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Fertilizer Focus

The hydrogen economy

- Latin America focus
- Clean ammonia
- Tackling nitrate pollution


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Looking further afield

Written by

Stef Worsley, *Editor, Fertilizer Focus Magazine,*
Argus Media, UK

Welcome to the first edition of the 2024! We are featuring a number of articles on Latin America in this edition. Firstly the University of Sao Paulo, Brazil and the University of Illinois, USA, looks at fertilizer logistics in Brazil.

Brazil is a significant global player in agribusiness, however, it relies heavily on the international fertilizer market and is one of the largest importers. The country relies predominantly on road transport for its large agricultural production, especially for exports involving long distances. The longer the route distance, the greater the transporter's interest in finding return loads.

Meanwhile, there has been a great deal of talk about the El Niño weather phenomenon recently and this has impacted the agricultural industries in both south America and Asia to varying degrees. The University of CEMA, in Argentina, looks at the information that has been produced regarding the impact of changes in temperatures in the Southern Pacific Ocean. Prompting questions such as; to what extent does climate variability influence fertilizer use decisions? What decision-making processes do farmers employ to adapt fertilizer use to unpredictable climate shocks? And how can the risk associated with investing in fertilizers be mitigated?

In a related article, Deise Dallanor, Head of Brazil and Latin America at Varda, Brazil, discusses the potential of Brazilian agribusiness following COP 28. Brazil stands out not only because it already operates with renewable energy bases but also due to its national agri- food system and sustainable practices, such as combating deforestation, recovering degraded pastures, intercropping, and others. However, discussing climate change is impossible without addressing the impact that extreme weather has had on global agriculture.

Another article on Brazil tackles nutrient use efficiency. The tremendous external dependence on the supply of nutrients makes the country's position quite fragile and heavily dependent on the national variation in input prices. Variations in prices and the uncertainty in supply have been the primary concern for Brazilian producers.

These articles will tie in with the upcoming Fertilizer Latino Americano event held between 5-7 February 2024 in Miami, USA. Topics up for discussion include the impact of geopolitical events on fertilizer trade flows, sustainability and decarbonization.

We are also continuing the "History of the modern mineral fertilizer industry" series. In this instalment, Michael Freeman looks at the establishment of multi-nutrient fertilizers.

I hope you enjoy the issue. ■

History of the modern mineral fertilizer industry
Volume 2: 1900-1950 (Part 3)

The establishment of multi-nutrient fertilizers

In this third instalment of a six part series, Michael Freeman explores the supply and demand of potash after WWII and the emergence of multi-nutrient fertilizers. (Please refer to all editions of Fertilizer Focus in 2022 for volume 1 covering the origins of the fertilizer industry)

Germany was the dominant force in the world potash industry in the 19th century, when it was the sole producing country, supplying world markets from its production that had reached 300 kt/y K_2O by the end of the 1890s. It retained this position in the first half of the 20th century although no longer the only producer of potash fertilizers as several other countries had discovered economic reserves and invested in their development. Germany's output of K_2O grew strongly to reach 1 mn t in 1911 and 2 mn t in 1937, then it fell back in WWII when a number of its production sites were damaged or destroyed.

After WWII, 60% of the potash industry's capacity fell in the eastern part of Germany which had become the Soviet Occupied Zone, and later the German Democratic Republic (GDR), and several of the mines were taken over for a few years by the Soviet occupying authorities who operated them to make potash fertilizer for delivery to the USSR as part of the reparations that it demanded. Production of potash in both halves of Germany continued to recover and the combined output again reached the 2 mn t/y level in 1950. At this point the combined German share of the world potash market was 46%, of which West Germany accounted for just 20%.

The German potash industry is unusual in that an important part of its output is based on salt minerals that contain not only potassium and chloride but also magnesium and sulphate, which offers the possibility of making a wider range of fertilizer products that offer magnesium as well as potassium, and can be based on sulphate as well as chloride, in contrast with the majority of potash producers that only offer potassium chloride to their fertilizer customers. To illustrate this, the table 1 shows the situation in 1922 when it extracted 13 mn t of potash minerals, of which 60% were mined in carnallite areas of the deposit and 40% from Hartsalz and sylvinite areas. This material was processed to yield 1.3mn t K_2O of potash products for sale, as well as some magnesium products that do not contain potassium and do not appear in table 1.

Table 1. Sales of German potash products in 1922

	kt product	kt K_2O
Potassium chloride	498	273
Potash fertilizer salts 18-22% K_2O	479	100
Potash fertilizer salts 28-32% K_2O	165	51
Potash fertilizer salts 38-42% K_2O	1,251	507
Potassium sulphate	102	51
Kalimagnesia	53	14
Crude salts	2,261	300
TOTAL	**4,810**	**1,296**

Source: Zeitschrift für Gewinnung, Verarbeitung und Verwertung der Kalisalz, Heft 14, 1923

French potash

In the following years some of the lower-grade fertilizer salts were cut back in response to changing consumer demand, and the range of fertilizers containing magnesium was expanded.

The French potash industry came into existence in 1910 in Alsace, when this region was still part of Germany, as it had been since 1870. The first mine in Alsace (Amélie) was followed by several others with the result that by 1914 there were eleven mines controlled by four companies – three German and one French (Kali Saint Thérèse). After the end of the war when Alsace reverted to France, the German-owned mines were requisitioned by the French government, which set up Mines Domaniales de Potasse d'Alsace (MDPA) to run them, and Société Commerciale des Potasses d'Alsace (SCPA) to handle the sales for both producers. During WWII, the Alsace mines again came under German control as Elsässische Kaliwerke, but in 1945 this was reversed with the French government resuming control and absorbing Kali Saint Thérèse into MDPA, so that there was now a single French potash producer. The annual output of K_2O in France grew from less than 50kt in the early years to 300-400kt in the 1930s and 600-700kt in the 1940s, surging to just under 900kt in 1950. The products were potassium chloride and some lower-grade potash fertilizers, but the potash ore mined in Alsace was not suitable for the production of sulphate salts. This led SCPA to enter into an agreement with Produits Chimiques de Tessenderlo (PCT) which operated sulphate furnaces in Belgium that could be switched to making potassium sulphate. In 1929, SCPA and PCT founded Produits Chimiques de Limburg to make potassium sulphate at a second site in Belgium, and the French company also established a fertilizer factory in France under the name Potasses et Engrais Chimiques (PEC) with capacity at Rouen that included sulphate furnaces.

The impact of WWI on potash shipments caused the United States to look for domestic sources of supply, which led to the start of potassium chloride production from the brine of Searles Lake CA by American Trona Corp. (later American Potash and Chemical Co.) in 1915. Production from this source climbed to 50-60kt/y K_2O, which was not enough to eliminate the need for imports. A more promising resource, in the form of an underground deposit of potash minerals, was discovered during oil exploration in southeast New Mexico. The first mine was built by US Potash Co. (later US Borax & Chemical Co.) in 1931, and it was followed in 1935 by Potash Co. of America and in 1940 by Union Potash Co. which was later acquired by International Minerals & Chemical Corp. (IMCC). These new mines boosted US production of K_2O to 1 mn t/y by the end of the 1940s. The main product was potassium chloride, but the minerals in the New Mexico deposit also offered the possibility of making potassium magnesium sulphate, which was part of the product range of IMCC's mine.

The Spanish market

Spain became a potash producer in 1926 when the Belgian Solvay company was the first to build a mine to exploit the potash deposit in Catalonia that had been discovered earlier in the century. Three more potash mines were established in the same area, two by Union Española de Explosivos and one (Sallent) by the French potash group. These were small operations and their combined output grew slowly to reach 150kt/y K_2O by 1950.

