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# GrainPlan - development of a practical tool to improve grain storage on UK farms: knowledge transfer in action

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## Abstract

The UK produces around 24 million tonnes of cereals per annum and it is estimated that approximately two thirds of this is stored on farm. These farm stores vary considerably in terms of capacity, facilities, and residence time of grain in store. This emphasis on farm scale storage offers the opportunity for full traceability from field to final product but presents the challenge of providing guidelines for good grain storage to large numbers of farmers who may lack specialist storage knowledge. To address this, HGCA has developed 'GrainPlan' in partnership with grain storage experts and software developers. This user-friendly, personal computer-based software tool enables farmers to create a plan of their storage facilities which is linked to an interactive database holding all the details of the grain in store, including grain temperature and moisture content information. GrainPlan users are prompted to enter these latter data at appropriate time intervals during storage. Models of risk of mycotoxin formation, loss of germinative capacity, and pest development use the temperature and moisture content data to generate warning messages and suggested remedial actions where safe limits are exceeded. These warnings and actions are supported by a comprehensive encyclopaedia of grain storage information. The development of this tool has been unique in its iterative approach to consultation with end users (farmers) to ensure its practical applicability and ease of use. Feedback to date indicates that use of this software can lead to substantial savings in management time and energy costs and its contribution to record keeping has been welcomed by grain assurance schemes in the UK. GrainPlan is an excellent example of ensuring that the latest research findings are delivered to end users in an accessible and helpful way: knowledge transfer in action.

*Key words:* grain storage, decision support, crop assurance, best practice, knowledge transfer.

## Introduction

In 2005, the UK produced 23 million tonnes of cereals including 15 m tonnes of wheat, 5.5 m tonnes of barley, 0.5 m tonnes of oats and 2 m tonnes of oilseeds (HGCA, 2006). It is estimated that approximately two thirds of the total cereal crop is stored on farm with the remainder stored at commercial grain stores (Anon, 2003a and b).

Farm stores in the UK vary considerably in terms of capacity, facilities, and residence time of grain in store. Approximately 74 % of farm-

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stored grain is stored on-floor with the remainder stored in bins (Anon, 2003a). This emphasis on farm scale storage offers the opportunity for full traceability from field to final product but presents the challenge of providing guidelines for good grain storage to large numbers of farmers using diverse facilities but who may lack specialist grain storage knowledge.

It is estimated that grain rejections cost the UK cereals industry at least £1m per annum (Hook, 2004). Reasons for rejections vary with season but storage related problems such as presence of live storage pests is commonly cited (Henley, 2005). In addition, the European Union has introduced legislation setting a maximum limit of 5 µg kg$^{-1}$ of ochratoxin A in unprocessed cereals. This mycotoxin may be produced by Penicillium verrucosum in poorly stored grain. Thus there is a financial and legal imperative for good grain storage.

The need for innovative approaches to dissemination of guidelines for good grain storage practice has become more urgent due to changes to the profitability and structure of the UK cereals industry over the past decade. Reform of the European Union's Common Agricultural Policy and other economic drivers have resulted in a substantial decline in farm incomes from the mid-1990s such that it is estimated that in 2001 35 % of farms in England, and 45 % in Scotland, recorded negative net farm incomes (Turner, 2004). The industry has responded to this reduction in profitability through cost savings and restructuring, which has resulted in a trend towards a smaller workforce responsible for managing increasingly large holdings. Over the same period, provision of free, independent advice has largely disappeared in the UK cereals industry. Arable farmers therefore need easy access to robust information and tools to enable them to implement best practice in their businesses.

Crop assurance schemes, which require UK growers to maintain rigorous and detailed records of crop history and grain store management, can play an important part in monitoring and raising standards of grain storage. They achieve this through inspections and audits of grain storage and other farm records and through dissemination of technical information. To assist with this, the Home-Grown Cereals Authority (HGCA) has developed 'GrainPlan' in partnership with grain storage experts and software developers.

