Scenario modelling of fertiliser prices and yield impacts

Winter and spring barley, winter wheat and oilseed rape

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1. REPORT SUMMARY

To help Defra understand the potential impact of nitrogen fertiliser reductions on 2023 UK grain and oilseed production, four scenarios were examined for winter wheat and barley, spring barley and oilseed rape.

The most likely scenario estimates a relatively modest reduction in grain/seed production of between 0.7% and 1.7% depending on the crop due to a 10% reduction in nitrogen fertiliser (Table 1).

Table 1: Summary of most likely scenarios for each crop - forecast change between 2022 and 2023

	Impact of 10% reduction in typical nitrogen rate on estimated 2023 UK production			Impact of adverse drilling weather plus N fertiliser reduction	
	Yield impact (tonnes/ha)	Yield impact on production (%)	Total production impact (tonnes)	Including minor weather impact (tonnes)	Including major weather impact (tonnes)
Winter wheat	-0.11	-1.3%	-187,000	-787,000 (-5.6%)	-3,405,000 (-24%)
Winter barley	-0.09	-1.3%	-40,000	-232,000 (-7.5%)	-932,000 (-30%)
Spring barley	-0.04	-0.7%	-28,000	-208,000 (-5.5%)	-321,000 (-8.4%)
Oilseed rape	-0.05	-1.7%	-18,000	-78,000 (-7.3%)	-300,000 (-28%)

If the potential impact of adverse drilling weather is included, then the overall percentage reductions could be between 5.5% to 7.5% in minor situations. For major weather events in winter-sown crops, the combined impact could be between 24% and 30% with spring barley down 8.5%.

So, it is most likely that the 2023 fertiliser approaches by cereal and oilseed rape growers, on average, will have a relatively low impact on production as long the growing season is favourable. The analysis of AHDB Farmbench results shows that there is a weak association between application rates and yields. What is notable though, is that adverse weather could have a much greater effect on total output than the most likely fertiliser application rates scenario.

There were around a dozen conversations with arable and mixed farmers but also with AHDB field staff who look after 40 grower discussion groups across the UK and a couple of agronomists who work with multiple clients. At the time of these conversations at end of June 2022, the most likely scenario given involved, on average, only a small reduction of 10% in the typical (what the grower would historically apply) nitrogen application rate for 2023.
The main reasons given for this included:

- Grain prices for 2023 crops seem to be holding up above £200/tonne
- Growers don't want to risk dropping yields too much to take advantage of the high grain and oilseed prices

- With regards to milling wheat, growers want to meet protein targets to achieve premiums and contract specifications
- Cash flows are going to be crucial as higher input prices will increase working capital requirements
- More frequent fertiliser applications but smaller doses to try and increase nitrogen fertiliser use efficiency

Table 2: Summary of the variables examined for each scenario

	Ammonium nitrate (AN) fertiliser price (£/tonne)	AN prices reasoning	Proportion applied of typical total nitrogen application rate	Futures price of grain and seeds (£/tonne) - all scenarios
Reasonable best-case scenario	600-650	Best prices during buying window in early May 2022	100%	Autumn 2023 prices as of 20/10/22 (source: AHDB) Feed wheat - £268/t Milling wheat - £313/t Feed barley - £248/t Malting barley - £268/t Rapeseed - £554/t
Most likely scenario	700-750	Prices paid by many arable farmers later in May and June 2022 buying window	90%	
Reasonable worst-case scenario	850-950	Highest average range of prices reported when production and supply were most limited in the 1st quarter of 2022	80%	
Extreme worst-case scenario	1000-1100	If fertiliser production is severely restricted due to higher-than-expected energy prices over the winter/spring of 2022/23 as a result of the fallout from the Ukraine war	70%	

In addition to the variables set out in the scenarios above, the impact of weather was also considered. In recent years it has been the weather at the time of drilling winter sown crops that have had the greatest impact on the crop areas grown and subsequent production levels. Over the last 11 years, the planted areas for winter wheat, barley and oilseed rape experienced two major shifts and two to three minor changes. For example, the very wet autumn of 2019 meant that winter wheat plantings reduced by a significant 25% compared to the 2018 winter-sown area. In contrast, a dry autumn in some parts of the country in 2016 led to a 2% decline in the winter wheat area.

Table 3: Summary of the average percentage reductions in planted area due to key adverse weather periods at planting time between 2011 and 2021

	% change in area	
	Minor	**Major**
Winter wheat	-3	-22
Winter barley	-5	-28
Spring barley	-4	-7
Winter oilseed rape	-4	-25

2. Introduction

Since the end of summer 2021, global fertiliser prices have increased to unprecedented levels. This has been due to global gas price rises, increased volatility in many market prices and supply chains due to the war in Ukraine.

Defra would like to understand what the potential impacts of various possible scenarios could be for UK agricultural commodity production, as part of its work to consider the impact on the food chain.

This report presents the findings of the modelling of different scenarios taking into account fertiliser prices, application rates, forward prices and the weather at planting on production levels in 2023.

2.1. Recent trends in prices of fertilisers and grain prices

Associated with sharp increases in energy prices during 2021, and with limits on the availability of natural gas, prices of manufactured nitrogen fertilisers have increased, and their availability for on-farm delivery has been reduced.

Over the same period, grain and oilseed prices have also increased albeit not at the same rate as fertiliser. Since November 2020 ex-farm feed wheat prices have increased by 40% by September 2022 compared with imported Ammonium Nitrate (AN) prices that have quadrupled over the same period.

Gas futures prices in 2022 have stayed more than double those seen in 2021. These high gas prices had forced fertiliser production in Britain to close. The subsequent impact was a further rise in nitrogen prices towards the end of the year. Although Allied Industries Confederation reassure that as of October 2022, there was still sufficient supplies to meet UK needs. Despite this, it all points to fertiliser prices remaining high in 2023.

