AHDB

from theory to field

Fertilising for quality

> *"Over £2 million is now being invested in N and S management research in cereals."*

New research is underway which will supply data to update recommendations for nitrogen and sulphur in milling wheat, spring barley and oat crops. *CPM* asks the researchers how they're going about determining the effect these nutrients have on grain quality.

By Lucy de la Pasture

The bible of nutrient management RB209 was updated in 2017 and, in the process, a number of gaps were identified where there was insufficient data available to support any significant change in recommendation, particularly for nitrogen and sulphur in some crops.

Much of the nutrient research was conducted decades ago, explains Sajjad Awan, who manages nutrient management research at AHDB. Since that time plant breeding has moved on and modern varieties are much higher yielding.

In an effort to bring the data behind RB209 bang up to date, AHDB has commissioned two new research projects on nitrogen (N) and sulphur (S) management in oats and wheat which will support any revisions to RB209 in 2022.

"The nutrient review conducted by ADAS in 2016 identified areas where data was scant or non-existent and three of the five knowledge gaps were in oats, spring barley and milling wheat," says Sajjad.

The two new projects dovetail with a complementary AHDB project on spring barley, which started in 2018. The funding injection from industry means over £2 million is now being invested in N and S management research in cereal production, with 80% of the funding coming from non-levy sources.

N-use efficiency

The role of nitrogen in supporting yield and grain protein is well known, but sulphur plays an equally important part in supporting yield, N-use efficiency and grain quality and is a nutrient that has become deficient in most UK soils since atmospheric depositions have all but ceased.

The link between N and S is also important, not only for yield and hitting market specification but for processing quality, and this is something the new projects are also looking at. NIAB's Dr Nathan Morris is leading the milling wheat project, which currently has trials in the ground at four sites around the country — in Norfolk (NIAB), Essex (Agrii), Lincs (Omex) and Scotland (SRUC).

"The trials will move over the three-year project so that we're able to collect data from milling wheat grown on different soil types under different climate conditions," he explains.

The aim of the trials is to evaluate the grain quality (primarily grain protein and specific weight) responses to nitrogen and sulphur fertiliser application rate and timing. Allied Technical Centre are supporting the analysis of the grain for dough rheology and baking performance.

"There are two replicated trials at each of the four sites. The first set of trials look at the grain quality responses to different rates and timings of nitrogen. This includes a foliar application at the milky-ripe stage which is common industry practice and thought to boost grain protein but has very little independent trials data to support it," says Nathan.

"It's important to carry out trial work with the modern varieties to support changes in RB209, especially where varieties are higher-yielding with a protein dilution effect, as noted in RGT Skyfall," adds Sajjad.

The second trial will assess the impact of nitrogen and sulphur fertiliser rate and timing on dough rheology and baking performance (protein quality), including the production of the amino acid, asparagine.

The problem with increased levels of asparagine is that it's linked with the formation of acrylamide, a processing contaminant that has been found in cooked foods and can form during high-temperature cooking and processing of wheat. ▶

The aim is to evaluate the grain quality responses to nitrogen and sulphur fertiliser application rates and timings, says Nathan Morris.

Under the current RB209 recommendations, ADAS have shown that target grain N would only be achieved in 60% of cases, says Sarah Kendall.

Nitrogen treatments and timing in milling wheat trial

		Nitrogen (kg N/ha)			
Varieties	**N Trt No.**	**Total N**	**GS32-35**	**GS37-39**	**GS73**
KWS Zyatt KWS Siskin RGT Skyfall	N1	No Nitrogen	-	-	-
	N2	RB209 rec.for yield	-	-	-
	N3	RB209 rec.for yield +40	40 AN	-	-
	N4	RB209 rec.for yield +40	-	40 AN	-
	N5	RB209 rec.for yield +40	-	-	40 Foliar N
	N6	RB209 rec.for yield +40 +40	40 AN	40 AN	-
	N7	RB209 rec.for yield +40 +40	-	40 AN	40 Foliar N
	N8	RB209 rec.for yield +40 +40 +40	40 AN	40 AN	40 Foliar N

Source: NIAB, 2019.

