Crisis in Feed, Fuel and Fertiliser Technical Note

Agriculture in the UK is facing significant challenges, many of which are unprecedented, including the current crisis in feed, fuel and fertiliser, pushing up costs for farmers to record highs. These crises are happening against a backdrop of knock-on effects from the Covid-19 pandemic, conflict in Ukraine, policy change, climate change causing more extreme and unpredictable conditions, as well as inflation rates rising quicker for agricultural inputs than outputs. This 'agflation' is rising faster than consumer prices. The domestic agricultural sector is also facing pressures for considerable change as we move towards delivering net zero commitments of 2050 in the UK.

Fertiliser manufacturing is heavily reliant on natural gas, both as a raw material and as energy for production, meaning the cost of producing nitrogen (N) fertiliser is directly linked to the cost of fuel, as shown in Figure 1. This is also a significant factor when considering the major agricultural sources of emissions as UK agriculture aims for the National Farmers' Union (NFU) target of net zero emissions by 2040[1]. Approximately 50% of the greenhouse gas (GHG) emissions associated with N fertilisers can be attributed to the production process due to the high energy requirements and the use of natural gas. Agriculture is responsible for 68% of UK nitrous oxide (N_2O) emissions, with N fertiliser making up a significant portion of these[2]. Nitrogen fertilisers are also associated with ammonia emissions, with around 88% of ammonia emissions in the UK come from agriculture; while not a greenhouse gas, ammonia is a significant air pollutant and under the Clean Air Act the government has agreed to reduce emissions by 16% in 2030 compared to 2005 levels[3].

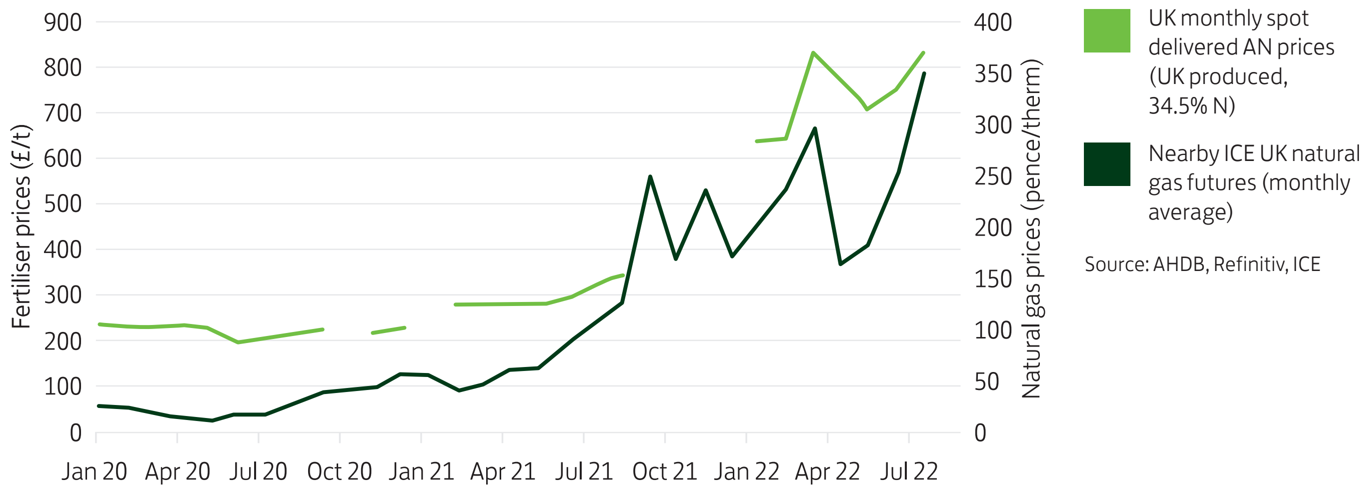

Figure 1. The close relationship of natural gas prices vs fertiliser prices (Source: AHDB)[4]

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Natural gas makes up to 60–80% of the costs of fertiliser production in Europe, and at one stage the prices peaked at 640.30p/therm at the end of August 2022[4]. This has had an impact on fertiliser price which in the UK reached £870 per tonne of imported AN, an increase of 150% on the previous year, when prices had already begun to rise[5]. Potassium chloride fertiliser costs have also been impacted, with peaks in the summer of 2022 of 165% higher than the previous year and phosphate fertilisers by around 120%. Fertiliser prices began to ease off in autumn 2022 however, reducing the need for manufactured fertilisers and improving the efficiency of their use remains vital in dealing both with the current cost crisis and the climate crisis.