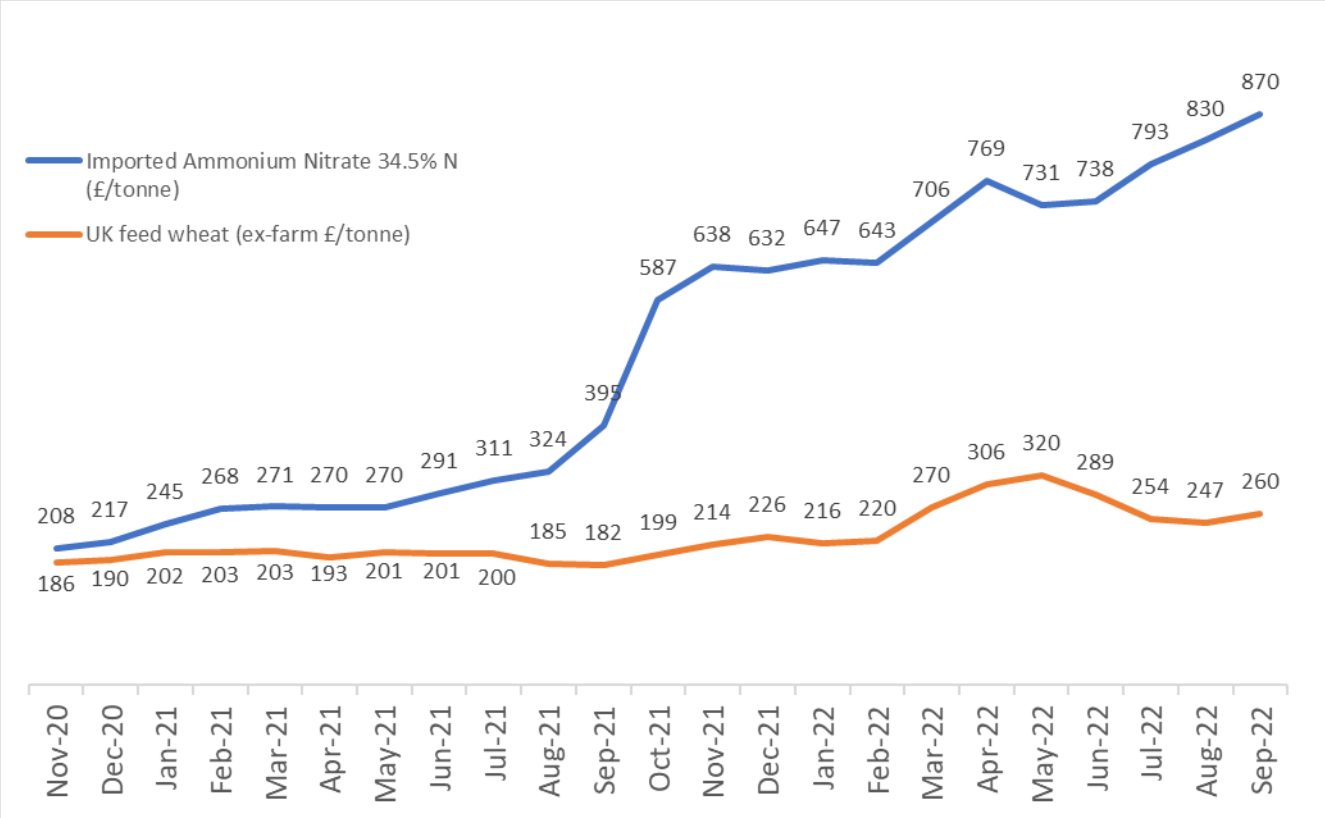

Figure 1: Imported ammonium nitrate fertiliser and ex-farm feed wheat prices (Nov 2020 to Sept 2022)

Source: AHDB Fertiliser Survey and AHDB Market Prices

2.2. Recent association between nitrogen application rate and yield

Individual crop results from AHDB Farmbench users were analysed for the association between the amount of nitrogen (N) fertiliser applied and resultant crop yields. The results cover the harvest years 2018 to 2021.

For wheat, the analysis showed a weak relationship between the amount of N fertiliser applied by Farmbench users and the grain yields achieved (n=2790, r^2=0.0974) (Figure 2). For barley there was a similar weak association (n=2919, r^2=0.1579) and oilseed rape had the weakest relationship between application rate and yields (n=1432, r^2=0.0596).

In all three crops there was a wide range in yields for any nitrogen application rate. For example, at 200 kg N/ha in wheat, reported yields were between 3 and 12 t/ha. The reasons for a weak historical trend between fertiliser application rate and crop yields are many and varied. But they would include differences in crop management, soils type, weather impacts, disease and pest pressures.

