LACC IGW

13th International Gluten Workshop

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International Maize and Wheat Improvement Center

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Hilton Reforma Hotel
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Developing new types of wheat with good processing quality at low grain protein content

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ABSTRACT

Nitrogen fertilisation is crucial for maximising wheat yield but applications above the optimum for yield may be required to achieve the grain protein content required for breadmaking. This increases the production costs and may also result in higher energy requirements for processing and an increased environmental footprint. We are therefore seeking to reduce the nitrogen requirement for producing breadmaking wheats grown in conventional intensive farming systems, by exploiting grain protein deviation and by identifying genotypes with good breadmaking performance at low grain protein content and the traits responsible for this.

INTRODUCTION

Nitrogen is the major agrochemical input for wheat production in conventional farming systems and hence the major production cost for farmers. The primary requirement for nitrogen is to increase the yield, by supporting the development of the canopy to capture carbon dioxide. In addition, nitrogen also plays a major role in processing quality, by determining the grain protein content. The protein content required for different processing systems varies widely, being particularly high (13%) for the Chorleywood Breadmaking Process (CBP) which is widely used in the UK and a number of other countries. This high protein requirement may necessitate the use of substantial amounts of nitrogen fertiliser, which may be above the fertiliser needed for optimal yield. This is illustrated in Fig. 1, which shows data from the Broadbalk long term wheat experiment at Rothamsted Research (Johnston 1994). In this figure, the nitrogen requirement to produce grain with 13% protein is about 50kg/Ha above that required for maximum yield. In addition to increasing production costs, the reliance on high protein grain increases the energy costs for processing, and can lead to an adverse environmental footprint if the fertiliser is not applied at the optimum time. We therefore consider that reducing the requirement for nitrogen fertiliser to produce breadmaking wheats is essential for economic and environmental sustainability, and are focusing on producing new types of breadmaking wheat which do not require the application of nitrogen above the optimum for grain yield.

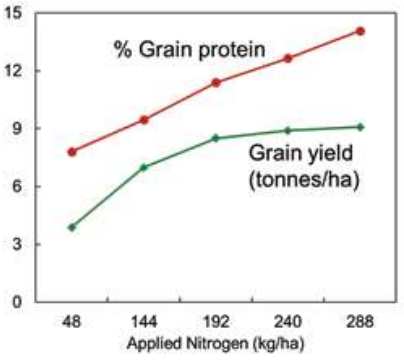

Figure 1. The relationship between applied nitrogen fertiliser (kg/ha), grain yield and grain protein content in wheat grown in the Broadbalk long term wheat experiment.

RESULTS AND DISCUSSION

Approaches to reduce the reliance on nitrogen for breadmaking wheats.

We are taking two approaches to reduce the nitrogen requirement for breadmaking wheats grown in intensive agricultural systems in the UK.

1. Exploiting grain protein deviation (GPD)
   There is a well-established inverse correlation between grain yield and grain protein content, which could result from dilution with starch and/or competition between starch and protein synthesis for substrates and energy (Munier-Jolain and Salon 2005; Arceche and Slafer 2009). However, some cultivars show reproducible deviation from the expected inverse correlation, with high yield being combined with higher grain protein content. This phenomenon is termed 'grain protein deviation' (GPD) (Monaghan et al. 2001).

   This is illustrated in Fig. 2, taken from the Wheat Genetic Improvement Network (WGIN) trials at Rothamsted Research, with cultivars falling above the line exhibiting GPD. We have explored this phenomenon, by using a novel statistical approach to identify gene transcripts associated with GPD in comparisons of 6 wheat cultivars grown in the UK in multiple environments (sites and years) (Mosleth et al. 2014).

   The high site-to-site and year-to-year reproducibility of GPD for some cultivars, such as the high quality UK breadmaking cultivars Cordiale and Hereward in Fig. 3 (Mosleth et al. 2014), indicates strong genetic control which we are now investigating using classical Mendelian genetics.

