Final Project Summary

Project title	Integrated strategy to prevent mycotoxin risks (Inspyr)		
Project number	RD-2007-3453	**Final Project Report**	PR549
Start date	1 October 2009	**End date**	31 September 2013
AHDB Cereals & Oilseeds funding	£210,020	**Total cost**	£1,388,830

What was the challenge/demand for the work?

Fusarium head blight (FHB) of cereals poses an increasing threat to the UK wheat and barley crops. In addition to yield loss, FHB is of particular concern because the *Fusarium* species produce a spectrum of trichothecene mycotoxins (DON, NIV, T2 and HT-2) within grain that are harmful for human and animal consumption.

FHB reached its highest recorded level in the UK in 2007 with 86% of samples from the Defra 'CropMonitor' project containing FHB pathogens. In 2008, although the percentage of samples containing FHB pathogens was reduced (64%), the delayed harvest (due to rain) promoted mycotoxin accumulation. Approximately 15% of wheat samples within the 2008 survey exceeded the EU limit for DON while 30% exceeded the limit for another *Fusarium* mycotoxin, zearalenone. These levels make the grain unsuitable for human consumption. In an epidemic year, with an average of 5% ear disease nationally the expected losses would be in the region of £54.7 million (at current prices). This does not include the cost of fungicide application or the losses due to reduced quality. The requirement to test for mycotoxins also incurs a very significant additional cost to producers and processors.

It is widely recognised that resistant varieties offer the best option to control FHB. All wheat and barley breeders consider it as a major but difficult target for resistance breeding. Incorporation of high levels of FHB resistance into wheat and barley will be critical to prevent mycotoxin contamination of grain from becoming a major problem for all elements of the UK food and feed chains.

Two forms of fusarium head blight (FHB) resistance are well recognised: Type 1 (resistance to initial infection) and Type 2 (resistance to spread within the head). Barley is much more resistant to DON than wheat and exhibits inherently high levels of Type 2 resistance. Thus, differential FHB resistance among barley varieties is due to differences in Type 1 resistance.

A previous AHDB Cereals & Oilseeds supported LINK project (REFAM) showed that most current UK wheat varieties are highly susceptible to FHB with little genetic variation for resistance. Much of the susceptibility of UK varieties was associated with the *Rht2* semi-dwarfing gene which was in

almost all UK varieties at that time. It was not known whether this effect was due to a pleiotropic effect of the semi-dwarfing gene itself or due to linkage with a gene conferring increased susceptibility to FHB. If it is the latter then this association must be broken to enable breeders to produce FHB resistant varieties with acceptable agronomic characters.

As stated above, UK wheat and barley varieties are highly or moderately susceptible to FHB. No commercially significant variety is sufficiently resistant to remove the need for fungicide application to control the species responsible for FHB under conditions conducive for infection. Timely application with appropriate triazole fungicides can restrict disease development and mycotoxin accumulation. Under moderate to high disease pressure, however, fungicide application often fails to reduce DON contamination to below EU legislative limits in susceptible varieties such as those currently grown in the UK.

An integrated approach, based on varieties with significantly enhanced resistance and appropriate fungicide application may provide the best means to achieve sustainable control of FHB and minimise the risk of mycotoxins entering the food and feed chains.

How did the project address this?

The project set out to identify and characterise new sources of FHB resistance in wheat and barley focussing on Type 1 resistance (preventing initial infection). In addition, it initiated study for the potential of developing an integrated and sustainable approach to FHB control through the use of resistant varieties combined with appropriate fungicide application.

The project was divided into five work packages to reflect the specific objectives:

1) Identification of FHB resistance in wheat and barley with emphasis on Type 1 resistance.
2) Exploitation of synteny to break the linkage between FHB susceptibility and *Rht2* (*Rht-D1b*) locus.
3) Identification and mapping of FHB resistance QTL in barley by association genetics.
4) Identification of the optimal integration of host resistance and fungicides to control FHB and mycotoxin accumulation.
5) Fine mapping of the Type 1 FHB resistance on chromosome 4AS of *Triticum macha*.