UK farmers are also being affected by rising costs for animal feed (Figure 2). This is in part due to rising fertiliser prices, with concentrate prices increasing by 65% in the year prior to November 2022[6]. The cost of sunflower meal spiked as export routes were closed from Ukraine, however some trade routes have now been re-established and the cost have subsequently dropped. Figures from the World Bank show that in September 2022 wheat prices were up 24%, having peaked at 56% in June, compared to the previous year[7]. In the UK this has led to price increases of 60% for pelleted wheat feed[6]. In addition to this soybean prices have risen 19% globally[7]. As markets remain volatile and many challenges will continue into the medium and long term, agriculture in the UK needs to develop resilient systems that are less reliant on imports of feed, fuel and fertiliser.

Actual v calculated concentrate prices

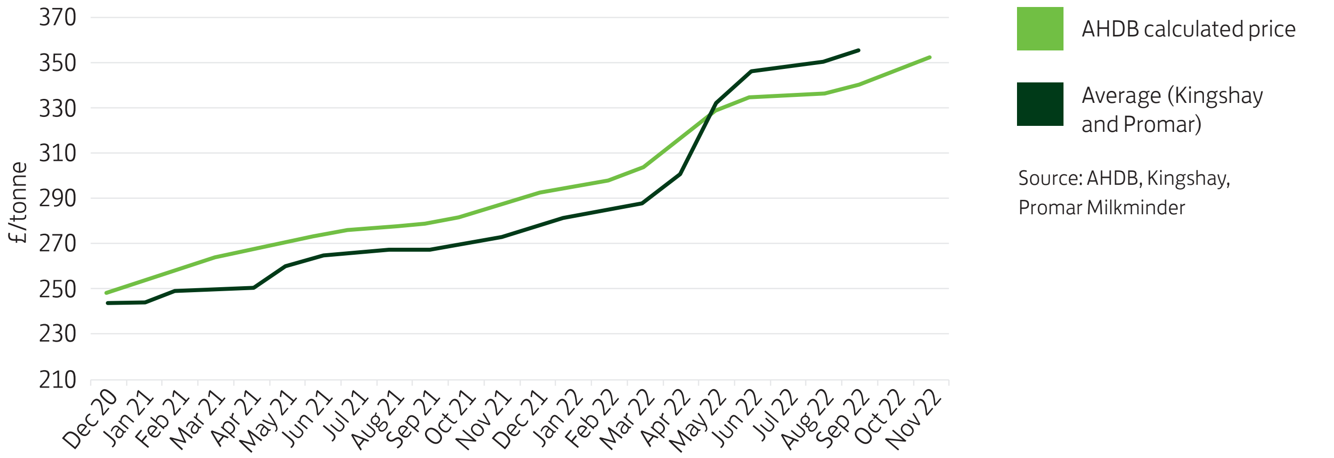

Figure 2. Feed concentrate prices, November 2022 (Source: AHDB)[6]

Drivers of the crisis

The rising prices over the last two years have been caused by a variety of pressures, both nationally and on a global scale. The cost of synthetic fertiliser began to increase in autumn 2021 when gas prices began to climb steeply, as natural gas is used as a raw material and an energy source for fertiliser production. The conflict in Ukraine has intensified this with supplies further limited.

Ukraine, Russia and Belarus are major producers and suppliers of fertiliser and their raw materials. Prior to Russia's invasion of Ukraine in February 2022, Russian exports accounted for 19% of potassium, 15% of nitrogen and 14% of phosphorous fertiliser globally. Belarus accounted for 18% of potassium fertiliser exports (Figure 3)[8]. Sanctions have disrupted the sale of fertilisers from Russia, and the UK has imposed a 35% tariff on Russian fertiliser, in addition to existing tariffs. Lithuania have halted the export of Belarusian Potassium fertiliser through its port in Klaipeda, which led to prices more than doubling[9]. In addition to this, Russia supplies about one-third of Europe's natural gas supply, the main feedstock to produce nitrogen fertilisers; at the end of July 2022 the Russian gas supplier Gazprom cut the supply of the single largest pipeline bringing natural gas to Europe via Germany to just 20% of normal capacity.