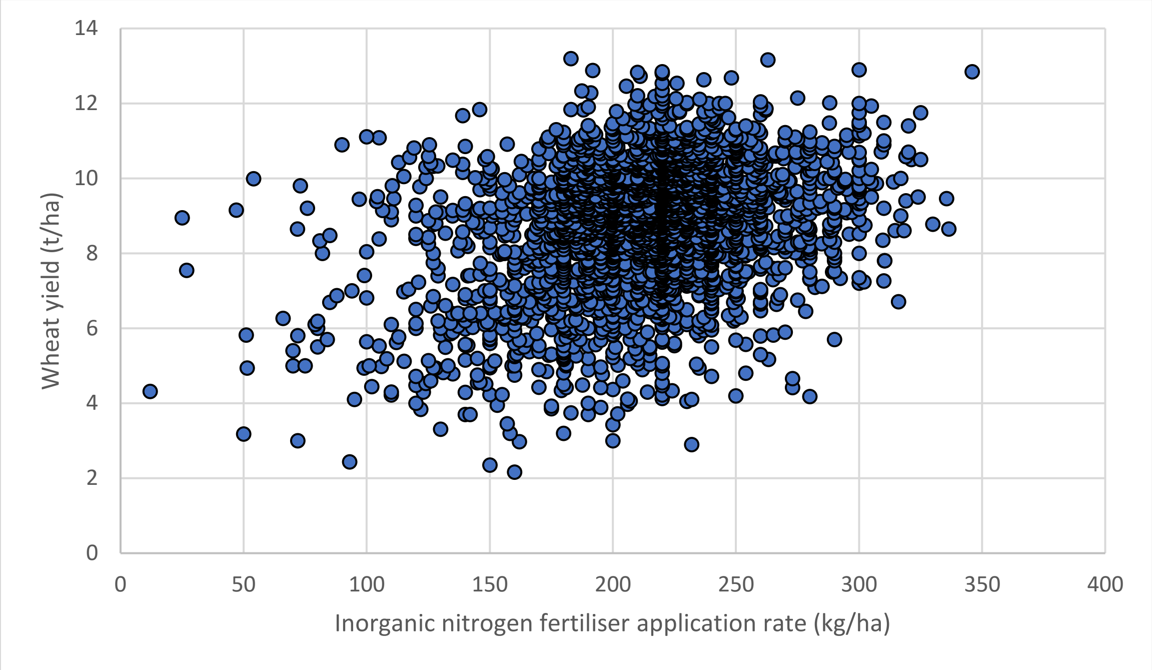

Figure 2: Individual wheat crop results - nitrogen fertiliser rate versus wheat yields (2018 to 2021)

Source: AHDB Farmbench (unpublished)

2.3. Recent trends in cereal and oilseed rape production

Winter wheat and barley production have experienced some volatility in the last few years which has largely been attributed to adverse weather conditions affecting drilling in the Autumn. For example, wheat production declined by 6.5 Mt (40%) in 2020 due to a prolonged wet period in autumn 2019 that shifted many plantings to spring crops instead.

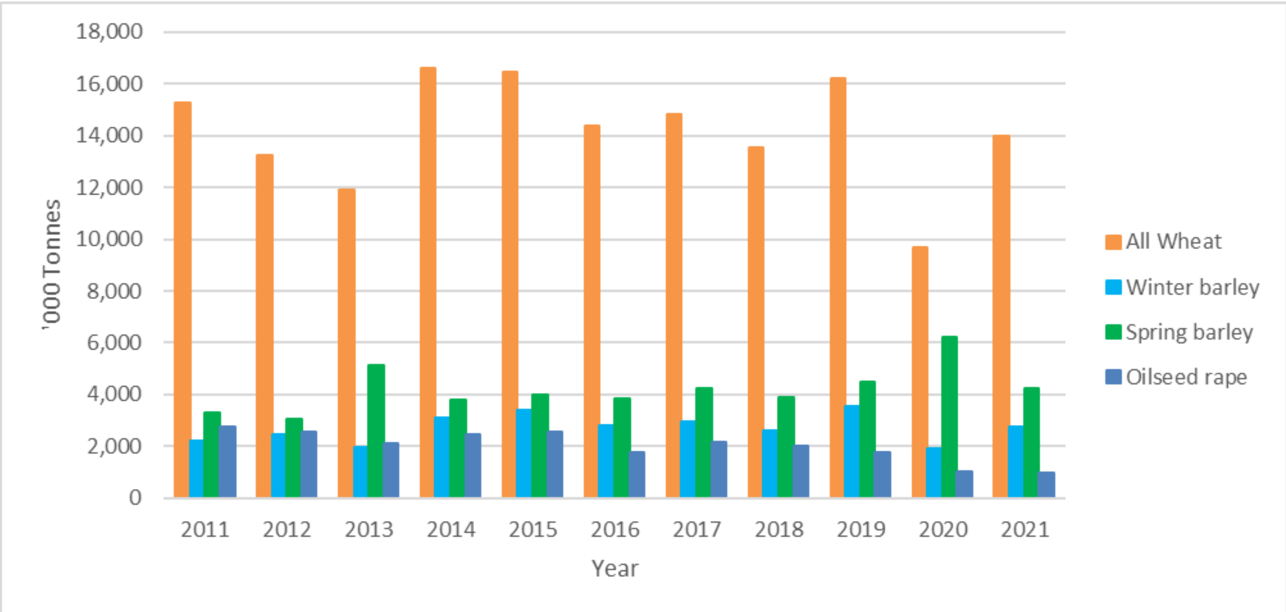

Figure 3: UK production of key cereals and oilseed rape (2011 to 2021)

Source: Defra Farming Statistics

3. Scenarios

There were four scenarios examined for each crop.

- Reasonable best-case scenario
- Most likely scenario
- Reasonable worst-case scenario
- Extreme worst-case scenario

The reasonable best-case scenario is considered possible if fertiliser market supply and prices improve or at the very least do not become worse. The extreme worst-case scenario sets out the real potential outcome should the gap between fertiliser and grain/seed prices widens significantly.

3.1. Assumptions

3.1.1. Fertiliser prices

For the majority of arable growers, fertiliser has historically been purchased around May to July to use in the following growing season. Based on personal communications with farmers and the Agricultural Industries Confederation (AIC) the trend has largely continued this year and so we have a reasonable idea of the ammonium nitrate (AN) prices paid and quantities bought ahead of the 2023 growing season.

Gas futures prices (Gas Futures ICE) indicate that energy prices may hold up this year and into 2023 at around 300% more than futures prices back in September 2021. This would indicate, and so is assumed, that AN fertiliser price may not drop below the levels seen so far in 2022.

