Final Project Summary

Project title	Improved Modelling of Fusarium to Aid Mycotoxin Prediction in UK Wheat		
Project number	RD-2008-3573	**Final Project Report**	PR566
Start date	01 April 2009	**End date**	15 July 2014
AHDB Cereals & Oilseeds funding	£283,527	**Total cost**	£283,527

What was the challenge/demand for the work?

Since 2001 there has been an increase in fusarium head blight (FHB) caused by *F. graminearum* and a corresponding increase in the concentration of mycotoxins produced by this species, namely deoxynivalenol (DON) and zearalenone (ZON) within wheat grain. Legislation in 2006 set maximum limits for DON and ZON in cereals and cereal products intended for human consumption. Previous projects have identified that fusarium mycotoxin contamination of wheat is highly seasonal with exceedances of legal limits in unprocessed cereals varying between 0 and 29% between years.

Previous projects have modelled the severity of *F. graminearum* infection and concentration of DON against agronomic factors and identified the large importance of regional and seasonal variation primarily due to the impact of weather on the *Fusarium* infection process and mycotoxin production.

The aim of this project was to improve the ability to predict fusarium mycotoxins in UK wheat by the incorporation of meteorological data within prediction models.

How did the project address this?

This project investigated *Fusarium* development in the growing season, assessed FHB severity in the summer and the mycotoxin content of grain at harvest. Each year, 300 wheat fields in England were assessed for FHB as part of the Defra-funded winter wheat disease survey. Grain samples from the same fields were requested from growers and analysed for fusarium mycotoxins. FHB pathogen levels and mycotoxin concentrations were modelled against meteorological data to provide a greater understanding of the important parameters involved and to provide models to predict FHB severity and mycotoxin content (DON and ZON) of harvested wheat. Data from a previous project was combined with this project to model six years data (2006 to 2011). Data from the two subsequent years, 2012 and 2013 were used to validate the models developed.

The project aimed to aid the prediction of risk at key stages of crop development:
a) Pre-flowering to allow T3 fungicide applications to be adjusted according to risk
b) Pre-harvest to allow the cereal industry to prepare for harvest.

Prediction of risk was also performed at different spatial scales:
a) national
b) regional (based of grower's agronomy data and met station data).
c) farm scale (based on grower's own agronomy and meteorological data).

Final Project Summary

What outputs has the project delivered?

Data was generated on the early season occurrence of FHB pathogens during the seasons of 2009 to 2011 as well as the occurrence of FHB pathogens at the soft dough stage (GS73) and on the concentration of fusarium mycotoxins in harvested grain for 2009-2013. Collated data from 2006-2011 was then used to develop models to predict fusarium pathogen incidence and mycotoxin risk at different timings (early and late season) and at different levels (national, regional and field).

Results showed large seasonal differences in fusarium pathogen incidence and mycotoxin risk with high levels in 2012 (10% and 15% exceeding legal limit for DON and ZON, respectively) and low levels in 2011 (no samples exceeding legal limits for DON and ZON).

Prediction of mycotoxin content early season was not successful with poor prediction in the validation years of 2012 and 2013.

Analysis of agronomic factors identified the same factors as previously determined, namely previous crop, cultivation and variety. A new factor determined was harvest date with a one month delay in harvest resulting in a large increase in risk for both DON and ZON (Figure 1), as was experienced with the delayed harvest of 2008.