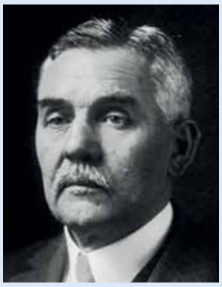
In Palestine, the Dead Sea was identified as a potential source of potassium chloride and capacity to recover it, consisting of evaporation pans and a refinery, was built on sites at northern and southern ends of the Dead Sea. The former was commissioned in 1932 and continued operating until it was destroyed in the 1948 war; at this point Palestine Potash Ltd had been producing some 40-50kt/y K_2O.

The southern works at Sdom was recommissioned in 1955 as Dead Sea Works in what had become the State of Israel.

The existence of potash as a component of Russia's huge Upper Kama salt deposit was known at the start of the 20th century, but development did not take place until the 1930s when a project for the construction of the first Solikamsk potash mine was included in the USSR's first five-year economic plan. It was implemented with technical assistance from the German potash industry and commissioned in 1932. Its annual production of K_2O reached 200kt in 1940, when mining ceased for four years during WWII, resuming in 1945 and recovering to the earlier output level by the end of the decade. There was no further development of new potash mines in the USSR until the 1960s, but the USSR's capacity was augmented by the country's acquisition of the Kalush and Stebnik mines located in eastern Galicia, a Polish region that had been absorbed into the Ukrainian Republic after having been occupied by the Red Army in 1939.

After the first potash mine was commissioned in Germany in the 1860s it soon became apparent that the reserve base in the country was huge and that it had the potential to support the entry of many new producers into the business and that the capital was available to support the construction of more potash mining projects. This inevitably created the conditions for the creation of a capacity surplus that threatened to undermine the economic viability of the nascent industry. The early producers responded to this in 1879 by making price agreements for carnallite, kainite and for refined products, and when this proved to be insufficient they created the first potash cartel in 1898 to determine production quotas that were in line with the size of the market, thus stabilizing prices.

Claude, Georges (1870-1960)



Georges Claude, who studied industrial chemistry in his home city of Paris, was an energetic inventor who in 1902 developed an aire liquifaction process that recovered oxygen, nitrogen and inert gasses, and in 1910 went on to pioneer the use of neon lights in signs. During WWI Claude worked on a high-pressure single-pass process for synthesising ammonia as an alternative to the Haber-Bosch process that had been successfully introduced in Germany.

Claude and his financial backers founded L'Air Liquide in 1902 to commercialise his process for extracting atmospheric gasses, building this into a substantial business. In 1919, La Société Chimique de la Grande Paroisse was set up as a joint venture by L'Air Liquide and St Gobain to build ammonia plants based on the Claude process and to licence it to other potential producers. By the mid-1930s, some twenty Clause ammonia process licenses had been sold for plants that accounted for 9% of total production capacity, most of which were in Europe, especially France.

The reputation of Georges Claude was damaged by his support for the Nazi occupying powers in France during WWII. This lead to his arrest after the end of the war, when he was tried and convicted of collaboration.

Table 2. German potash syndicate quotas for 1928

Wintershall AG	38.58%
Dr W.Sauer-Werke[a]	2.51%
Burbach Kaliwerke[b]	16.78%
Salzdetfurth-Aschersleben-Westergeln	21.66%
Preussag	5.98%
Anhaltische Salzwerke Leopoldshall	3.12%
Mansfeld Einigkeit	5.11%
Kali Chemie AG	3.95%
Deutsche Solvaywerke	2.22%

Source: Wachstum Erleben, K+S Gruppe Kassel, 2006

Inevitably the success of this cartel attracted more investors into what appeared to be a stable and well-managed business, with the result that they had to be accommodated in a new cartel from 1899. In the three decades up to the end of WWI, there were a total of five German potash cartels, also called Syndicates after 1905, each one lasting for between three and eleven years. At the start of the new century there fifteen potash works in Germany, but construction activity intensified in the years that followed so that by the end of the decade there were 69 potash works (with 141 shafts), not all of which chose to join the fourth syndicate. The situation was further destabilized when producers outside the syndicate sold substantial quantities to the US fertilizer market at prices that were substantially below the levels set by the syndicate. This unstable situation was eventually resolved by government intervention and the formation in 1909 of the Fifth Potash Syndicate, in which all of the potash producers were obliged to participate. However

After the end of WWI the German government passed a new potash law

A modern potash heap

there continued to be strong interest in building new capacity and 96 new potash works were completed in 1911-1914, followed by 45 more in 1914-1917. These new operations were not always commissioned as their owners simply wanted to obtain production quotas that could be traded with the established producers. The demand for German potash remained stable during the WWI years as the collapse of export sales was balanced by the growth of consumption in the home market.

The German Potash Syndicate

After the end of WWI the German government passed a new potash law in April 1919 that led to the re-establishment of the German Potash Syndicate with enhanced powers to control the industry. The included responsibility for eliminating uneconomic producers that were contributing to the industry's capacity surplus, a major task that resulted in the number of active mine shafts being cut back from 141 in 1914 to just 38 in 1933. At the same time consolidation of the ownership of potash mines was taking place with the larger and better-funded producers buying up many of the smaller operators. Table 2 shows the situation in 1928, when three quarters of the industry's capacity was in the hands of groups associated with Wintershall and Salzdetfurth.

In addition to re-ordering the potash industry inside Germany, the post-War syndicate was empowered to established relationships with the new potash producers that had emerged elsewhere in the world outside Germany. Its first priority was to negotiate an agreement with SCPA, representing the French industry that resulted in the Paris Agreement of 1926, under which export markets were allocated on a 70:30 basis to the German and French exporters. The two exporters were also required to improve their marketing and distribution network, setting up joint sales offices in major markets that included Belgium, the Netherlands, England, Italy, Spain, Spain, Japan and South Africa, while the two producers retained monopoly positions in their home markets. Poland joined the world potash syndicate in 1932, and was followed by Spain in 1935 and Palestine in 1936. There was also an agreement with the new Russian producer in1934 giving it an export quota. The US industry could not join the syndicate, but was able to participate in talks in 1935 to agree measures concerning price structure, advertising and research. As a result of these efforts the German industry was in a position to control the world market in the mid-1930s. This continued until the outbreak of WWII.

The syndicate was broken up at the end of the War and the Verkaufsgemeinschaft Deutscher Kaliwerke was founded in 1948 to handle the sales of the West German producers; a state trading organization took up this role in Communist East Germany. Producer collaboration in export markets continued in the post-War era until it was eventually banned by the EEC in the 1970s.

Multi-nutrient fertilizers

Mixing of fertilizers to combine the qualities of different products was already well established at the start of the 20th century. It involved the physical of dry powders to create binary and ternary fertilizers with what were, by today's standards, low concentrations of N, P_2O_5 and K_2O. This is not the technique that is called bulk blending - mixing of granular fertilizer materials – that did not become popular until after the 1950s, nor did it involve chemical reaction between the components as in the processes to make compound fertilizers.

In the United States between 50% and 70% of the fertilizer nutrients delivered to farmers were in the form of physical mixtures. Their average nutrient content rose from 14% in 1900 to 23% in 1950, withmost of the increase being in the K_2O component, probably because of the improved availability of potash salts associated with the start of potash mining in New Mexico in the 1930s.

In 1937, the US Department of Agriculture (USDA) looked into the technology for granulating NPK fertilizers, but at that time there was little interest from end-users in having an improved product. The situation changed after WWII and in the decade after 1950 TVA began to work on developing rotary-drum ammoniation-granulation and pan granulation as ways of making NPK compounds.