Table 4: Summary of the range in ammonium nitrate fertiliser prices assumed for each scenario

Reasonable best-case scenario	£600 - 650/t AN. Best prices during buying window in early May 2022
Most likely scenario	£700-750/t AN. Prices paid by many arable farmers later in May and June 2022 buying window
Reasonable worst-case scenario	£850-950/t AN. Highest average range of prices reported when production and supply were most limited in the 1st quarter 2022
Extreme worst-case scenario	£1000-1100/t AN. If fertiliser production is severely restricted due to higher-than expected energy prices over the winter/spring 2022/23 as a result of the fallout from the Ukraine war

Source: Prices based on AHDB Fertiliser Survey and those reported in trade press articles

3.1.2. Fertiliser application rate

There were around a dozen conversations with arable and mixed farmers but also with AHDB field staff who look after 40 grower discussion groups across the UK and a couple of agronomists who work with multiple clients. From these conversations, the amount of nitrogen (N) fertiliser application rates for the 2023 growing season may be reduced by, ranging between 0% to 20%. This sets the rates used in the scenarios. Typically, though, around a 10% reduction on the usual rate used by growers seemed to be the most common and this has been used for the most likely scenario. The reasons captured include:

- Grain prices for 2023 crops seem to be holding up above £200/tonne
- Growers don't want to risk dropping yields too much to take advantage of the high grain and oilseed prices
- With regards to milling wheat, growers want to meet protein targets to achieve premiums and contract specifications
- Cash flows are going to be crucial as higher input prices will increase working capital requirements
- More frequent fertiliser applications but smaller doses to try and increase nitrogen fertiliser use efficiency.

Table 5: Percentage of the typical nitrogen fertiliser rate assumed for each scenario

Reasonable best-case scenario	100% of average N application rate
Most likely scenario	90% of average N application rate
Reasonable worst-case scenario	80% of average N application rate
Extreme worst-case scenario	70% of average N application

The Defra GB fertiliser survey was used to provide the average field rates of N applications from 2015 to 2020. The average field rates provide the baseline for that amount of the reduction in N in each scenario.

Table 6: Typical nitrogen fertiliser rate for each crop, average 2015 to 2020

	Total nitrogen application rate
Winter wheat	188 kg/ha
Winter barley	147 kg/ha
Spring barley	103 kg/ha
Oilseed rape	184 kg/ha

Source: Defra. The British Survey of Fertiliser Practice 2021

To compare the typical application rate with the AHDB Nutrient Management Guide RB209 guidance on applications, we need to ensure we review the Soil Nitrogen Supply (SNS). This is an index score from 0 to 6 based upon the available soil nitrogen supply as tested by in-field soil samples.

The benchmark for available nitrogen in soil is 75 kg/ha (nitrate and ammonium) at soil N supply (SNS) Index 1. In the UK, more than 50% of soils are Index 1 or above. Soil N availability is increased by unrecovered fertiliser from previous crops or organic residues, such as legume roots or animal manures.

If we look at winter milling wheat as a specific example, the recommended application rate with an SNS index of 1 range from 150 kg/ha to 240 kg/ha depending on soil type. Light sandy soils are recommended to receive the least nitrogen, whereas shallow soils see the largest application rate.

Using medium soils as an example, the guidance on application rates ranges from 220 kg/ha at SNS 1 to 160 kg/ha at SNS 3. When compared to the average application rate actually applied by GB farmers of 194 kg/ha for milling wheat and 164 kg/ha for feed wheat, we can see that the ranges are very similar.

It is very difficult to prove or disprove whether cereal and oilseeds growers are over-applying fertiliser as the requirements for their usage will change seasonally depending on the crop, weather and available nitrogen in the soil.

However, as the ranges of recommended to actual are very close, we can confidently say that there is not an over-zealous application of fertiliser, and that cereal and oilseed growers make conscious decisions to only apply the amount needed for both agronomic and financial reasons.

3.1.3. Weather

For each scenario, it is assumed in the first instance that the 2022/23 growing season will be favourable, and an impact estimate is provided without the influence of adverse weather on production.

Weather can have an impact at any point in the growing season, from wet autumns affecting planting, prolonged frosts in winter, hail stone storm damage in spring to summer droughts. Analysis of the area grown by each crop in question over the last 11 years reveals that some years are linked to adverse weather periods. These periods and the influence of a change in planted areas have had a bigger impact on production output than weather events experienced during the growing season.

Analysis of the average change in these year-on-year changes can be split into minor (confined) and major events. For example, the very wet autumn of 2019 meant that winter wheat plantings were reduced by a significant 25% compared to the 2018 winter-sown area. In contrast, dry autumn in some parts of the country in 2016 led to a 2% decline in the winter wheat area. Table 7 presents the averages of the major and minor area percentage changes where there were known adverse weather periods at planting.

Table 7: Summary of the average percentage reductions in planted area due to key adverse weather periods at drilling time between 2011 and 2021

	% change in area	
	Minor	Major
Winter wheat	-3	-22
Winter barley	-5	-28
Spring barley	-4	-7
Winter oilseed rape	-4	-25

These percentages are assumed as reasonable weather impacts to apply to each crop and scenario in addition to the N fertiliser reduction estimates.

3.1.4. Forward commodity prices

For this exercise, the futures prices of grains and oilseeds in autumn 2023 were used as published by the AHDB on the 5th of July 2022. It has been assumed that the same prices would apply to each scenario as they are the market projections for 2023.

Table 8: Forward commodity prices used in each scenario

Futures price and date
Feed wheat - £250/t – Nov 23
Milling wheat - £265/t – Sep 23
Feed barley - £230/t – Nov 23
Malting barley -£250/t – Nov 23
Rapeseed - £535/t – Nov 23

Source: AHDB Cereals and Oilseeds Futures Prices/Refinitiv

These would be the prices that would guide growers in making decisions around the level of inputs they would use.

Futures prices are changing all the time in response to global news events, crop reports and economic influences. For example, between 5 July and 8 September, daily London feed wheat futures have deviated from -£23/t to £11/t compared to the £250/tonne baseline.