## Materials and methods

The development of the GrainPlan software was initiated by the HGCA in 2003 and has involved extensive consultation with potential users and crop assurance schemes. Feedback from these consultations has ensured that the software is focussed on the needs of end users in terms of both functionality and user interface. Details regarding consultation and the iterative approach to software development are described in full by Parker et al. (2006) and Shields and Parker (2005).

## Results

The current release of the software (version 3) has been developed in Delphi$^{TM}$ and uses a Microsoft Access$^{TM}$ database. The user interface consists of a simple graphical representation of the storage facilities with considerable scope for users to modify this to represent their own stores. This includes scaleable graphics for grain stores, yards and silos and the use of icons to represent doors and bulkheads (Figure 1).

The database provides the facility for recording information at three levels. Firstly, at the storage site level, users can record, for example, rodent baiting data, details regarding maintenance or calibration of equipment and the qualifications of operative staff. Secondly, at the grain store level, users can record information regarding cleaning and preparation of the store. Thirdly, at storage area level, users can record data relating to specific stored grain lots include variety, harvest location (field), quality data such as protein content, grain treatments such as fumigation, pest monitoring results and temperature and moisture content (m.c.; Figure 2).
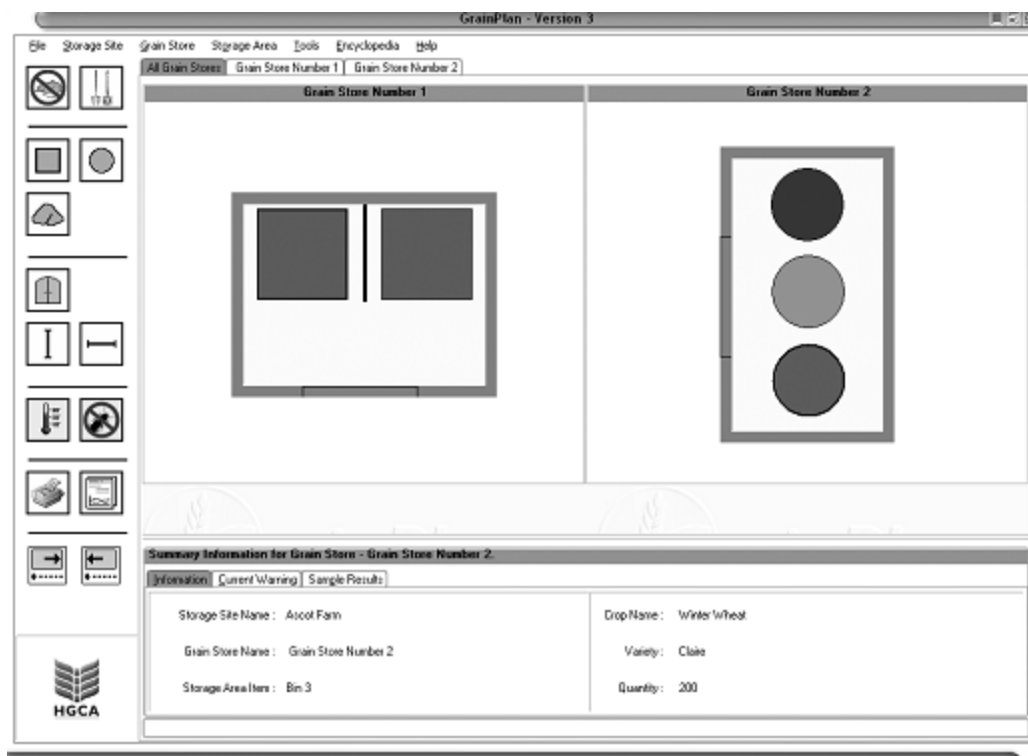
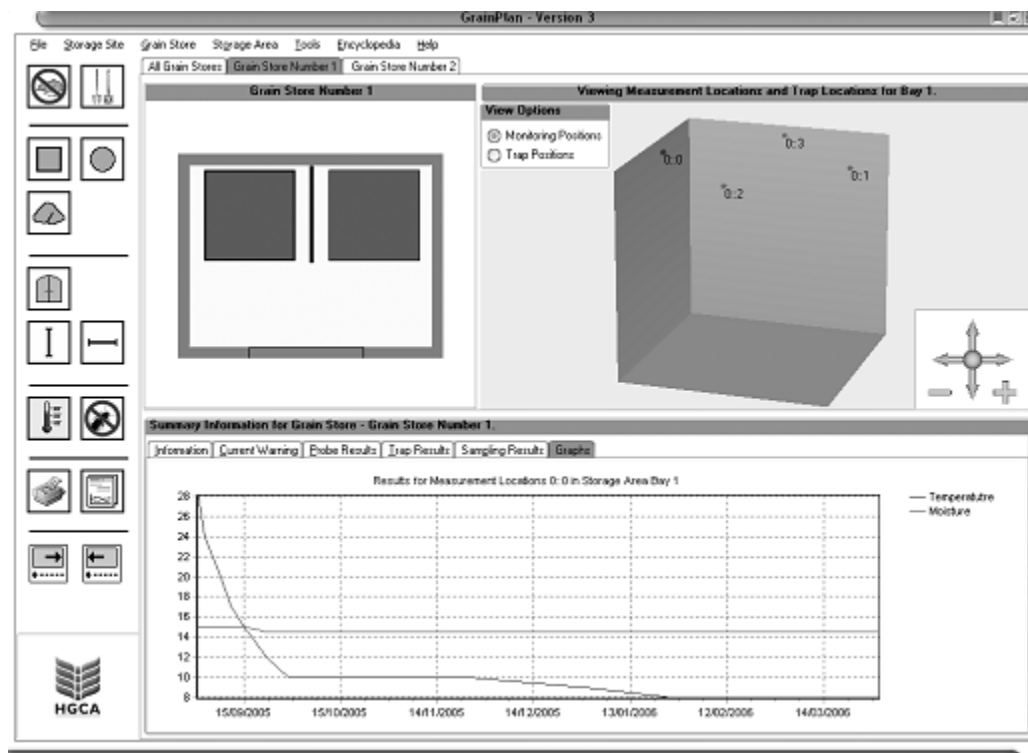**Figure 1.** User interface for GrainPlan showing graphical representation of two grain stores.