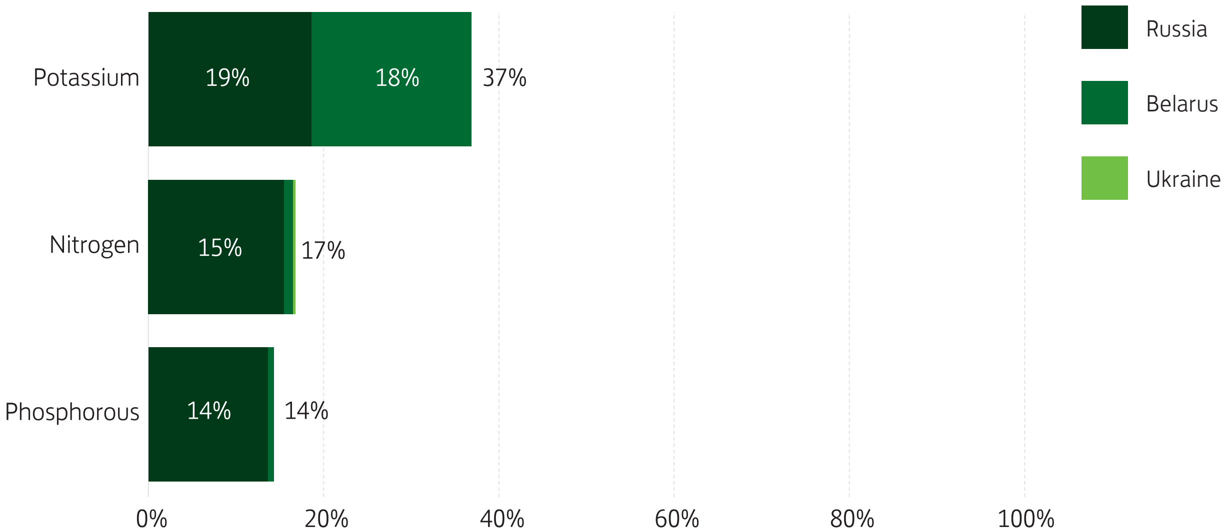

Figure 3. Fertiliser exports from Russia, Belarus and Ukraine, 2019 (Source: Our World in Data)[8]

The UK has, however, dramatically reduced its reliance on imported gas, as the UK government aims to increase the UK's energy security. Figures show that domestic gas production in the first half of 2022 was 26% higher than the same period in 2021, meeting 44% of the country's electricity generation in July and heating 85% of homes as well as fuelling other industrial processes. In 2022, the UK ended energy imports from Russia, with a House of Commons briefing note confirming that in June, the UK imported no oil, gas or coal from Russia[10].

Despite this, CF Industries, Britain's biggest fertiliser producer (and carbon dioxide supplier to the country's meat, beer and soft drinks sector), announced permanent closure of one of its two UK plants in 2022 due to the elevated cost of natural gas. In August 2022, CF announced a temporary pause to production at its other site in Billingham, citing market conditions as the cause. Closures and disruption to these plants further increase reliance on imports. As gas prices remain high, domestic fertiliser prices are likely to follow suit for the foreseeable future.

Animal feed prices also increased as a direct impact of the war in Ukraine. Prices of sunflower meal (a by-product of sunflower oil), soybean and wheat increased significantly during 2022. In 2019, exports from Ukraine made up 42% global sunflower oil exports, with Russia adding a further 21%. In addition, Ukraine exported nearly 9% of wheat, 10% of barley and 16% of corn globally, while Russia was the world's largest wheat exporter (Figure 4)[8]. Along with disruption of agricultural production due to war, typically 90% of Ukraine's grain is exported by sea, but these have been held up by Russian blockades. Drought in the USA and Brazil has led to poor soybean harvests, leading to price increases.