As far as can be foreseen at the time of this report, AHDB cereals and oilseeds market specialists comment that commodity prices will hold up on the back of a limited supply of grains coming from Ukraine and Russia.

Should grain and seed prices reduce to close to £200/tonne or even below this, unless fertiliser and other input prices also fall, then the extreme worst-case scenario becomes more likely.

4. Modelling Approach

The following outlines the approaches taken in the model to arrive at an impact on production estimate.

4.1. Fertiliser application rates

For each scenario, the assumed proportion of the typical nitrogen application rate is applied to the reported average nitrogen rate for that crop. For example, the average winter wheat nitrogen application rate is 188 kg/ha. The proportion of this assumed used in the most likely scenario is 90% of that total or 169 kg/ha.

4.2. Yield and nitrogen response

The impact on yield is based on the difference between the average nitrogen application rate and the reduced amount assumed applied in each scenario. So, the difference applied to winter wheat between the reasonable best-case scenario (188 kg/ha) and the most likely scenario (169kg/ha) is 19kg N. Using the nitrogen response curve for winter wheat this calculates as a yield reduction of 0.11t/ha.

Table 9: Effect on yield from reducing nitrogen rate (t/ha)

N rate reduction (kg/ha)	Winter wheat (standard cereal curve)	Winter barley	Spring barley	Winter oilseed rape
10	-0.05	-0.06	-0.06	-0.03
20	-0.12	-0.12	-0.14	-0.06
30	-0.19	-0.2	-0.24	-0.09
40	-0.27	-0.29	-0.37	-0.13
50	-0.36	-0.4	-0.55	-0.18
60	-0.47	-0.53	-0.64	-0.24
70	-0.59	-0.68	-0.88	-0.29
80	-0.72	-0.85	-0.99	-0.36
90	-0.87	-1.05	-1.1	-0.44
100	-1.04	-1.28	-1.35	-0.52

Source: AHDB Nutrient Management Guide RB209/ADAS Review of how best to respond to expensive fertiliser nitrogen for use in 2022

The model uses algorithms created from the table above to calculate the yield impact of any reduction in the nitrogen fertiliser rate.

Yield responses to nitrogen rates that are close to the average or the RB209 recommended application rates will be relatively small. The greatest effect of nitrogen application on yields comes from the first 100kg/ha after which the response reduces and flattens out. Crops may derive the first 100kg/ha from fertiliser but also soil available nitrogen left from the previous crop.

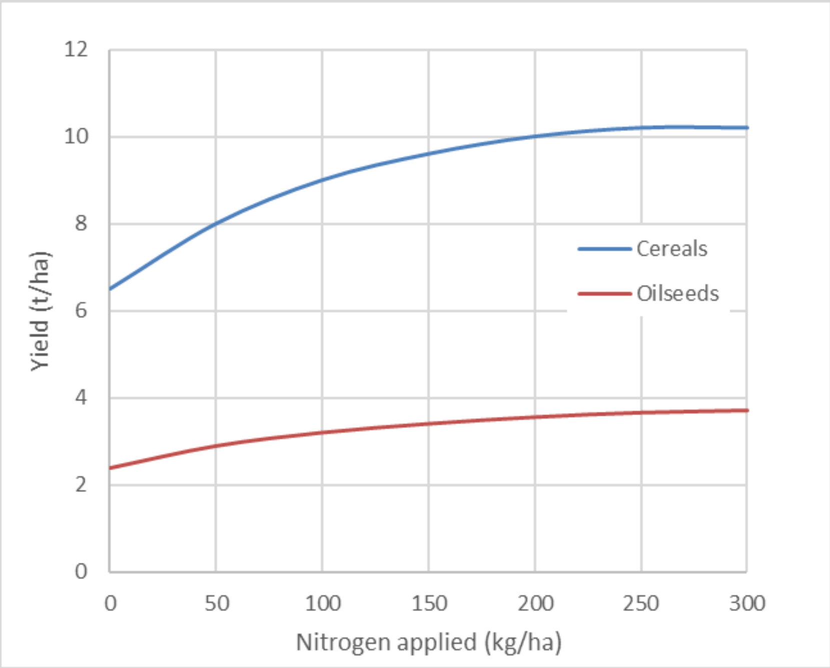

Figure 4: Average response shapes for cereals and oilseeds to applied N as used in the current version of RB209

Source: AHDB Nutrient Management Guide RB209

4.3. Yields

To then estimate the production levels in each scenario, yields are multiplied by the planted area. The crop yields used in the modelling are based on the 5-year average to 2021. The yield impact from nitrogen fertiliser reduction is taken away from the average yield in each case. For example, yield impact in the most likely scenario for winter wheat is -0.11 t/ha and the 5-year average yield is 8 t/ha. The resulting 7.89 t/ha yield is multiplied by the planted area to arrive at the total grain production.

4.4. Planted area and production estimates

The production estimates for 2023 are compared with 2022 forecasts. AHDB's Planting and Variety Survey 2022 provides an estimate of the area sown to the main UK crops. When the 5year average yields are applied to the areas reported in the survey this gives a production forecast for 2022.

For the 2023 production estimates, it is assumed that the same crop area is planted as in 2022 but multiplied by the reduced yields due to a nitrogen rate reduction.

4.5. Weather impact

Section 3.1.3 described how the weather impact on production was assumed for this project. The minor and major percentage reductions in areas planted were applied to the 2022 planted area estimates. The decreased planted areas were then multiplied by the reduced yields from lower N rate usage to estimate a combined weather and yield impact on production.

5. Limitations

1) The yield impact is just an average.

The relationship between crop yield and nitrogen application used in the modelling is based on numerous research studies over many years. Actual yield to nitrogen response curves will vary between seasons, fields and crop varieties.

2) Fertiliser intentions are from direct communications with growers, colleagues' feedback from discussion groups and advisors.