Nitrogen and sulphur treatments and timings in milling wheat trials

		Nitrogen (kg N/ha) / Sulphur (kg/ha SO_3)					
Varieties	**N Trt No.**	**Total N**	**Pre GS30**	**GS30-31**	**GS32-35**	**GS37-39**	**GS73**
KWS Zyatt RGT Skyfall	N1	RB209 rec.for yield +40	0 SO_3	0 SO_3	0 SO_3	40 AN	0 Foliar N
	N2	RB209 rec.for yield +40	0 SO_3	25 SO_3	0 SO_3	40 AN	0 Foliar N
	N3	RB209 rec. for yield +40	0 SO_3	50 SO_3	0 SO_3	40 AN	0 Foliar N
	N4	RB209 rec. for yield +40	0 SO_3	75 SO_3	0 SO_3	40 AN	0 Foliar N
	N5	RB209 rec. for yield +40	0 SO_3	0 SO_3	0 SO_3	0 AN	40 Foliar N
	N6	RB209 rec. for yield +40	0 SO_3	25 SO_3	0 SO_3	0 AN	40 Foliar N
	N7	RB209 rec. for yield +40	0 SO_3	50 SO_3	0 SO_3	0 AN	40 Foliar N
	N8	RB209 rec. for yield +40	0 SO_3	75 SO_3	0 SO_3	0 AN	40 Foliar N
	N9	RB209 rec. for yield +40	0 SO_3	25 SO_3	25 SO_3	40 AN	0 Foliar N
	N10	RB209 rec. for yield +40	25 SO_3	25 SO_3	25 SO_3	40 AN	0 Foliar N
	N11	RB209 rec. for yield +40	0 SO_3	25 SO_3	25 SO_3	0 AN	40 Foliar N
	N12	RB209 rec. for yield +40	25 SO_3	25 SO_3	25 SO_3	0 AN	40 Foliar N

Source: NIAB, 2019.

▸ AHDB trials have shown that asparagine levels can increase if wheat is grown under conditions of S deficiency. Current guidelines for growers are that acrylamide formation can be minimised by applying 50kg SO_3/ha to wheat, which is the maximum recommended application rate in RB209.

"By the end of the project the aim is to have generated data to form the basis of new recommendations for nitrogen and sulphur fertiliser applications for milling wheat quality," adds Nathan.

The spring barley project already has a season's results under its belt but it's not enough to begin to draw out any conclusions, especially after the extraordinary weather experienced in 2018, says ADAS's Dr Sarah Kendall who's leading the research.

Getting a better handle on N and S management in spring barley was highlighted after the review of RB209, when ADAS were able to demonstrate that using the recommendations, target grain N would only be achieved in 60% of cases, she points out.

"There's a lot of uncertainty in the industry

The Miller's Tale

The latest AHDB research has been warmly welcomed by the milling industry, says nabim's policy and research officer, Joe Brennan.

"There's a recognition that there needs to be a reassessment of N and S management for some of the newer high-yielding varieties so that protein levels can be reliably attained. It's a step in the right direction from a research perspective because the milling wheat project isn't just looking at the agronomic effects of nutrient management, it's also assessing how this impacts the protein and baking quality. This is hugely important for millers and our customers."

"Sometimes a crop can be grown that hits all the specs but there's still the chance the actual protein quality isn't as good as the millers would like it to be, even though the protein quantity is good," he says.

Protein content and variety act as indicators of quality, which is why they are specified in milling wheat contracts. But ultimately protein quality itself can't be measured in an intake laboratory or specified in a contract and is influenced by the season as well as fertiliser inputs.

Sulphur plays a number of important roles in protein quality. It's necessary for the formation of disulphide bonds, which affect the strength of the gluten. But sulphur also has a close relationship with the amount of a naturally occurring amino acid (asparagine) in the grain, which increases when the wheat crop is grown in sulphur-deficient soils.

"Asparagine levels have come to the fore because it's the precursor of acrylamide, a chemical which has been identified as a possible carcinogen. Currently there are benchmark levels for acrylamide in baked goods and if products exceed these levels then the manufacturer has to review their processes and take steps to reduce them," explains Joe.

It's likely in the future that the EU will introduce maximum levels for acrylamide, which will mean products have to be taken off the market if they're found to exceed them.

"There is no rapid test for asparagine on intake and, even if there was, testing loads wouldn't be desirable because growers can take preventative action and reduce the risk of high levels occurring by applying sulphur to their crops.

"Findings by Rothamsted Research have shown there is a natural variation in asparagine levels in different varieties, but this becomes negligible if soils are low in sulphur, indicating this is the primary driver," he explains.

"In terms of protein quality there's still a lot to learn. But this new work is much needed to update the data behind recommendations and make sure they're optimal for protein level and quality in the modern milling wheat varieties."

when it comes to spring barley fertiliser recommendations and many growers rely on their past experience. But as crop rotations adjust to include more spring crops to help manage blackgrass, the industry has many growers who are relatively new to the crop," she comments.

"Some of these are growing malting varieties on heavy ground and are pushing them for yield. So we need to develop more sophisticated recommendations based on the modern varieties, whose yields in RL trials exceed those of older varieties by 12% or more."

The spring barley project has four trials sites (in Norfolk, Notts, N. Yorks and E. Lothian) which reflects a number of different soil types so that the data produced will of relevance to all growers. The varieties include Concerto as a benchmark variety, with Laureate, RGT Planet and LG Diablo representing the more recent varieties on the AHDB Recommended List.