In Europe, fertilizer producers were more active in the inter-war years looking for ways to produce granular NPK fertilizers to replace the traditional powder mixtures. BASF, which had begun mixing fertilizers at its Oppau site in 1913, moved on to researching the feasibility of granulating a slurry of AN and DAP to which potash salts had been added. This process was patented by IG Farben in 1926 and five Nitrophoska compounds were introduced into the market in the following year. Among other German producers Chemische Fabrik Kalk brought to the market in 1930 its Kampdűnger range of NP fertilizers based on CAN and DAP, that it later extended to Kampka NPKs in 1953. In the UK, concentrated compound fertilizers (CCFs) were introduced in 1931 by ICI which had developed a process making granular NPKs based on the ammoniation of mixed acids.

A different route to NPK fertilizers, invented in 1927 by Erling Johnson of Odda Smelteverk in Norway, was the nitrophosphate process in which phosphate rock was treated with nitric acid to give a slurry from which calcium was crystallized out; the residue was neutralized with ammonia and potash added to give an NPK fertilizer product. Johnson's employer was not interested in using this process so he offered licences to Norsk Hydro, BASF, Hoechst and DSM. Norsk Hydro modified the technology and began regular production of NPKs in 1938 at its new Herøya site. BASF introduced a modified version of the Odda NPK process at Ludwigshafen in 1953. The French company developed its own version of the nitrophosphate process which it installed at Grande Couronne (Rouen) in 1942. Despite this interest in the nitrophosphate route to NPKs, the majority of NPK compounds fertilizer factories built in Europe in the post-War era were based on P_2O_5 from phosphoric acid or ammonium phosphates, mainly using TVA's technology.

Bulk blending started to emerge in the United States at the end of the 1940s: four blenders were reported to be operating in Illinois in 1947 and a strong trend began to emerge in the Mid-West. A decade later there were more than 200 blenders in the US, of which two thirds were in the grain belt. This trend crossed the Atlantic in the 1960s when bulk blending was introduced into Ireland and spread across Europe. ■

Table 3. Export shares of international Potash Syndicate Members in 1925-1939 (percent)

	1925-1931	1932-1933	1934	1935-1939
Germany	70.0	67.3	60.1	53.4
France	30.0	28.8	25.8	22.9
Poland	0.0	3.9	3.4	3.1
USSR	0.0	0.0	10.7	9.5
Spain	0.0	0.0	0.0	11.1
TOTAL	**100**	**100**	**100**	**100**

Source. Schrőter, Die Internationale Kaliwirtschaft 1918-1939

Table 4. United States consumption of mixed fertilizers between 1900-1950

	1900	1910	1920	1930	1940	1950
Consumption of mixtures million short tons product	1.77	3.44	4.06	5.62	5.51	12.31
% Total Nutrients	13.9	14.8	13.9	17.9	19.9	23.2
% N	2	2.1	2.3	3.1	3.8	4
% P_2O_5	9.4	9.3	9.2	9.8	9.6	10.9
% K_2O	2.5	3.4	2.4	5	6.5	8.3

Source. USDA

Table 5. NPK formulations of BASF and ICI

BASF Nitrophoska (1927)	ICI CCFs (1931)
15-15-30	10.4-20.8-10.4
16.5-20-16.5	10.4-10.4-20.8
17.5-22-13	7.5-26-7.5
15-26.5-11	12.5-12.5-15
15.5-19-15.5	'8-16-16
	6.5-22.5-3

Hydrogen for a future clean energy system

A new economy or revival of the old?

Written by

Dr. Minh Khoi Le, *Head of Hydrogen Research,* ***Rystad Energy, Norway***

The 2015 Paris Agreement and its aftermath has fixed much of the world's attention on the transformation of energy systems and the global economy to be more sustainable. This has been exacerbated by an increased focus on energy security, in particular since Russia's invasion of Ukraine in early 2022. What makes the transformation so difficult is the fact that the global economy is heavily reliant on molecules, and mostly hydrocarbons such as oil and gas.

So, despite the significant cost reductions seen in renewable energy sources such as wind and photovoltaics (PV) as well as the prevalence of these resources, direct electrification is still not a preferrable option in some cases, while remaining outright impossible in certain other applications. Enter hydrogen, with the promise of being a renewable molecule to help the world achieve significant decarbonization across all sectors. Interestingly, the use of hydrogen is not exactly new as it has been present in modern industries since the early 1900s, and was even back then produced by renewable energy. Hydrogen has been crucial for the development of modern societies and, with respect to the energy transition, its role in the global economy will only expand.

Around 100 mn t per annum (tpa) of hydrogen is currently being consumed by industries, with some 45% of this going to refineries, feeding numerous processes such as hydrocracking and desulphurization. Another 29% of the hydrogen is being consumed as feedstock for ammonia, which then serves the fertilizer sector, while the remainder goes to chemical production such as methanol, as well as for other uses. As most of the consumed hydrogen is from synthesis gas – a product of natural gas reforming or coal gasification, and also known as syngas – up to 1.2 gigatonnes of carbon dioxide (CO_2) emissions is currently associated with hydrogen production. This emission level surpasses that from current oil and gas upstream activities, including extraction and flaring.

Back to the electrolysis

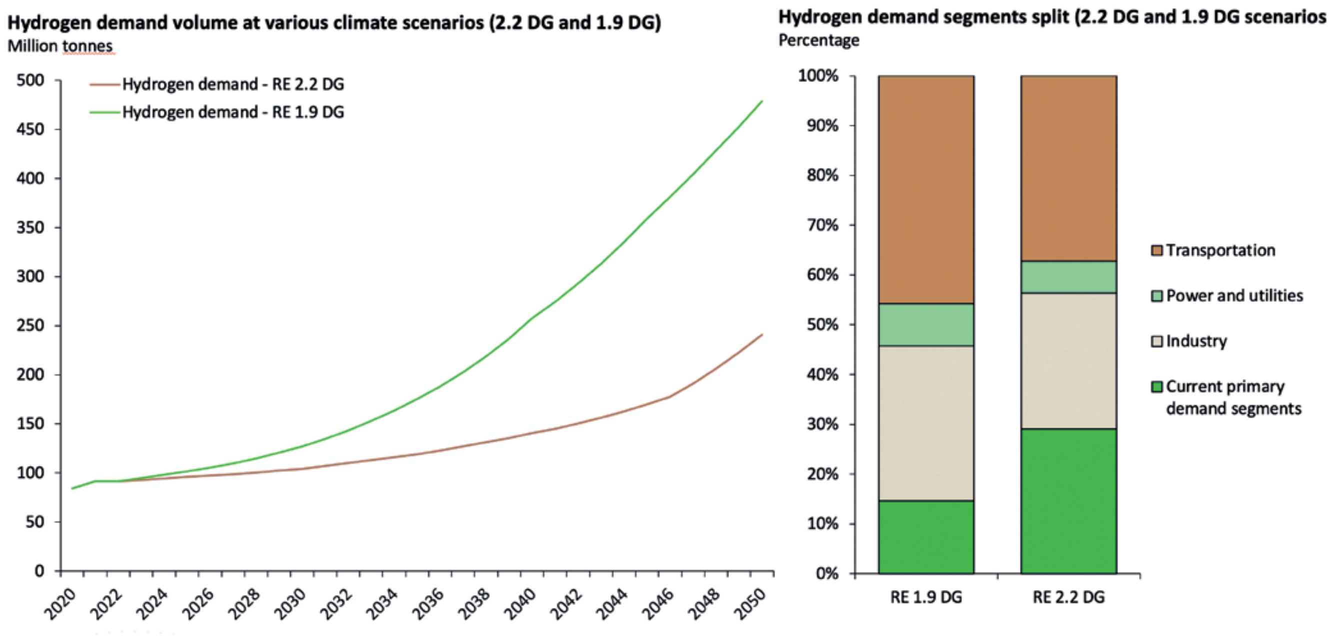
Amid the ongoing energy transition, some of these use cases will face demand destruction. For instance, as electric vehicle (EV) adoption continues to grow in many countries, demand for hydrogen use in the desulphurization of gasoline and diesel will drop significantly. Nevertheless, hydrogen consumption in chemical production for conventional use (for example,

> ***In the past, hydrogen production for ammonia used to be much cleaner***

ammonia for fertilizers) is still expected to grow and emissions from existing hydrogen production will need to be abated to reach global climate change mitigation goals.