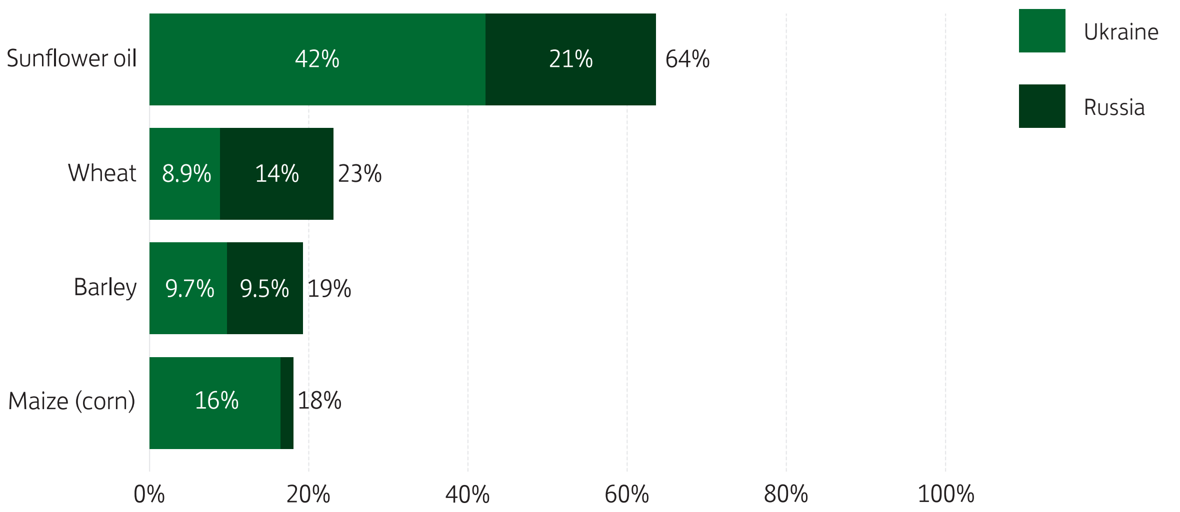

Figure 4. Food exports from Russia and Ukraine, 2019 (Source: Our World in Data)[8]

Impact of rising costs on farmers

These rising costs come at a time when many farm businesses are struggling financially. DEFRA reported that between 2015 and 2018 only the top 25% of UK farm businesses made a profit from agricultural activity alone, with many others making little or no profit from agricultural activities, relying on diversification along with direct EU payment subsidies. It is estimated that the loss of the Basic Payment Scheme will leave 42% of UK farms as loss making, and necessitating cost cutting by 10% to compensate[11].

There are concerns that these increasing fertiliser and feed prices could seriously disrupt global food supplies as soon as 2023 according to Maximo Torero, Chief Economist for the UN Food and Agriculture Organization: "If we don't resolve the problem of fertiliser, and trade of fertilisers doesn't continue, then we'll have a very serious problem of [food] supply next year,"[12]. Seventy-five percent of all agriculture around the world uses fertiliser, with British farmers using around 1m tonnes of manufactured nitrogen each year, to grow crops for human consumption, and grass for animals to eat[13].

High fertiliser prices already have farmers planning to reduce the amount of land being planted, causing further problems for food security, particularly with the need to take up the slack from blocked Ukrainian and Russia deliveries. As demonstrated in Figure 5, the costs of inputs are exceeding that of outputs for UK agriculture as a whole[14]. A third of arable farmers told the NFU they're cutting back on planting crops for food, with many switching from growing wheat for bread to wheat for animal feed, as it uses less fertiliser[15]. Research by the NFU also found that more than 3% of dairy producers in the South West alone have closed over the last 6 months, with 7% of dairy farmers nationally considering stopping milk production by 2024[16].

Pig farmers are also being forced to scale back production and the sector has already reached a crisis point. In 2021, thousands of pigs were culled and burnt due to a shortage of skilled workers arriving from Europe since Brexit. These losses were compounded by increasing feed and fuel prices leaving most producers unable to make a profit. The National Pig Association (NPA) reported that four in five producers will go out of business within a year unless their financial situation improves[17]. They called upon retailers for support, and while many are now paying more through dedicated supply chains, in May 2022 farmers were losing in excess of £50 per pig.