As well as investigating the effects of N and S rates, the project will investigate timing of application, says Sarah.

"We're looking at various timings but the latest is at GS37-39, which is later than growers would normally apply in practice because of worries it could influence grain N. This work will help establish the effect of N application timing and understand if timings can be used to increase yield while still meeting market specifications," she explains.

MAGB are one of the industry partners in the project and will be making micro-malting assessments of grain from the trials and establish any effects on grain quality characteristics. There's also interest in the sulphur interaction with grain quality after earlier AHDB-funded work established a link between sulphur application in deficient crops and flavour of beer and the Scottish Whisky Research Institute will be assessing grain samples from the trials to understand flavour effects due to sulphur on whisky.

One of the most neglected crops in nutrient research has been oats, says Sajjad, with the most recent data for spring oats produced in the 1980s, though a small amount of work has been done since the last review of RB209 in 2017.

But it's a crop on the up and provides a rich source of dietary fibre, beta-glucans, which has led to an increase in human consumption. ADAS's Dr Sarah Clarke says that the majority of oats in the UK are grown for milling and consumption has been increasing by 5% each year since 2008, with no sign of slowing.

The sulphur content of spring barley grain can have an affect the flavour of beer and whisky.

Milling oats

She's leading the new project on milling oats, dubbed NoatS, looking at the effects of nitrogen and sulphur on yield but with an emphasis on quality. This will include specific weight, hullability and kernel content and will be tested by IBERS, Aberystwyth University.

"The recommendations in RB209 don't consider the effect of nitrogen on milling quality and the timings for winter oats currently follow those for wheat, with no timing recommendations given for spring oats," she explains.

The first step in the project was to set up a survey which asked growers and agronomists how they were growing their oat crops with the aim of establishing normal practice so this could be fed into the trials protocol.

"We found that most growers were applying 40kg SO_3/ha, but some weren't applying sulphur at all. When it came to nitrogen, agronomists were generally advising an average of 140kgN/ha on winter oats, which is lower than a recommendation for an SNS index 1 crop in RB209, and 120kgN/ha on spring oats," says Sarah.

Oats for human consumption is a growing market but there's very little recent data available, especially for spring oats, explains Sarah Clarke.

"Timings of N applications were as per RB209 for winter oats, so the same as for wheat, but a few growers were applying late N and this is something we're going to look at in the trials. Spring oats were receiving half their N in the seedbed and the other half at tillering or early stem extension," she adds.

The yield data from the survey really underlines the potential of the crop where there's attention to detail, highlights Sarah. "For winter oats the average yield was 7.6t/ha, which is higher than Defra stats, but some growers were achieving 10t/ha. Historically oats have been seen as a low input, low output crop but there's a lot we can learn to improve oat output, in terms of yield and quality," she says.

One of the difficulties with growing spring oats is achieving good specific weights, especially in East Anglia where the crop has gained in popularity. "The survey highlights that most growers are achieving specific weights of 50kg/hl in winter oats but struggle to do this in East Anglian spring oats crops consistently. ■

Research roundup

AHDB Project No: 21140040, 'Nitrogen and sulphur fertiliser management to achieve grain protein quality targets of high-yielding winter milling wheat' runs from July 2018 to March 2022, at a cost to AHDB of £179,548. (total funding £230,999, including in-kind contributions). The project is led by NIAB and partnered by SRUC, Masstock Arable (UK) Ltd (trading as Agrii), Omex Agriculture Limited, RAGT Seeds, KWS UK Ltd, Allied Technical Centre Ltd (ATC).

AHDB Project No: 21140039, 'Nitrogen and sulphur fertiliser management for yield and quality in winter and spring oats' runs from Aug 2018 to May 2022, at a cost to AHDB of £120,000 (total funding £616,560, mainly in-kind contributions by project partners). The project is led by ADAS with partners: IBERS Aberystwyth University, Teagasc (Ireland), Seges (Denmark), PepsiCo, Richardsons Milling, BOBMA, Saaten Union, Senova, KWS, RAGT Seeds, Camgrain, Golett Grain, Frontier, CF Fertilisers, Omex, Chadacre Agricultural Trust, Felix Thornley Cobbold Agricultural Trust.

AHDB Project No: 21140038, 'Updating nitrogen and sulphur fertiliser recommendations for spring barley' runs from March 2017 to April 2021, at a cost to AHDB of £139,980 (total funding £211,830, plus a further in-kind contribution of £993,000 from industry). The project is led by ADAS in partnership with SRUC and Adams & Howling Ltd, CF Fertilisers, Limagrain, MAGB, Seges (Denmark), Syngenta, Tegasc (Ireland).