Interestingly, hydrogen production for ammonia used to be much cleaner in the past. After the invention of the Haber-Bosch process, Norway's Norsk Hydro built and operated multiple alkaline electrolysis plants for fertilizer production from the 1920s until as late as 1990s, utilizing plentiful hydroelectric resources in Norway to produce hydrogen. This hydroelectric-derived ammonia is essentially very low in carbon and could even be considered 'green' based on current definitions. However, to meet the demands of a growing global population, the emergence of natural gas reforming then took over as the predominant way in which hydrogen is produced for ammonia production

Figure 1. Hydrogen demand into 2050 for different climate scenarios



Source: Rystad Energy Hydrogen Solution

and other uses. Towards the end of this decade, the cost competitiveness of renewable energy sources such as solar PV and wind in many regions is envisaged to be a game changer. Utilizing this, hydrogen production can make a comeback to the electrolysis method while still being able to handle the scale of current and future demand, although now with the added benefits of being more sustainable and secure in supply.

Decarbonization impact

Most of the new applications for hydrogen in other sectors will need to utilize clean hydrogen to count toward the energy transition. To keep global warming under 1.9 degrees Celsius (°C) above pre- industrial levels, hydrogen demand will reach just above 450 mn tpa, which is 4.5 times current hydrogen consumption. Even to keep the average global temperature rise under 2.2°C, hydrogen demand would need to approach 200 mn tpa, which is still double current consumption. New demand will come from sectors such as power generation, steel making, shipping fuel, aviation fuel (pure hydrogen and sustainable kerosene) and plastic manufacture, among others. Direct electrification in these so-called hard-to-abate sectors is difficult, if not almost impossible, and these sectors are where hydrogen could really have a strong decarbonization impact.

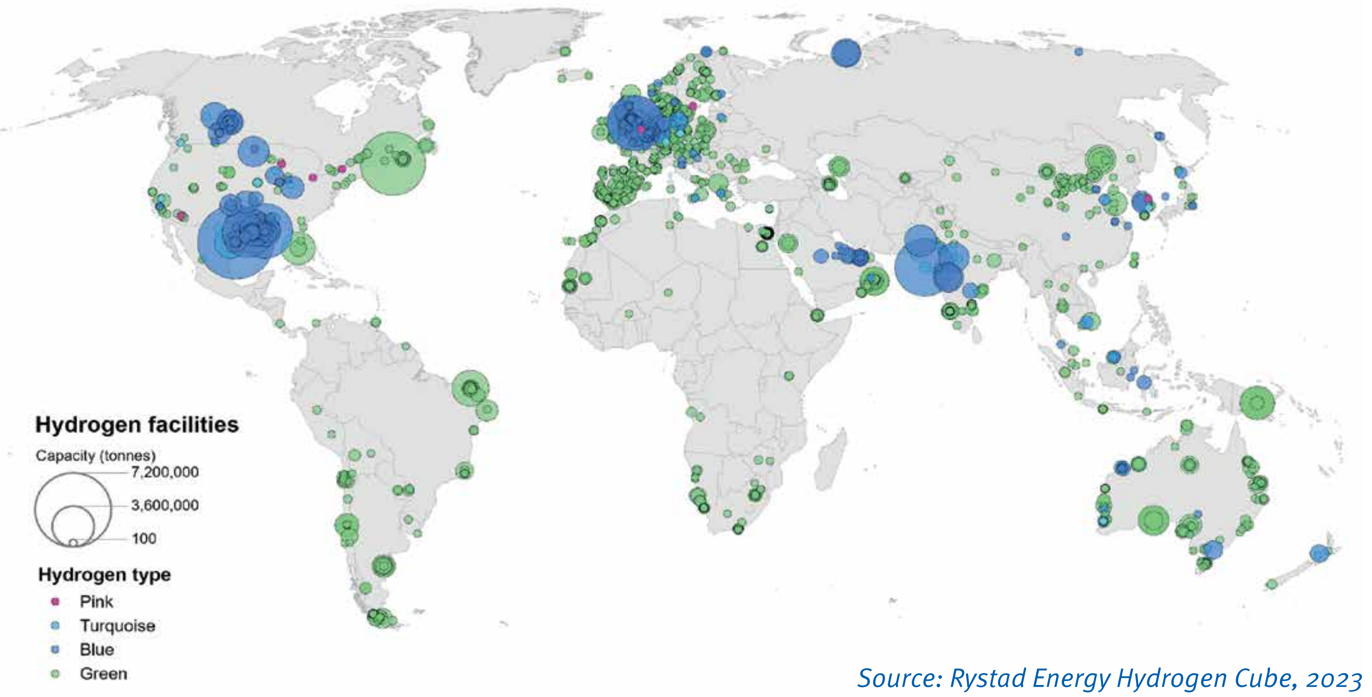
Industries and private sectors have now started to act

Industries and private sectors have started to act, albeit driven by regulations. For instance, Danish shipping conglomerate AP Moller-Maersk is going full steam ahead to adopt green methanol and bio-methanol for shipping fuel, while Finnish engine manufacturer Wartsila has recently announced an ammonia engine for shipping, promising a new market for the compound. These two hydrogen derivatives will be key for the future decarbonization of the shipping industry. Another case is aviation where sustainable aviation fuel (SAF) remains the dominant decarbonization pathway. While it is theoretically possible to meet all our SAF demand in 2050 through bio-SAF, bio feedstock is the bottleneck here and synthetic kerosene from hydrogen may be needed to make up to 45% of final SAF demand. Green steel from hydrogen direct-reduced iron has also seen some success, with pilot plants operating and offtake contracts being signed.

Geographical constraints

Other use cases may prove controversial to some, but geographical constraints of certain regions must be taken into consideration. For instance, long trucking routes in the US and China

Figure 2. Map of clean hydrogen projects announced globally



Source: Rystad Energy Hydrogen Cube, 2023

as well as heavy freight may be better decarbonized by hydrogen fuel cell trucks rather than battery ones. The case for power generation is another interesting one. While solar PV and wind will be the heavy lifters of power decarbonization, the intermittency nature of these power source means seasonal energy storage is required – and converting these green electrons into green molecules of hydrogen offers an opportunity to increase the mix of solar and wind while maintaining energy security. This takes on a more important role for countries where the ability to build out good and cheap renewable energy facilities is limited, meaning imported green hydrogen can offer green base-load power generation here. Japan is one example, with efforts being made for both the use of ammonia and hydrogen for power.

Hydrogen does, however, pose several problems, the first of which is cost. Despite the falling cost of renewable power, green hydrogen still cannot compete with 'grey' hydrogen from natural gas reforming, and it might not get there until the late 2040s, even with forecast cost reduction. Of course, green hydrogen is not the only solution as carbon capture on current hydrogen production sites can also offer carbon-emission reduction – and often at a much lower cost. Which type of clean hydrogen production will prevail will be heavily influenced by policies and regulations. Now more than ever, the decisions made in key demand regions such as the European Union or North Asia will have a significant global impact. Secondly, it is quite difficult to transport hydrogen across long distances, which could prevent the hydrogen economy being global and limit hydrogen use to what it has always been: on-site and captive. This is where trusty ammonia can become a potential solution, given the existing infrastructure driving the annual 20 mn t that is currently traded globally. Of course, there are also options to produce green methanol, green steel, green e-fuels, where renewable energy is competitive and plentiful, and trade these products instead – and this may very well transpire.