The pig industry is not the only agricultural sub-sector to have struggled with retailer prices. The British Egg Industry Council (BEIC) and the British Free Range Egg Producers Association (BFREPA) warned that hundreds of farms are in real danger of going out of business by mid-2023, with input costs up by 30%[18]. They called for prices to be raised by retailers, however retailers are keen to protect their own margins and keep consumers happy. Analysis by BFREPA in July 2022 highlighted that consumers are paying around 20p/dozen more for free-range eggs than they did a few months ago, but farmers are only receiving an extra 5p/dozen, while needing at least 40p/dozen more to remain viable.

Export bans have also affected the energy market as cereals and vegetable oils are major components of biofuels, which have become particularly attractive to the EU as the bloc races to reduce its reliance on Russian oil and gas.

In the longer term, it is estimated that the world does not currently produce enough fertilizer to feed the anticipated growth in population by 2050, so looking at sustainable solutions to the crisis is vital not just in the short-term but also medium- and long-term.

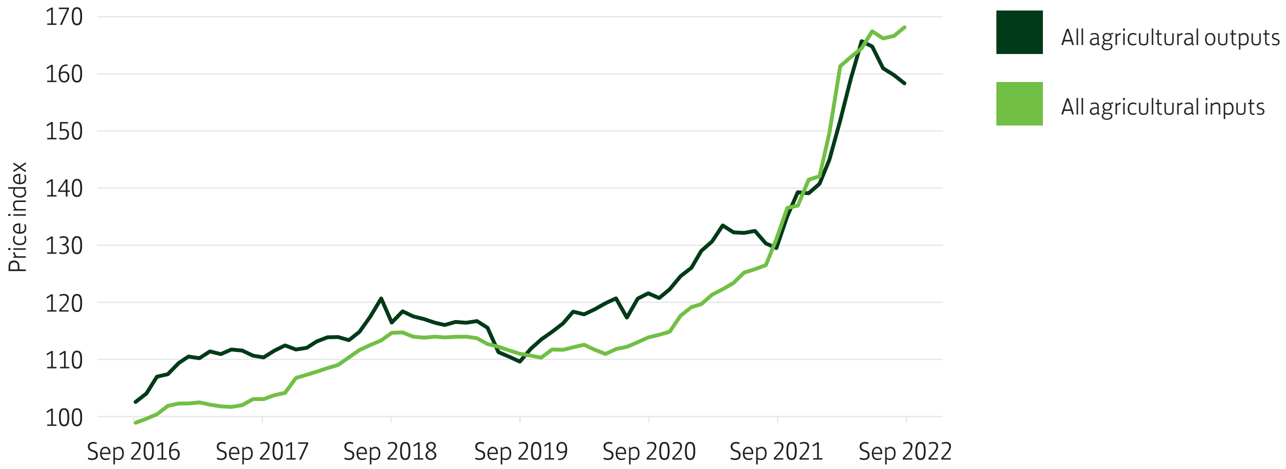

Figure 5. Monthly average price indices for agricultural outputs and inputs to September 2022 (Source: DEFRA)[14]

How can UK farm businesses limit the impact of continuing crisis?

With volatility in both grain and fertiliser markets continuing, it is important to take action to limit the impact of the current, continuing and future crises. There are many steps that can be implemented across a range of farms and systems moving forward.

Energy Efficiency

Limiting energy usage on farm and ensuring maximum energy efficiency is important for farm business resilience to rising prices and market shocks. Measuring energy efficiency via an energy audit is useful for the farm business to understand where and how much energy is being used and where reductions can be made. By identifying and benchmarking energy usage comparisons can then also be made against industry averages or similar farms. As shown in Figure 6, the major areas of energy consumption vary sector to sector. Energy efficiency measures can then be implemented such as building fabric improvements (e.g. insulation, draught-proofing, double glazing), installing low energy (LED) lighting, using more energy-efficient appliances/machinery, lagging pipes and using smart devices to minimise energy use[19].

Farming activity	Major areas of energy consumption
Horticulture	▪ Heating of greenhouses
Pigs	▪ Waste and manure management ▪ Feeding systems ▪ Maintenance of environmental conditions for stock rearing
Poultry	▪ Maintenance of environmental conditions for stock rearing
Beef	▪ Feed delivery to cattle
Dairy	▪ Milk production process ▪ Water heating ▪ Lighting and pumping ▪ Cooling and refrigeration of milk
Arable	▪ Milk production process ▪ Water heating ▪ Lighting and pumping

Figure 6. Areas of energy consumption by farming activity (Source: The Carbon Trust)[21]

With costs skyrocketing even small improvements can make a big difference. For example, research has shown that fuel use in the growth of glasshouse crops can be reduced by 10–30% by sealing any air leakages and draughts[20]. Energy saving and energy efficiency are important first steps as outlined in the energy hierarchy in Figure 7 below.