What outputs has the project delivered?

The project revealed that the presence of awns appears to increase FHB resistance in wheat. This was observed in several populations. It is not known whether this effect is due to the awns

themselves or genes near to that encoding the gene responsible for the presence of awns. Some reports have suggested that awns may increase susceptibility to FHB and perhaps further work is warranted to clarify to effect of the presence of awns on FHB susceptibility. This finding is significant because almost all UK wheat varieties lack awns and this may in part account for the overall high level of susceptibility in UK wheat varieties.

Most UK varieties carry the semi-dwarfing gene (*Rht2*). The presence of this gene has long been associated with susceptibility to FHB. The Inspyr project revealed that the effect is due, not to the *Rht2* gene itself but to a nearby gene. Using markers located near the susceptibility gene it is now possible for breeders to select lines of the desired height for UK conditions but that lack the FHB susceptibility factor. This should provide a very rapid means to improve the overall FHB resistance of UK wheat varieties.

The Inspyr project demonstrated that an integrated approach of growing FHB resistant varieties and treating with appropriate fungicides at the time of flowering provides a means to reduce the risk of DON accumulation in grain exceeding EU thresholds. This offers an approach to maintain crop and consumer health, even under conditions of high disease pressure.

While in wheat, greater resistance to FHB is often associated with greater plant height, this does not appear to be the case for barley. A potent FHB resistance was identified in the heritage barley variety Chevallier that functions independently of plant height.

Study of a large panel of barley varieties revealed several regions of the barley genome associated with differential resistance to FHB. These provide targets for breeders to select when seeking to improve the FHB resistance of their varieties.

The findings of the Inspyr project offer plant breeders and growers a number of ways in which to improve the overall FHB resistance of UK wheat and barley varieties and to reduce the risk of mycotoxin accumulation in grain in their crops even when exposed to high disease pressure.

Further work will be required to find the optimum number and type of FHB resistances required to work alongside the available fungicides to eliminate the risk posed by FHB in most circumstances. Additional work will also be required to identify how the resistances interact with different fungicide chemistries to provide optimal control.

Who will benefit from this project and why?

The Inspyr project benefits the cereal industry through assisting breeders to more effectively develop varieties with resistance to all FHB species by expanding knowledge of the genetics of

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resistance. Widespread cultivation of FHB resistant varieties will also reduce the need for highly expensive mycotoxin testing by millers and maltsters.

Growers will, in a short time, benefit through new highly resistant varieties with desirable agronomic characteristics (e.g. semi-dwarf). These will combine increased yield with reduced inputs to significantly improve efficiency and reduce the carbon footprint of the industry.

Most importantly, the Inspyr project provides information on resistance that is relevant to both wheat and barley, to all FHB pathogens and to attempts to limit the accumulation of DON, T-2 and HT2 mycotoxins in grain. New knowledge has been gained about the genetics of resistance and sources of resistance that can be applied immediately in plant breeding programmes in the UK and Europe.

The project produced molecular markers to the region about *Rht2* allowing breeders to maintain this agronomically important allele in their breeding programmes while selecting against the putative linked FHB susceptibility factor.

This project also demonstrated how appropriate fungicide application to varieties carrying enhanced disease resistance combines to reduce both disease and mycotoxin levels thereby greatly reducing yield and quality losses and increasing consumer safety.

If the challenge has not been specifically met, state why and how this could be overcome
It is important to recognise that while the project has produced significant new information and plant materials that will contribute markedly to reducing losses due to FHB, this does not mean that the risk to UK cereal crops has been eliminated. UK varieties are highly susceptible to FHB and there is an urgent need to maintain focus on improving varietal resistance further to ensure that the risks posed to growers and consumers remain minimal.

Lead partner	John Innes Centre
Scientific partners	FERA, NIAB, James Hutton Institute
Industry partners	BASF plc, KWS UK Ltd, MAGB, nabim, Premier Foods, RAGT Seeds, Secobra, Sejet Plant Breeding, SW seeds, Syngenta,
Government sponsor	BBSRC, Defra, RERAD