A hydrogen economy is tied to decarbonization and sustainability

The existence of a hydrogen economy is one that is very much tied to decarbonization and sustainability development, and it is one of the few ways where there is potential to store and export renewable energy over large distances, which has until now been limited to their geographical locations, and hence, allowing for arguably better returns. It may not, however, be clean hydrogen that we will end up being traded but rather the usual suspects of hydrogen derivatives – ammonia, methanol and synthetic hydrocarbons, among others. The difference is they will be cleaner. ■

Key global clean ammonia production hubs

Written by

Mr Karan Chechi, *Research Director,* ***TechSci Research, India***

Energy is undeniably crucial for our existence, powering our daily lives and enabling progress. Over time, our global energy consumption has surged due to escalating demands across various sectors. The constant introduction of energy-intensive technologies, vehicles, systems, and applications in our routines has significantly elevated the need for fuel and power to fuel economic activities and societal advancements. However, these escalating needs have put considerable pressure on the energy equation, posing several challenges related to the environment, public health, and the pursuit of sustainable development.

Karan Chechi, Research Director, TechSci Research

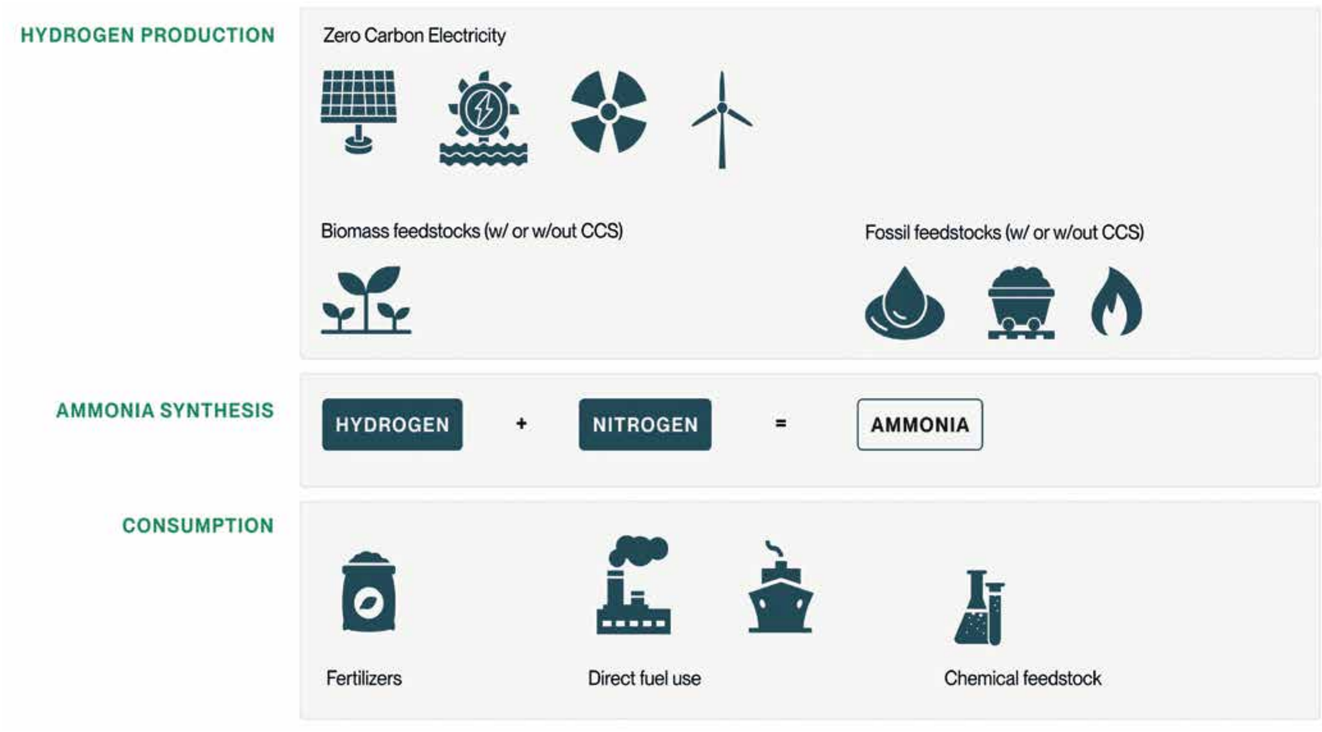
There is an anticipated rise in ammonia consumption

It is widely acknowledged that around one-third of the world's energy consumption is attributed to the transportation sector, primarily reliant on fossil fuels to produce common transportation fuels such as diesel, gasoline, and jet fuel. This heavy reliance on fossil fuels has led to alarming levels of greenhouse gas emissions, accounting for roughly 20-30% of emissions, varying based on a nation's level of development. Despite significant efforts by manufacturers and governments to shift towards electric and hybrid vehicles, transitioning entirely within a short timeframe faces challenges related to infrastructure, economics, and raw materials. However, current environmental indicators strongly signal the urgent need for swift and effective actions. Moreover, diesel- and gasoline-powered generators, extensively used in residential, commercial, utility sectors, and off-grid applications, contribute significantly to fossil fuel consumption and subsequent CO_2 emissions. Introducing ammonia into combustion processes, such as internal combustion engines and gas turbines, presents a promising solution for expediting the transition towards a hydrogen-based economy.

Rise in consumption

Ammonia (NH_3) is a colourless gas with a distinctive pungent odour at room temperature. It is a compound made up of nitrogen and hydrogen. Pure ammonia has a hygroscopic nature, meaning it easily absorbs moisture and dissolves readily in water or humidity. However, owing to its alkaline properties, ammonia is corrosive. It holds a significant position as one of the most extensively manufactured industrial chemicals worldwide. More than 75% of the produced ammonia finds its primary use in the agriculture sector as a crucial fertilizer. Additionally, ammonia serves as a working fluid in refrigeration cycles due to its favourable thermodynamic properties. Another common application of ammonia is in household cleaning solutions, where its properties make it effective for various cleaning purposes. Globally, approximately 146 mn t of ammonia were produced in 2019. Interestingly, only a small fraction, roughly 4%, is utilized directly, while the larger portion serves as a chemical in various industrial applications or as a fertilizer in agriculture. However, there is an anticipated rise in ammonia

Figure 1. Clean ammonia adoption may reduce greenhouse gas emissions



consumption, especially with its usage in the energy sector due to mounting environmental concerns and efforts to reduce CO_2 emissions. Ammonia is gaining attention as a potential carbon-free fuel, prompting numerous initiatives worldwide. Several countries have unveiled numerous projects centred around ammonia for power generation, off-grid applications, internal combustion engines, and more. This trend is expected to amplify, particularly with the increasing adoption of hydrogen-powered systems, considering ammonia's role as an efficient carrier of hydrogen. Ammonia has long been utilized in refrigeration systems, fertilizer production, household cleaning products, and disinfectants. However, it has recently caught the attention of researchers, scientists, engineers, and technologists due to its potential as a carbon-free fuel, offering a means to decrease CO_2 emissions. Its unique properties position it as a significant player in addressing challenges linked to hydrogen energy options and the hydrogen economy, notably serving as an effective hydrogen storage medium with its three hydrogen atoms. Importantly, it presents opportunities for transportation and distribution without requiring major changes to existing infrastructure commonly used by industries.