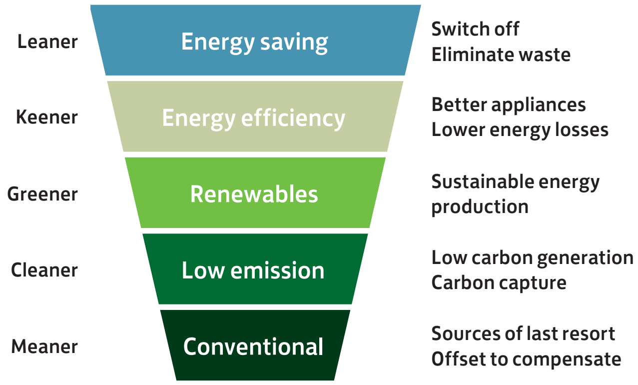

Figure 7. Energy hierarchy (Source: RASE)[19]

Renewable Energy

Many farms are looking to renewable energy as a diversification option, and the addition of farm-level battery storage is becoming a good option to cope with intermittent renewable sources. A major source of energy use on farms is for heat, for a range of purposes including grain and vegetable drying, produce chilling, and controlled livestock environments. These are energy intensive and seasonally variable processes, meaning heat storage, transfer and recovery are increasingly important[19].

Solar panels are a good option for those with large sheds and farm buildings (e.g. dairy and poultry), potentially supplying electricity for the majority of a farming operation (and also the home). This does require significant capital investment, but payback can be seen in 7–10 years for a modestly sized installation[21].

Another option is anaerobic digestion, which has the potential to provide 24/7 energy production, as well as providing an alternative fertiliser source. Anaerobic digestion (AD) is the biological decomposition of organic materials such as animal manures or food wastes in the absence of oxygens, producing a biogas and digestate. The methane-based biogas can be used flexibly for heat, electricity and transport fuels. Digestate is a fertiliser high in readily available nitrogen (RAN) as well as phosphate, potash, sulphur and magnesium, with added benefits of weed seed reduction and improved animal health when spread on grazing land in replacement of raw slurry. A 2015 study found that based on a small-scale AD, largely fed by manures/slurries resulted in significant carbon emission savings, concluding that each tonne of dry matter of cattle manure processed through anaerobic digestion results in the avoidance of 1,449 kg CO_2e. This figure took into account the fertiliser replacement value as well as the energy production[22].

The cost of AD plants is significant, often requiring capital grants or loans. Energy production in the UK from AD followed a rapidly growing trend from 2009–2016, continuing into 2020 at a slower rate (latest available figures). This was supported in part by schemes such as the Renewables Obligation (RO) which closed in 2017, and the non-domestic Renewable Heat Incentive (RHI), which closed March 2022[23]. However, with rising energy and fertiliser costs AD is likely to be a cost-effective option in the longer term. Alongside the high initial investment, there are further risks to AD; the equipment is complex and high standards of maintenance and management are required. This can make larger off-site AD plants an attractive option, particularly for smaller farms. This can involve supplying feedstock crops of slurries to larger plants, and the future could see groups of farms develop digesters on their own accounts, with larger scale centralised systems enabling more efficient heat and energy production increasing the economic viability[24].

Making the most of fertilisers

Utilising both manufactured and organic manures efficiently is key to minimising both costs and the associated greenhouse gas emissions. It is of note that overall manufactured fertiliser use in England and Wales has decreased by around 30% since 1982, while significantly more for phosphate and potash-based fertilisers[25].

Fertiliser inputs represent one of the largest single variable costs of producing a crop. In order to remain profitable farmers must balance the cost of fertiliser with the value of the crop that will be produced, which is known as the 'breakeven ratio'. For cereal crops this has recently been around six, (6kg of grain needed to pay for 1kg of nitrogen fertiliser), but it is currently around ten. To remain profitable, farmers may potentially use less fertiliser. However, this risks yields and quality, adding to pressure on the food system as a whole[26].