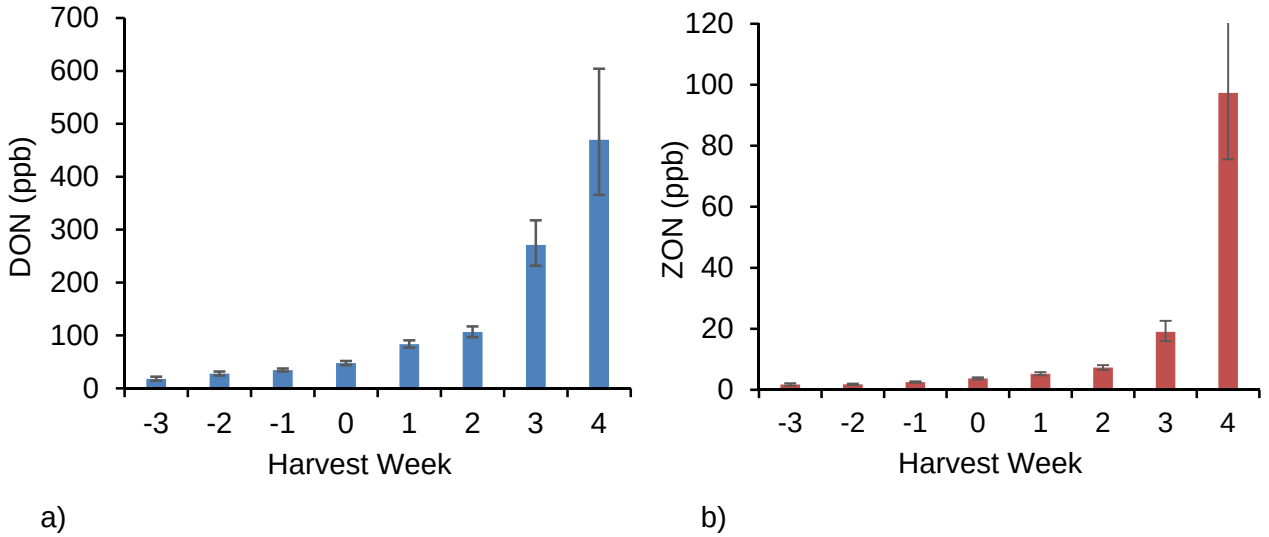

Figure 1. a) DON and b) ZON predicted mean concentration of wheat samples grouped by harvest week. Week zero represents the long term average local harvest date. Minus weeks are early harvests, plus weeks are late harvests. Bars represent 95% confidence limits for predictions.

Final Project Summary

Prediction of mycotoxin late season, based on a combination of fusarium head blight pathogen incidence (as recorded at growth stage 73) and agronomy was a better predictor of risk and proved reasonable at the national and field scale.

At field scale, the DON model was a better predictor of risk than the ZON model and could be used to predict ZON as well as DON risk.

As false negatives have a greater consequence for the industry (consignments of wheat exceeding legal limits entering the food chain), then the probability of exceeding the legal limit can be calculated and this can be used to determine a lower risk threshold for predicting false negatives.

With a threshold of 5%, then a sample is deemed to be a low risk of exceeding the legal limit if the probability that the actual concentration will exceed 1250 ppb DON is below 5%.

With a 5% probability that a sample exceeded the DON limit, no samples above the legal limit were predicted not to exceed the DON limit (zero false negatives) (Table 1) and only 0.4% of ZON samples exceeded the ZON limit of 100 ppb but were predicted not to (0.4% false negatives).

A lower probability threshold results in an increase in false positive samples (predicted to exceed legal limits when actually they are below the limit). This would result in these consignments of wheat requiring mycotoxin testing.

Table 1. Matrix of predicted against actual DON concentration based on the legislative limit of 1250 ppb weighted against false negatives (5% probability). Correct predictions are shown in green, false positives in orange and false negatives in red.

		Actual DON (ppb)		
		<1250	>1250	
Predicted DON (ppb)	<1250	47	0	47
	>1250	46	8	53
		92	8	100

Who will benefit from this project and why?
This project has the potential to benefit the whole supply chain for wheat for human consumption as well as the consumer.

Final Project Summary

The identification of seasonal risk to fusarium mycotoxins will aid the industry in setting the level of due diligence testing required and as such will help lower the risk of exceedances occurring in wheat and wheat products and as such reduce consumer exposure to these harmful mycotoxins.

The development of a late-season risk prediction based on models developed in this project would allow selective testing of wheat consignments for fusarium mycotoxins. Currently all wheat destined for human consumption is tested for DON in store at a typical cost of £35 /test. In seasons with predicted low risk a minimal number of consignments would require testing vastly reducing the costs to the industry.

If the challenge has not been specifically met, state why and how this could be overcome

Prediction of mycotoxin content early season was not successful with poor prediction in the validation years of 2012 and 2013. This is likely due to a number of factors including the large number of zero values in the model, the poor ability to predict the key growth stages for fusarium infection in winter wheat and the paucity of local meteorological data for some fields.

This study has highlighted the need for greater recording and/or prediction of growth stages to improve mycotoxin prediction alongside greater availability of in-field weather data. Alternative modelling methodology including mixed models or mechanistic models may be better approaches.

The incidence of fusarium head blight pathogens as determined by Fera from the Defra funded winter wheat disease survey proved to be useful parameters in the late season prediction of both national, regional and field mycotoxin risk. The continuity of funding for this program of work should be promoted and the development of a national and field scale risk assessment based on the model developed using the pathogen incidence data should be considered.

Lead partner	Harper Adams University
Scientific partners	Fera Science Ltd, NIAB TAG
Industry partners	
Government sponsor	