**Figure 2.** Graphical presentation of temperature and m.c. information for a grain lot in store.

To avoid the need to take a personal computer into the grain store, and to minimise manual data entry, GrainPlan has the facility to receive temperature and m.c. information via synchronisation with a hand-held device.

Once grain temperature and m.c. data have been entered, the software compares the values with data in a series of decision rules to determine whether conditions are suitable for long term storage. Where temperature and m.c. values of the stored grain exceed threshold values, based on risk of mycotoxin formation, loss of germinative capacity, or pest development, the user is alerted to appropriate remedial actions (Figure 3). These actions are backed up by a comprehensive encyclopaedia of grain storage information. In addition, the user is periodically alerted to the need to check grain condition.

The software has been demonstrated to hundreds of growers and store keepers at numerous workshops and other events in the UK over the past four years. Each version has been provided to the UK cereals industry free of charge on request. In addition, the most recent release has been distributed by the UK's Assured Combinable Crops Scheme (ACCS) to approximately 16,000 members in time for harvest 2006. GrainPlan is supported by a dedicated technical support desk with telephone and email support and trouble-shooting.

Feedback over the past 4 years shows significant interest in the software and there is a growing community of users.

## Discussion

GrainPlan provides a flexible framework for growers and store keepers to record important information regarding their grain store management. Users are able to construct a graphical representation of their storage facilities, which enables an intuitive interface with the database. This can store information regarding such diverse operations as rodent baiting, equipment maintenance, grain temperature and m.c. monitoring, as well as data regarding the quality of the grain in store. In addition, the interactive risk assessment ensures that users are alerted to potential risks such as pest infestation
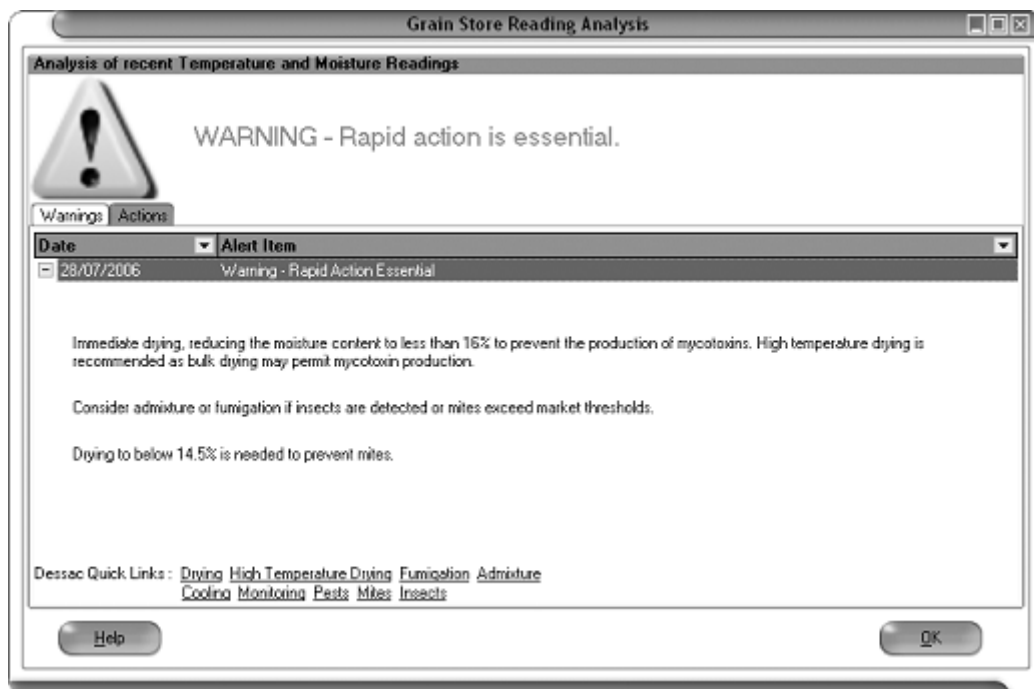


**Figure 3.** An alert message and suggested remedial actions generated by GrainPlan.

or mycotoxin development and provided with guidance on appropriate remedial actions. Data stored within the system can be readily retrieved in graphical and tabular formats suitable for crop assurance schemes.

As such, GrainPlan represents a powerful knowledge transfer tool to improve best practice in grain storage. It can also contribute to full traceability by providing a comprehensive record of the grain from field through to out-loading. This has been recognized by UK assurance schemes including ACCS. Whilst use of GrainPlan is not mandatory for ACCS members, it is regarded as a useful tool to assist members to comply with scheme requirements regarding record keeping. In addition it reduces the need for paper recording systems and gives a full history of stored grain that can demonstrate that it has been maintained under food and/or feed safe conditions.

The potential savings in management time alone are considerable. One user has estimated a saving of three man-days per year associated with improved record keeping (Horne, 2006). The benefits of improved knowledge transfer have also been demonstrated, with the same user reporting a 20 % reduction in electricity costs through improved aeration strategies prompted by information within the GrainPlan encyclopaedia (Horne, 2006).

The total cost for development and distribution of GrainPlan has been approximately £196,000. Given that a significant proportion of the £ 1 m annual cost of grain rejections in the UK is due to storage related issues, if GrainPlan provides just a modest improvement in grain storage practice this investment will have been worthwhile.

Throughout development of the software, emphasis has been placed on ease of use to ensure maximum uptake. Nevertheless, it is clear from feedback at workshops and other events that it is unlikely to be rapidly adopted by all growers and storekeepers. There are several possible reasons for this. The most obvious is that only 55 % of farms use computers for their business (Defra, 2002), and only 20 % of these are used for

activities associated with the arable enterprise. Most are employed for accounting and other financial management tasks. In addition, due to the poor profitability of the industry, a proportion of the computing equipment in service may not be of sufficiently high specification to support GrainPlan. More encouragingly, however, the software has been recognized as a useful teaching aid for agricultural colleges. As a consequence, the next generation of UK arable farmers is being introduced to GrainPlan at an early stage in their careers.

## Acknowledgements

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