This is the opposite of the observed relationship for harvest rainfall and ZON concentration in wheat and barley.

Analysis of agronomic factors has again highlighted the impact of previous crop and variety on HT2 and T2 concentrations in UK oats. Analysis of HGCA RL trials over 6 years has identified consistent significant differences between winter oat varieties and that all spring varieties are consistently low.

New to this project was the identification that cereal intensity is important, with a stepwise increase in HT2+T2 as more cereals exist within a rotation.

The level of HT2 and T2 has been monitored in UK barley and oats from 2002-2008. During this time the proposed lower investigative limit for unprocessed barley (100 ppb) has only been exceeded seven times in seven years (0.9%) whilst the percentage exceeding the lower investigative limit for unprocessed oats (1000 ppb) has fluctuated between 1 and 30% with an overall average of 16%.

The introduction of European legislation on HT2 and T2 mycotoxins would have limited impact on UK barley production but could have serious implications for UK oat production and oat processing industries based on current levels in UK cereals.

To reduce the concentration of fusarium mycotoxins in UK barley growers should consider:

- Avoiding growing barley after maize
- Avoiding delays in harvest

To reduce the concentration of fusarium mycotoxins in UK oat growers should consider:

- Growing spring oats
- Growing oats in less cereal intense rotations
- Growing conventional winter varieties with consistently low HT2 and T2 levels (eg SW-Dalguise and Millennium)
- Growing naked oats for animal feed
- Avoid delays in harvest