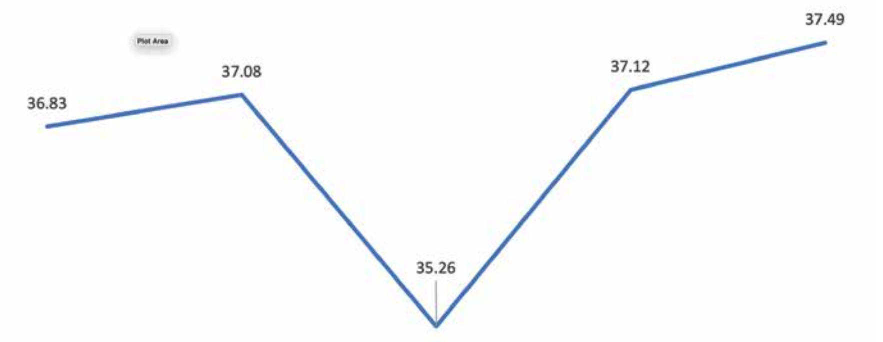
Carbon capture and storage

Over the past decade, there has been a notable increase in efforts to employ ammonia in internal combustion engines and gas turbines, reflecting a growing interest in exploring its potential as a fuel source in these applications. Moreover, using ammonia as a hydrogen storage medium is regarded as a safe and efficient method. However, employing ammonia as a fuel source for generators necessitates design modifications and material substitutions. Overcoming associated challenges—such as high auto-ignition temperature, pressure, corrosion, cooling, and NO_x emissions—will be pivotal to make ammonia use in conventional generators feasible. Ammonia holds immense promise as a carbon-free fuel, offering a sustainable solution to mitigate environmental impact. Although challenges persist, resolving these obstacles could pave the way for a cleaner and more sustainable energy landscape, positioning ammonia as a frontrunner in the pursuit of carbon-neutral energy generation.

Clean ammonia refers to ammonia produced using methods that minimize or eliminate greenhouse gas emissions, energy consumption, and other environmental impacts associated with conventional ammonia production processes. Also, clean ammonia is categorized into blue ammonia and green ammonia which are variations of clean ammonia production methods. Blue ammonia typically involves the utilization of fossil fuels in the production process, with carbon capture and storage (CCS) employed to minimize emissions,

Clean ammonia could become a mainstream solution for many industries

Figure 2. Annual carbon dioxide (CO_2) emissions worldwide from 2018 to 2022 (bn t)



rendering it a cleaner alternative to conventional ammonia production. On the other hand, green ammonia is produced using renewable energy sources like solar or wind power, ensuring zero carbon emissions throughout the production cycle. Both blue and green ammonia are considered clean alternatives, contributing to reduced environmental impact compared to traditional ammonia production methods.

Advancements in technology

The development of clean ammonia aligns with global efforts to reduce carbon emissions and combat climate change. Historically, the Haber-Bosch process has been the dominant method for ammonia production. This process involves combining nitrogen extracted from the air using the Haber process with hydrogen derived from natural gas through steam reforming. While effective, this method relies heavily on fossil fuels and releases significant carbon dioxide (CO_2) emissions. Advancements in technology and sustainability have led to the exploration and development of cleaner methods for ammonia production such as green hydrogen-based production. One avenue for clean ammonia production involves utilizing green hydrogen, which is generated through electrolysis powered by renewable energy sources like solar or wind. This approach eliminates reliance on fossil fuels, reducing carbon footprints associated with hydrogen production. Another promising method involves electrochemical synthesis, where ammonia is produced by electrochemically combining nitrogen and water-derived hydrogen. This method operates at lower temperatures and pressures compared to the Haber-Bosch process, potentially reducing energy consumption and emissions. Certain biological processes can convert biomass into hydrogen, which can then be used to produce clean ammonia. Biomass-derived hydrogen offers a renewable and potentially carbon-neutral route to ammonia synthesis, as the carbon emitted during ammonia production can be balanced by the carbon absorbed during biomass growth. While the concept of clean ammonia production holds promises, there are challenges to overcome such as clean ammonia technologies often face higher initial costs compared to conventional methods. However, advancements in technology and scaling up production could lead to cost reductions. Transitioning from pilot projects to large-scale production remains a challenge. Infrastructure development and market adoption are critical factors for widespread implementation. Continuous efforts are underway to optimize clean ammonia production processes for increased energy efficiency and reduced environmental impact.

However, clean ammonia production methods aim to significantly reduce or eliminate greenhouse gas emissions, contributing to global efforts to combat climate change. By using renewable energy sources, clean ammonia supports the integration of sustainable energy into various industries. Clean ammonia maintains its versatility for use in fertilizers, refrigeration, and various industrial processes while aligning with sustainability goals. The pursuit of clean ammonia production aligns with the growing emphasis on sustainability and carbon neutrality. As technology advances and economies of scale are achieved, clean ammonia could become a mainstream solution for industries reliant on ammonia while minimizing environmental impact.

Ammonia production hubs

Clean ammonia production hubs are the centralized facilities designed to produce ammonia using advanced and sustainable methods, focusing on minimizing or eliminating greenhouse gas emissions, reducing energy consumption, and mitigating other environmental impacts associated with traditional ammonia production processes. These hubs serve as key contributors to global efforts aimed at transitioning towards cleaner and more sustainable energy solutions. Their role is multifaceted and pivotal in the context of sustainable energy production and environmental

Table 1. Overview of existing and planned facilities for fossil-based ammonia with a lower carbon footprint (existing capacity of 2.6 mn t/yr; planned capacity of 17.4 mn t/yr)

LOCATION	COMPANY	START-UP YEAR	CAPACITY (KT/YR)	CARBON FOOTPRINT REDUCTION RELATIVE TO SMR (%)	HYDROGEN SOURCE	SOURCE
Central Sulawesi, Indonesia	PAU, Mitsubishi, Jogmec, Bandong IoT	2026 or before	≤ 660	≥ 70%	Hydrogen is produced from natural gas with CCS.	*(Argus Media, 2021b)*
Ruwais, UAE	ADNOC	2025	1 000	≥ 70%	Hydrogen is produced from natural gas with CCUS.	*(ADNOC, 2021)*
Pilbara, Australia	Yara (revamp)	2024-2025 or earlier	≤ 800	≥ 70%	Hydrogen is produced from natural gas with CCS, to be used by JERA (Hasegawa, 2021).	*(Hasegawa, 2021)*
Jubail, Saudi Arabia	SAFCO	2021	1 160	62.5%	CO_2 is used for methanol synthesis and enhanced oil recovery.	*(Herh, 2020)*
Redwater, Canada	Nutrien	2020	245	62.5%	CO_2 is used for enhanced oil recovery	*(Adair, 2020)*

stewardship. Firstly, these hubs serve as innovation centres where cutting-edge technologies and methodologies for clean ammonia production are researched, developed, and implemented. They act as testbeds for novel approaches, fostering advancements that optimize production processes to enhance energy efficiency and minimize environmental harm. For instance, in 2023, Mitsubishi, a Japanese trading house, contemplated transforming the Namikata terminal located near Hiroshima into an import hub specifically designed for fuel ammonia. This strategic plan was shared by a company executive during a business conference held in Tokyo.

Another critical aspect of clean ammonia production hubs is their role in scaling up clean production methodologies. They aim to move from smaller-scale pilot projects to large-scale commercial production, addressing challenges related to initial costs, infrastructure development, and market adoption. By achieving economies of scale, these hubs can potentially drive down the costs associated with clean ammonia production, making it more economically viable for widespread adoption across industries.