Low efficiency of fertiliser use involves substantial, avoidable costs to farmers and avoidable emissions and pollution. Improving N use efficiency from manufactured fertilisers as well as organic sources such as manures, composts, biosolids, and anaerobic digestate, and to minimise losses is key to limiting the continuing impact of rising costs. UK farming has made many improvements in efficiency. 45% of applied N fertiliser (85 kg N/ha) is not taken up or retained by crops or grassland and this excess is leached, mainly as nitrate, or lost by volatilization[27]. However, using a combination of approaches it has been suggested that a goal for European agriculture could be an approximately 20% increase to 75% nitrogen use efficiency by 2050.

Organic manures from livestock farms are a significant source of nutrients. Making the most of organic manures is a crucial factor in reducing reliance on manufactured fertilisers. Careful storage and application of these materials to land benefits both crops and soil. The management of slurry for ammonia is under more scrutiny from the Clean Air Strategy[3]. Covering manure and slurry stores can reduce ammonium losses via volatilisation, which has the benefit of reduced air pollution as well as to the quality of the slurry as a fertiliser. By excluding rainwater, the volume of storage needed can be reduced, allowing farmers more options when it comes to timing of applications to ensure they are applying only in the right conditions and when there is a crop need, reducing the need for manufactured fertilisers. The Slurry Infrastructure grant is opening soon for pig, beef and dairy farms to help replace, build new or expand existing slurry stores to provide 6 months storage[28]. The application of organic manures to land is a key part in ensuring maximum crop uptake and minimum losses. Understanding the nutrients available in slurry is vital for calculating crop requirements and therefore the slurry, and the soil should be tested using RB209 guidance to produce a nutrient management plan. Applying slurries with low emission techniques such as trailing shoe, shallow injection or a dribble bar can significantly reduce emissions of methane and nitrous oxide to the atmosphere, leaving more nutrients available for the crop at lower nutrient input rates.

In the arable sector, precision N fertilisation using soil testing and crop sensors can improve the effectiveness of timing and spatial targeting of applications, to minimise the amount of fertiliser applied while meeting crop requirements. This, combined with careful timing of applications informed by medium-range weather forecasting and soil moisture assessments can minimise N_2O losses from nitrate fertilisers and NH_3 losses from manure and slurry applications.

However, the effectiveness of precision fertiliser application is often constrained by poor soil health, especially by the depletion of organic matter. This leads to poor soil structure, reducing soil pore space and infiltration rates, increasing the likelihood of compaction and poor drainage which restrict root growth, thereby reducing nutrient uptake efficiency and increasing losses. Improving soil health, especially soil organic matter, will be central to achieving nutrient use efficiency gains.

Feed efficiency

Key to ensuring business sustainability in the background of rising feed and fertiliser prices is feed efficiency. Minimising protein inputs while maintaining efficient and profitable outputs may be key for dairy and beef production to minimise costs and ammonia losses. Feed costs contribute up to 60% of dairy production costs, and therefore improving the feed efficiency of feed conversion to milk can have a significant impact on profitability[29]. This can also have benefits to reduced farm carbon footprints. For example, by matching the amount of nitrogen in the diets of cattle to the expected level of production and growth stage of the stock, the amount of excess nitrogen being excreted can be minimised[28].

Alternative proteins are of increasing importance. Soya has historically been a protein of choice due to its amino acid profile, with 2.7 million tonnes of soybean meal imported to the UK in 2020[30]. However, due to increasing costs and long-term market fluctuations as well as poor sustainability performance, alternative sources are increasingly of interest. Alternative proteins have the potential to be produced with less water, land and energy. More common alternative protein sources include oilseed meals, pulses, brewers grains and lucerne.

Feed emissions typically account for 87% of the farm carbon footprint of free-range egg production; this is due in large part to the large quantity of soya in the diet. A study by BFREPA[31] modelled a nil-soya ration resulting in a decreased carbon footprint of 34%. The study also found where it is not possible to fully eliminate soya from diets, it is important to look at the country of origin and prioritise sustainable production.