Due to time restrictions, it was not possible to conduct a structured survey. This also meant that it wasn't possible to robustly survey by farm size or tenure. In the direct responses received the fertiliser application approach didn't appear to be significantly different between farm size and tenure. However, the feedback that was received from all parts of the UK was consistent and hence formed the basis used in this work.

3) Weather impact focuses just on the period at planting and the area sown.

From analysing the planted areas of crops over the last 11 years, the effect of adverse weather at drilling time has, at times, significantly affected production. More than within-season weather impacts. However, weather events during a growing season may also affect yields and therefore production. This would have needed an extra level of complexity and sub-scenarios for the modelling. Hence for this project, the weather impact focused on the most significant influence.

6. 2023 UK production impact estimates

The assumptions and model approach has produced the following results of the impact of fertiliser reduction and adverse weather scenarios.

6.1. Winter wheat – 2023 production impact estimates

	Impact of nitrogen rate reductions			Impact of adverse drilling weather plus N fertiliser reduction	
	Yield impact (tonnes/ha)	Yield impact on production (%)	Total UK production impact (tonnes)	Including minor weather impact (tonnes)	Including major weather impact (tonnes)
Reasonable best-case scenario	0.00	0.0%	0	-418,000 (-3%)	-3,072,000 (-22%)
Most likely scenario	-0.11	-1.3%	-187,000	-787,000 (-5.6%)	-3,405,000 (-24%)
Reasonable worstcase scenario	-0.25	-3.1%	-429,000	-1,264,000 (-9.1%)	-3,836,000 (-28%)
Extreme worst-case scenario	-0.43	-5.4%	-751,000	-1,899,000 (-13.6%)	-4,410,000 (-32%)

Comparison baseline – 2022 – 13,964,000 tonnes

6.2. Winter barley – 2023 production impact estimates

	Impact of nitrogen rate reductions			Impact of adverse drilling weather plus N fertiliser reduction	
	Yield impact (tonnes/ha)	Yield impact on production (%)	Total UK production impact (tonnes)	Including minor weather impact (tonnes)	Including major weather impact (tonnes)
Reasonable best-case scenario	0.00	0.0%	0	-150,000 (-5%)	-863,000 (-28%)
Most likely scenario	-0.09	-1.3%	-37,000	-232,000 (-7.5%)	-932,000 (-30%)
Reasonable worstcase scenario	-0.18	-2.7%	-78,000	-314,000 (-10%)	-1,005,000 (-33%)
Extreme worst-case scenario	-0.32	-4.7%	-136,000	-436,000 (-14%)	-1,112,000 (-36%)

Comparison baseline – 2022 – 3,084,000 tonnes

6.3. Spring barley – 2023 production impact estimates

	Impact of nitrogen rate reductions			Impact of adverse drilling weather plus N fertiliser reduction	
	Yield impact (tonnes/ha)	Yield impact on production (%)	Total UK production impact (tonnes)	Including minor weather impact (tonnes)	Including major weather impact (tonnes)
Reasonable best-case scenario	0.00	0.0%	0	-152,000 (-4%)	-267,000 (-7%)
Most likely scenario	-0.04	-0.7%	-30,000	-208,000 (-5.5%)	-321,000 (-8.5%)
Reasonable worstcase scenario	-0.15	-2.7%	-106,000	-350,000 (-9.2%)	-461,000 (-12%)
Extreme worst-case scenario	-0.27	-4.7%	-188,000	-505,000 (-13%)	-614,000 (-16%)

Comparison baseline – 2022 – 3,805,000 tonnes

6.4. Oilseed rape – 2023 production impact estimates

	Impact of nitrogen rate reductions			Impact of adverse drilling weather plus N fertiliser reduction	
	Yield impact (tonnes/ha)	Yield impact on production (%)	Total UKproduction impact (tonnes)	Including minor weather impact (tonnes)	Including major weather impact (tonnes)
Reasonable best-case scenario	0.00	0.0%	0	-46,000 (-4%)	-287,000 (-25%)
Most likely scenario	-0.05	-1.7%	-19,000	-83,000 (-7.2%)	-321,000 (-28%)
Reasonable worstcase scenario	-0.12	-3.7%	-42,000	-129,000 (-11%)	-361,000 (-31%)
Extreme worst-case scenario	-0.21	-6.4%	-74,000	-191,000 (-17%)	-417,000 (-36%)

Comparison baseline – 2022 – 1,075,000 tonnes

7. Impact of nitrogen reductions on grain quality

7.1. Wheat

When wheat was fertilised optimally for yield at the pre-fertiliser price rises, grain protein concentrations of 11% for feed varieties and 12% for milling varieties would be expected on average. Research by ADAS has shown that a 50 kg/ha reduction in nitrogen application will approximately reduce protein concentrations by 1 percentage point.