Furthermore, these hubs serve as catalysts for market transformation. They play a vital role in promoting the adoption of clean ammonia as a sustainable alternative within various sectors. Collaborating with industry stakeholders, governments, and research institutions, these hubs facilitate the dissemination of knowledge, best practices, and technological advancements, encouraging industries reliant on ammonia to transition towards cleaner production methods.

Clean ammonia hubs serve as catalysts for market transformation

Collaborative platforms

On a global level, the establishment of clean ammonia production hubs signifies a concerted effort towards a more sustainable and environmentally conscious future. Countries and regions worldwide are recognizing the importance of reducing carbon emissions and transitioning towards cleaner energy sources. These hubs play a crucial role in supporting global sustainability agendas by offering a scalable and viable solution for reducing the environmental impact of ammonia production. In 2023, Adams Fork Energy, LLC, CNX Resources Corp, and other partners announced the advancement of a multi-billion-dollar clean ammonia production facility in Mingo County, WV, with anticipated construction slated to begin in 2024.

Moreover, these hubs act as global benchmarks and collaborative platforms for sharing best practices and fostering international cooperation in sustainable ammonia production. Through knowledge exchange, partnerships, and collaborations between countries, these hubs contribute to the global knowledge base and accelerate the adoption of clean ammonia production technologies worldwide. In essence, clean ammonia production hubs represent the convergence of technology, innovation, and sustainability. They serve as hubs of transformation, driving the transition towards cleaner and more sustainable ammonia production methods. By championing eco-friendly practices, advancing technology, and fostering global collaboration, these hubs pave the way for a greener future and contribute significantly to global efforts in combating climate change and promoting sustainability. ■

News in brief

EUROPE

Yara is acquiring the organic-based fertilizer business of Italy's Agribios

Yara has announced that it is acquiring the organic-based fertilizer business of Agribios Italiana, the company's second bolt-on acquisition supporting its organic strategy in Europe. This signifies Yara's commitment to further expand its offering in this sector as a complement to its mineral fertilizers to help promote regenerative agriculture and improve soil health.

By combining Agribios' expertise in high-quality organic-based fertilizers in Italy with Yara's scale and reach in Europe, we can continue to meet the evolving needs of European farmers, regardless of their farming method. The acquisition will also allow Yara to continue to play its part in helping achieve the European Union (EU) ambition of increasing EU farmland under organic farming.

"We are thrilled to welcome Agribios to the Yara family," said Mónica Andrés Enríquez, Executive Vice-President for Europe at Yara. "Soil health is the foundation for resilient crop production and sustainable farming. This acquisition reflects our commitment to preserve and further improve soil health, helping grow a nature-positive food future. By expanding our existing crop nutrition portfolio in Italy, we can continue to support farmers in making every nutrient count."

Balanced crop nutrition, together with good agricultural practices and digital tools, is crucial for the regeneration of our soils. An analysis of more than a hundred long-term fertilizer trials shows that fertilized land has a higher soil organic matter content than unfertilized land. Using organic sources of nutrients, in addition to mineral sources, results in the highest content of soil organic matter. Therefore, this acquisition will enable Yara to maximize the synergies between organic-based and mineral fertilizers, which is integral to our regenerative agriculture offering. Used in combination, organic and mineral nutrients enhance soil health, improve resource use, increase nutrient use efficiency, and boost crops' resistance to climate change.

"We're excited to join forces with Yara," said Giovanni Ravagnan, CEO of Agribios Italiana. "This is a pivotal moment for Agribios as we bring our expertise in organic-based fertilizers to the European stage. We eagerly anticipate embarking on this new adventure, marking the beginning of another phase of development in the year of our 50th anniversary. The new challenge ahead is to support both organic and conventional farmers across Europe, providing them with products that enhance the quality of their crops and soils."

Agribios has a broad portfolio of organic-based fertilizers produced using animal and agricultural by-products, contributing to the circular economy and reducing environmental impact. Its products can be used in both organic and conventional farming. With a volume of approximately 60,000 t produced in 2022, Agribios has a market share of around 10 percent of the organic-based fertilizer market in Italy. By acquiring Agribios, Yara will gain a strong foothold in Italy – the second largest organic-based fertilizer market in Europe. Agribios' solid market position combined with our strong commercial presence will allow Yara to increase sales in the organic-based fertilizer market in Italy and neighboring countries by around 30% within the next three years.

Yara will also be able to offer Agribios' products to customers outside Italy thanks to its well-established sales and distribution platform in Europe. In addition to Italy, Yara already sells organic-based fertilizers in many European countries, including France, Spain and Germany as well as in the Nordic and Baltic regions. The organic fertilizer market in Europe, which is playing a role in promoting sustainable agriculture and contributing to the EU's strategic autonomy, is expected to grow at a compounded annual growth rate (CAGR) of 11.53% from 2023 to 2030, according to global market research firm Kings Research.

Yara acquired Ecolan, a Finnish producer of organic-based fertilizers, in 2021. We will continue to explore ways to grow our organic-based fertilizer business so we can provide farmers in Europe with tailor-made solutions adapted to local conditions because crops, raw material sources, and climate conditions vary by country.

Poland's Grupa Azoty gets EUR40mn state aid

Dominant Polish fertilizer producer Grupa Azoty has received PLN173mn, or roughly EUR40mn, in state aid as compensation for high gas and power prices.

Azoty has been "forced to compete in the EU market with products from countries outside the EU, where gas, energy and production prices are significantly lower and where production processes are not burdened by the high costs of ambitious climate policies," Grupa Azoty management board president Tomasz Hinc said. The funding is "much needed" to compensate Polish firms for the "significantly higher costs of conducting production within the EU", Hinc said.

Azoty is the largest single gas consumer in Poland. The company has struggled financially this year — it recorded a significant PLN743mn loss in the third quarter, bringing its net loss to over PLN1.8bn in January-September 2023. The company has made a net loss for five consecutive quarters. The third-quarter loss was the highest so far this year, which the company attributed mainly to non-fertilizer divisions.

Azoty recently dropped a plan to sell its largest fertilizer production plant Pulawy to Polish oil company Orlen, saying the deal would be economically "unjustified".

Hy2gen Germany acquires plant and project pipeline of kiwi AG in Werlte

Hy2gen, the global project developer, financier, builder, owner, and operator of plants for the production of renewable hydrogen and hydrogen-based e-fuels, has announced the successful acquisition of kiwi AG in Werlte, Lower Saxony, Germany. The acquisition includes what is currently the world's largest operating power-to-eMethane plant in Werlte. The integration of kiwi AG marks an important milestone for Hy2gen, as it means the internationally active company is now entering into the production of renewable hydrogen and its derivatives, such as renewable natural gas (RNG) and renewable liquefied natural gas (LNG). This also gives Hy2gen access to a pipeline of further projects with a total capacity of 300MW for electrolysis and methanation. Hy2gen now has the opportunity to utilise kiwi AG's already established industry connections and expand them further in order to maintain its position at the forefront of the renewable hydrogen market.

“This is an important day for Hy2gen AG as we are now starting to produce hydrogen molecules,” announces Hy2gen's proud CEO, Cyril Dufau-Sansot. “kiwi AG can look back on ten years of experience in the hydrogen market, in which time they have built and operated a truly pioneering plant. The integration of kiwi AG into Hy2gen AG allows us to benefit from their technical expertise and brings us a lot closer to our goal of becoming an independent market leader in the production of renewable hydrogen and its derivatives.”

Matthias Lisson, Hy2gen's Country Manager for the DACH region, also shared his views: “I am delighted that the first plant which we are using for production in Germany, in Werlte, is currently the world's largest operating power-to-eMethane plant. The acquisition of the plant also enables us to expand our product portfolio from renewable hydrogen, renewable ammonia, e-methanol, e-methane and e- kerosene to include renewable natural gas and liquefied natural gas. We have already received a commitment from our renowned partner, Plug Power, to purchase the full production volume. It is important for me to mention that production processes will be maintained and that we will continue to rely on the expertise of all our employees.”