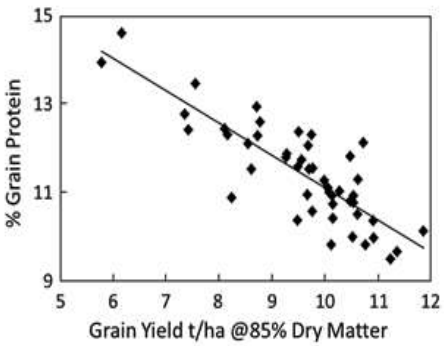

Figure 2. Mean grain N contents and yields for 47 wheat cultivars grown at Rothamsted Research between 2004 and 2012. (Modified from Hawkesford 2014)

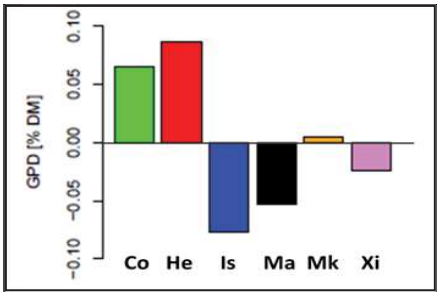

Figure 3. Grain protein deviation calculated for 6 cultivars grown for three years on 2 sites with 200 kgN/ha. Taken from Mosleth et al (2014). Co, Cordiale; He, Hereward; Is, Istabraq; Ma, Malacca; Mk, Marksman; Xi, Xi 19. All are good quality breadmaking wheats except Istabraq which is a feed wheat.

2. Identify types of wheat with good breadmaking quality at low protein content
   We are carrying out multi-site field trials in the UK of 40 lines, most of which are commercial breadmaking cultivars, on six sites at two levels of nitrogen fertilisation: 150 (low) and 250 (high) kg N per hectare. This shows substantial variation in grain protein content, including between cultivars with good breadmaking performance (Fig. 4).

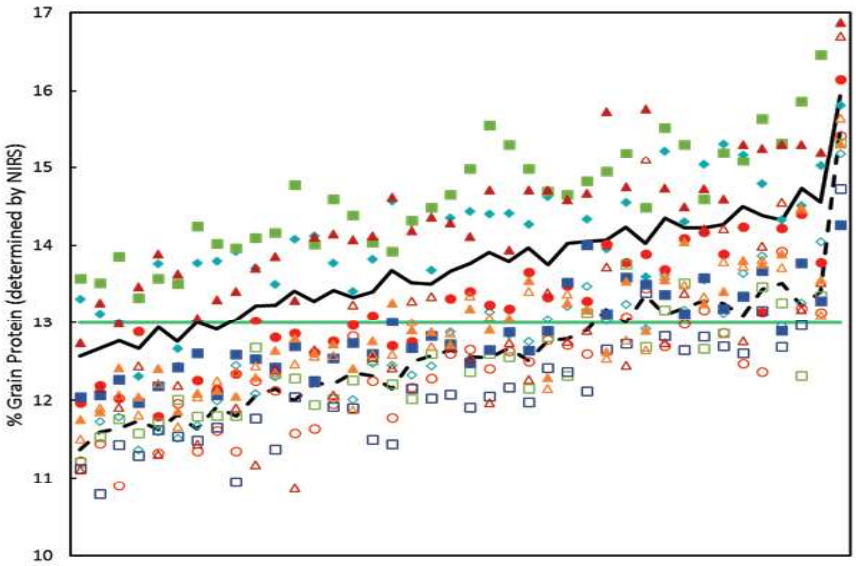

Figure 4. Grain nitrogen contents of 40 wheat genotypes grown in 2017 on 6 sites (shown in different colours) and at 2 nitrogen levels: 150 kg/ha (open symbols) and 250 kg/ha (closed symbols). The black lines indicate the varietal averages for 150 kg/ha (broken) and 250 kg/ha (solid). The straight green line is the protein requirement for top grade breadmaking wheat set by millers (NABIM) in the UK.

White flour produced by Buhler milling was tested for gluten protein and polymer composition, dough rheology and breadmaking using CBP, spiral and long fermentation processes and selected lines grown on the same sites for two further years. It is expected that this project will identify traits related to good and stable breadmaking quality at low grain protein content.

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