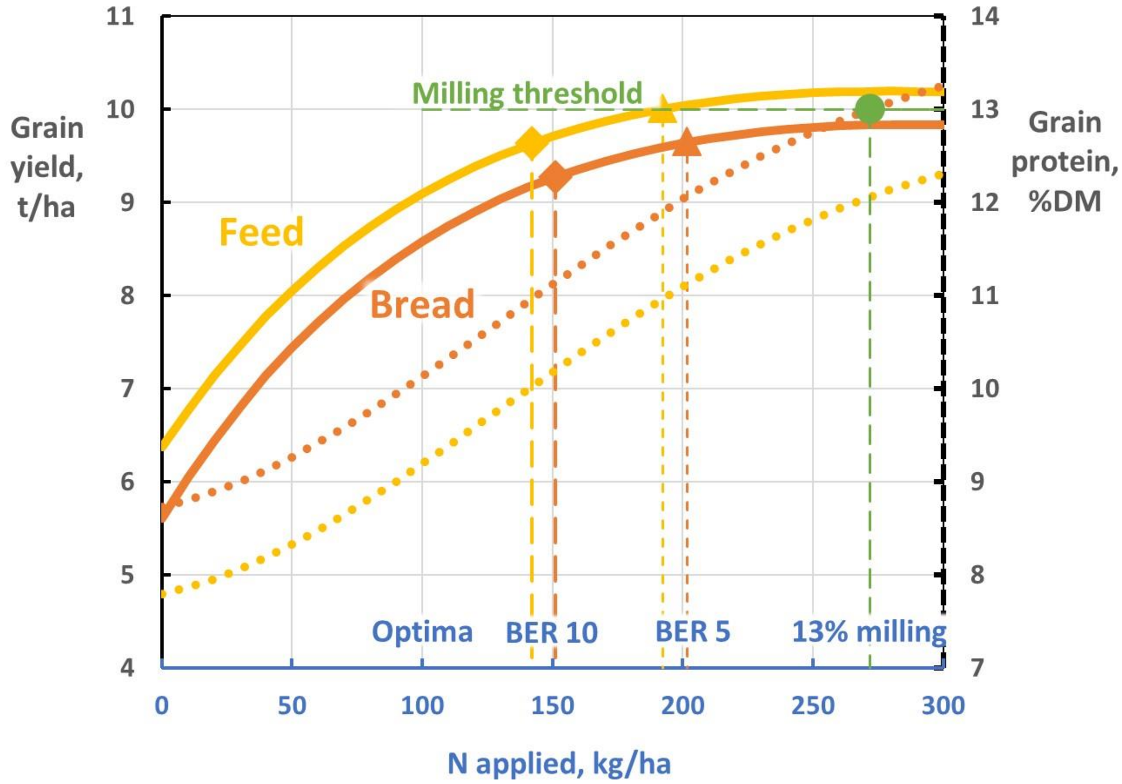

Figure 5: Effects of total fertiliser N applied in spring on grain yield (full lines) and grain protein (dotted lines) of feed (yellow) and milling (orange) wheat varieties based on curves adopted for AHDB's 'Nitrogen fertiliser adjustment calculator for cereals and oilseeds' and on RB209 advice about protein concentrations at N rates that optimise grain yield at break-even price ratios (N:grain; BER) of 5 (as in RB209) and 10.

Source: ADAS. Review of how best to respond to expensive fertiliser nitrogen for use in 2022 (part four: late N for milling wheat)

The most likely scenario estimates a ~20 kg/ha reduction in nitrogen application compared to the best case (no change in usage rate). Therefore, a 0.4 percentage point reduction in protein concentration would be expected as long as the weather is favourable.

In 2022 the AHDB cereal quality survey reported group 4 feed wheats had protein concentrations of 10.4% as opposed to 11.5% in 2021. This was due to the combination of dry weather restricting crop uptake of fertiliser and lower rates of application. For livestock feed rations using feed-grade wheat, this will mean a reformulation of rations to enable nutrient levels to be maintained.

Milling wheats have market specifications for 13% protein concentration. Extra nitrogen is required to achieve this. Anecdotal conversations with growers of milling wheat suggest that they will largely continue to apply late additional nitrogen to boost protein levels to receive milling premiums. Advice from ADAS to growers about whether to apply late nitrogen depends on the premium available and the farm's previous success in meeting milling specifications.

Table 10: ADAS guidance for milling wheat growers

Premium £/tonne	Farm's past success in meeting milling spec. Seldom	Sometimes	Usually
~£10	Omit late N & hope!	Continue with usual past practice for milling wheats	Continue with usual practice for milling wheats
~£20	Only apply late N (60 kg/ha) if spring N applied was as in previous years. Otherwise, omit late N & hope!		
>£20		Apply 60 kg/ha late N even if not usual past practice	

Source: ADAS. Review of how best to respond to expensive fertiliser nitrogen for use in 2022 (part four: late N for milling wheat)

In 2022 however, the dry weather from spring onwards in many parts of England meant that late applied nitrogen either wasn't taken up by the crop or wasn't applied at all because conditions were already too dry. As a result, protein concentrations were lower. The 2022 AHDB cereal quality survey reported group 1 premium milling wheats had average protein percentages of 12.5% compared to 13.2% in 2021.

7.2. Barley

Barley generally requires lower rates of nitrogen than wheat. And malting barley needs less nitrogen (~30 kg/ha) than feed barley due to the demand for lower nitrogen % in the grain required for brewing. Depending on the target market there can be a minimum level of grain nitrogen % required. Table 11 shows the effect of adjusting nitrogen rates on nitrogen percentages.

Table 11: Impact of adjusting nitrogen (N) rate on barley grain nitrogen % and yield

Deviation in N rate from RB209 recommendation for feed at BER 5:1 (kg/ha)	Impact on grain N% (percentage points)	Impact on yield (t/ha)
-50	-0.17	-0.55
-30	-0.10	-0.24
0	0.00	0.00
30	0.10	0.09
60	0.20	0.11
90	0.30	0.08
120	0.40	0.03

Source: ADAS. Review of how best to respond to expensive fertiliser nitrogen for use in 2022 (part two)

The most likely scenario for barley estimates a 10 kg/ha reduction in nitrogen application compared to the best case (no change in usage rate). Therefore, a potential 0.04 percentage point reduction in nitrogen concentration is estimated and assuming favourable weather conditions.

8. Potential longer-term impact of nitrogen fertiliser reduction

Applying less nitrogen (N) fertiliser will reduce the nitrogen balance (N inputs minus N offtake in grain and straw) after harvest. This impacts the amount of nitrogen residue in the soil and hence what could be available for the following crop.