Alternative / Green Fertilisers

Long-term UK natural gas production is expected to drop from 33.9 million metric tons of oil equivalent in 2022 to 6.6 million metric tons by 2040, while demand for gas is forecast to see only slight fluctuations in comparison and is expected to remain at similar levels over the next few decades (Sönnichsen, 2022). This indicates a need to move towards alternative fertilisers and methods of production.

Green fertilisers are nitrate-based mineral fertilisers. They have the same composition as those produced from fossil fuels, however they have a much lower carbon footprint as they are produced using renewable energy (hydro, wind and solar). Ammonia is the base of all mineral fertilisers and is conventionally produced using hydrogen from fossil fuels. To produce green ammonia the hydrogen comes from water using electrolysis based on renewable energy. Other processes remain the same, including the use of a best available technology (BAT) for the catalytic processes that reduce greenhouse gas emissions (GHG) during production[32].

Green fertilisers are important to help decarbonise the food value chain. By incorporating green fertiliser, the reliance on energy decreases and this reduces reliance on fossil fuels and improves energy security. Green fertilisers can reduce the carbon footprint of wheat by around 20% and bread by 12%[32]. However, green ammonia is estimated to cost between two to four times as much to make as a conventional ammonia. With the cost of fuels increasing however, green fertiliser may become more competitive.

Alternative fuels / Hydrogen

The decarbonisation of the agriculture must include the replacement of diesel as the main vehicle fuel. Green energy such as hydrogen fuel can act as alternatives to move away from fossil fuels. Green hydrogen can be produced by using renewable energy, such as solar or wind power, to power the electrolysis process which splits water into hydrogen and oxygen.

Most agricultural vehicles run on diesel, and hydrogen is proposed as a long-term diesel fuel replacement for heavy vehicles such as tractors. Hydrogen can be utilised either in an internal combustion engine (ICE) or in a fuel cell (FC) to drive electric powertrains. However, there is not yet an established fuel infrastructure for hydrogen, and it currently has very high production costs, making it a medium-long term solution. Furthermore, the replacement of the internal combustion engine in agriculture is unlikely before 2050[33].

Policy response

The UK government have announced a range of measures in response to the rising prices. These include the more frequent payment of subsidies and the new Sustainable Farming Incentive.

In March 2022, DEFRA announced a delay in implementing changes to the use of urea fertiliser by at least a year. The changes were due to come into force in 2023, meaning farmers would only be able to use untreated or unprotected urea fertilisers from 15 January to 31 March each year. The delay is planned to help farmers manage costs and allow more time for adaption.

Revised statutory guidance on the use of slurry and manure under the Farming Rules for Water has been released, clarifying the rules around using slurry and manure in the autumn and winter, subject to avoiding significant risk of pollution. This will allow application when there is a crop need in some instances, which may help minimise the need for artificial fertilisers.

The Sustainable Farming Incentive (SFI) opened from 30 June 2022 and is the first of three new environmental schemes being introduced under the Agricultural Transition Plan[34]. This aims to 'help farmers manage land in a way that improves food production and is more environmentally sustainable', which includes reducing reliance on manufactured fertilisers. As part of this scheme, farmers can access funding towards the cost of nitrogen fixing plans and green manures in an effort to substitute some of the artificial fertiliser requirements.

The frequency of payments under the Basic Payment Scheme has been increased to two instalments per year to aid farmers' cash flow. DEFRA are hoping this will enable farmers more flexibility in making business decisions[35]. However, this will not have a direct impact on farms' profits.

While these policy responses are positive, there is a need for wider policy shifts to ensure the market supports the transition to lower input and lower import sustainable farming. There is also a need for policy to support the wider decarbonisation of agriculture as, for example, agriculture is not currently included in the replacement pathway for red diesel.

Looking to the future

Inflation rates are leading to cost increases across all areas of the businesses in addition to the continuing crises in fertiliser, feed and fuel and the pressures to meet net zero targets. Market volatility looks set to continue, with the climate change pressures intensifying weather variations and adding complexity to net zero targets as we approach deadlines to these commitments. To ensure long term business sustainability, it is vital to evaluate all aspects of farm business and look at options available for reducing reliance on imported and manufactured feed, fuel and fertilisers while making the most of the resources available. There are options available on both the small and large scale to farmers across sectors, requiring differing levels of capital investment. Many of the solutions available to these crises are still evolving, and decarbonising technologies may be more widely available in the future.

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