Whether the smaller N residues will have a detectable impact on the soil nitrogen supply (SNS) for the following crop depends on several factors including the yield of the crop harvest in 2022, the amount of mineralisation/immobilisation that occurs after harvest and the amount of hydrologically effective winter rainfall (difference between total rainfall and actual evapotranspiration). Previous research has shown that reducing the rate of fertiliser by about 50 kg N/ha has a relatively modest impact on the SNS for the following crop (Defra Report IS0223). Over the short term (1 to 3 years) it is unlikely that the use of moderately lower N rates will on their own have a large enough impact to justify a change in N rates for the following crop.

If N fertiliser prices remain high for several years, then this could have an impact on the SNS in some rotations, particularly those with a high proportion of cereal crops. This is because the N balance is likely to become negative for winter wheat and spring barley and the effects of this will accumulate over years. The result of this will be a reduction in organic N levels, less N mineralisation and smaller SNS unless wholly or partly substituted with organic N sources.

9. Discussion

The most likely scenario estimates a relatively modest reduction in the UK production of between 0.7% and 1.7% depending on the crop. If the potential impact of adverse drilling weather is included, then the overall percentage reductions could be between 5.5% to 7.5% in minor situations. For major weather events in winter-sown crops, the combined impact could be between 24% and 30% with spring barley down 8.5%.

It was apparent with the responses from growers etc that there did not appear to be any significant trend of a different approach between larger versus smaller farms or tenure status. However, with some of the mixed farms, the approach taken in 2022 was to prioritise the crops over the grassland. It was reported by these farmers that the grassland had received a significantly reduced amount of inorganic nitrogen fertiliser or even none at all.

So, it is most likely that the 2023 fertiliser approaches by cereal and oilseed rape growers, on average, will have a relatively low impact on crop production as long the growing season is favourable, and grain prices remain above £200/tonne. It is notable though that adverse weather could have a much greater effect on total output than the most likely or even the extreme worst-case fertiliser application rates scenario.

10. References

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11. Appendix

11.1. Table of Scenario Assumptions

	Reasonable best-case scenario	Most likely scenario	Reasonable worst-case scenario	Extreme worst-case scenario	Notes	Evidence
Fertiliser prices	£600 - 650/t Ammonium Nitrate Best prices during buying window in early May 2022	£700-750/t Ammonium Nitrate Prices paid by many arable farmers later in May and June 2022 buying window	£850-950/t Ammonium Nitrate Highest average range of prices reported when production and supply was most limited in 1st quarter 2022	£1000-1100/t Ammonium Nitrate If fertiliser production is severely restricted due to higher than expected energy prices over the winter/spring 2022/23 as result of the fallout from the Ukraine conflict	Most growers will tend to purchase fertiliser in May and June to use in the following season.	Sources: AHDB fertiliser price survey UK natural Gas Futures ICE Gas futures prices indicate that energy prices may hold up this year and into 2023 at around 300% more than futures prices back in Sept 21. Oil prices are also expected to say high due to limited supplies exported from Russia. This would indicate and so is assumed that AN fertiliser prices may not drop below the levels seen so far in 2022.

Proportion of N fertiliser farmers are likely to use compared with the average 2015 – 2020	100%	90%	80%	70%	It is assumed that the amount of N fertiliser on farms will be similar to the amount of N fertiliser used. This is do to with storage constraints, difficulty at which inorganic N can be substituted for organic N in the main crop growing areas and fear of risk of yields dropping too much. In the worst-case scenarios, the amounts used is assumed to be lower due to a combination of the higher prices and reduced supply.	Sources: AIC fertiliser deliveries The current figures on fertiliser deliveries show that from July 21 to end of May 22 straight N fertiliser deliveries were 5% lower and 32% lower with compound fertilisers. For May 22 alone the N fertiliser deliveries were up 10% for straight fertilisers but down 48% for compounds fertilisers. Personal communications with AHDB Knowledge Exchange Managers and discussion groups, farmers, agronomists

Weather	Minor impact: such as seen in autumn/winter 2016 and 2017 Winter wheat: -3%; Winter barley: -5%; Spring barley and winter oilseed rape: -4% Major impact: such as seen in autumn/winter 2012 and 2019 Winter wheat: -22%; Winter barley: -28%; Spring barley: -7%; Winter oilseed rape: -25%	As there can be many combinations of weather impacts through a growing season that can impact whether crops are drilled to, they grow or yield. To keep the analysis relatively simple this variable will concentrate on how weather conditions at time of drilling could impact available production	Sources: June survey 2011 to 2021 - crop areas Based on changes in crop areas the following provides a guide to minor/not widespread and major/widespread impact of weather at drilling

Commodity forward price	Feed wheat - £268/t Milling wheat - £312/t Feed barley - £248/t Malting barley - £268/t Rapeseed - £554/t				In the best case scenarios, it is assumed that if current futures prices are realised next year, this will be enough of an incentive to growers to want to maintain yields and use similar amount of N fertiliser to typical usage. In the worst-case scenarios, it is assumed that fertiliser is bought at higher prices but grain prices remain unchanged so that the breakeven ratio increases. The assumed proportion of N fertiliser used is still likely to be above the economic optimum as growers attempt to maximise yield.	Sources: AHDB market prices for Autumn 2023 (as at 22/6/22) Corn returns survey for 20152021 (estimate malting barley futures using average premium of malting grain to feed grain)
Nitrogen fertiliser application rates	Winter wheat - 188kg/ha Winter barley - 147kg/ha Spring barley - 103kg/ha Oilseed rape - 184kg/ha	Winter wheat - 169kg/ha Winter barley - 132kg/ha Spring barley - 93kg/ha Oilseed rape - 166kg/ha	Winter wheat - 150kg/ha Winter barley - 118kg/ha Spring barley - 82kg/ha Oilseed rape - 147kg/ha	Winter wheat - 132kg/ha Winter barley - 103kg/ha Spring barley - 72kg/ha Oilseed rape - 129kg/ha	The nitrogen applications rates with scenario reductions applied	Sources: Defra GB Fertiliser Survey 2015 to 2020 AHDB RB209