Stamicarbon (MAIRE Group) signs supply contracts with Shandong Lianmeng Chemical Company

Shandong Lianmeng Chemical Company has awarded licensing and equipment supply contracts for a grassroots urea melt and prilling plant in China to Stamicarbon, the nitrogen technology licensor of MAIRE Group. The plant located in Shouguang city of Shandong province in China will use Stamicarbon's Ultra-Low Energy design with a highly efficient pool reactor concept and have a capacity of 2334 MTPD.

Stamicarbon will provide the license, proprietary equipment, including high-pressure equipment made of super duplex stainless steel and associated services. This grassroots project will be the eighth urea plant worldwide to utilize Stamicarbon's proprietary Ultra-Low Energy design.

The ultra-low energy design allows heat supplied as high-pressure steam to be used three times instead of two, compared to the conventional CO_2 stripping processes. This results in a 35% reduction in steam consumption and a 16% decrease in cooling water use. The efficiency of this design is proven with two operational plants, making its energy savings unparalleled in the market.

"We are thrilled to start this project in collaboration with Stamicarbon, a global leader in urea technology. We are looking forward to seeing the cutting-edge technology in action and are confident in the advantages it will bring," said Mr. Wang Xinjian, the General manager of Shandong Lianmeng Group.

"We're excited to launch a project using our Ultra-Low Energy design, which has shown itself to be the top choice for energy efficiency and sustainability in urea production. With this project, we are further expanding our footprint in China, aiming to address the region's growing demand for urea," said Pejman Djavdan, Stamicarbon CEO.

NORTH AMERICA

OCI Global Announces Agreement for the Sale of IFCO to Koch

OCI Global, a leading global producer and distributor of hydrogen products has announced that it has reached an agreement for the sale of 100% of its indirect interest in its large-scale US greenfield nitrogen fertilizer facility Iowa Fertilizer Company LLC, located in Wever, Iowa, USA to Koch Ag & Energy Solutions for a total consideration of USD3.6bn on a tax free basis, subject to a customary cash, debt and normalized level of working capital adjustment.

Consummation of the transaction remains subject to receipt of certain US antitrust approval and other customary closing conditions. The transaction does not require OCI's shareholders to vote on approval. The transaction is expected to close in 2024.

Morgan Stanley & Co. International plc is serving as financial advisor to OCI on the transaction. Cleary Gottlieb Steen & Hamilton LLP is acting as its legal advisor.

OCI launched a multi-faceted strategic review in March 2023, with the objective of closing the discount to OCI's intrinsic value and unlocking value for its shareholders.

The announcement marks an important step in delivering these objectives, with the crystallisation of USD3.6bn of value for OCI.

The transaction is expected to result in a reduction in holding company net debt and deliver a capital return to shareholders, enabling the remaining enterprise to explore incremental value accretive opportunities in the energy transition space, building on its early mover lower-carbon ammonia and green methanol platforms.

Nassef Sawiris, Executive Chairman of OCI commented: "The announcement marks an evolutionary step in our journey to create value for shareholders, and to enhance our focus on efforts in lower carbon initiatives. IFCO was the first world-scale greenfield nitrogen fertilizer facility built in the United States in over 25 years. We are confident that under KAES's stewardship, IFCO will be well positioned for its next phase of growth. Our strengthened balance sheet will support the acceleration of our strategy in the field of decarbonisation projects, driving future growth and supporting the energy transition goals we share with many of our stakeholders, establishing us as a leader in the low carbon space."

Ahmed El Hoshy, CEO of OCI commented: "We are incredibly proud of IFCO's extraordinary achievements since commissioning in April 2017 and want to thank all the OCI and IFCO employees who have contributed to this remarkable success. We are exceptionally proud to have single-handedly built a world-class global nitrogen facility and revitalised a core industry in the United States. This transaction is a testament to the team's efforts and marks a natural evolution in OCI's journey to create long-term sustainable value for all its stakeholders. I look forward to continuing the journey of value creation and fast-tracking sustainability focused value accretive projects across our platform, including our blue ammonia project in Texas, with expected completion in 2025 and continued growth in our low carbon methanol business."

Hassan Badrawi, CFO of OCI commented: "Combined with the recent sale of Fertiglobe, OCI is crystallising USD7.2bn of tax-free gross cash proceeds. The resultant financial profile provides significant flexibility to achieve all OCI's goals, including to explore future value accretive growth opportunities and to afford the ability to meaningfully return capital to shareholders."

SOUTH AMERICA

Petrobras, Unigel in fertilizer agreement

Brazil's state-controlled Petrobras signed a tolling contract for fertilizer production with Brazilian petrochemicals group Unigel, enabling nitrogen-based production at Unigel's units in Sergipe and Bahia states.

Under the tolling agreement Unigel will provide manufacturing services and Petrobras will provide natural gas as a feedstock to the fertilizer production. Details regarding timeframe, production volumes and contract values were not provided.

Unigel proposed a tolling agreement to Petrobras in November as it has faced difficulties with its natural gas supply agreement, causing its production to be on and off in 2023. The company suspended production in its Laranjeiras unit, in Sergipe state, in May 2023. Ammonia and urea production were resumed in September, after revised contracts with service providers.

Activities were also halted in Camacari unit, in Bahia state, in June. Automobile-grade urea production in Camacari was resumed in July.

The two plants have combined capacity to produce 900,000t/yr of ammonia and 1.1mn t/yr of urea.

The tolling contract represents "the first step in the analysis of joint businesses" between the two companies, Unigel said, encompassing opportunities in the areas of fertilizers, green hydrogen and low carbon projects.

Petrobras said the agreement is in line with its 2024-2028 strategic plan, in which the company reinforces its intention to invest in fertilizer production.

The agreement may also be key to boost the national fertilizer plan, which aims at reducing Brazilian dependency on imports.

MIDDLE-EAST

Egyptian parliament approves H2 incentives package

Egypt has become the latest country to offer incentives to invest in renewable hydrogen projects, including tax credits, tax exemptions and less bureaucratic processing.

The country's parliament approved regulations that were first drafted by the government in May last year. These are now highly likely to be implemented, according to industry body Hydrogen Egypt.

Egypt's plans include tax breaks of 33-55% on profits from plants producing renewable hydrogen and derivatives, and VAT exemptions for machinery and equipment required for projects. The government also plans to waive taxes and fees on contracts and land registrations, as well as customs tax on goods imported for projects.

Egypt aims to become "one of the leading countries in the low-carbon hydrogen economy in the world" and aims to capture 5-8% of the global hydrogen market, the government said. It hopes its hydrogen strategy will create 100,000 jobs by 2040 and add USD10-18bn to GDP.

Around 23 developers have signed preliminary deals to explore projects in the country and about 10 of these have been upgraded to firmer "framework agreements".

Egypt last week also approved plans by Belgian engineering firm Deme to make renewable hydrogen and derivatives such as green ammonia at a site near the port of Gargoub on the country's Mediterranean coast, the cabinet said. Deme will fully cover the USD3.1bn needed to develop the first phase of the project, although the statement did not give details of capacity for the initial stage.

Deme was part of a consortium including Belgian gas company Fluxys and the port of Antwerp-Bruges carrying out a feasibility study for a 500MW electrolyser project supported by 800MW of solar and 700MW of wind capacity, the government said in November. Deme is also developing a large-scale hydrogen project in Oman.

Earlier this week, another Egyptian renewable hydrogen plant secured a preliminary supply agreement to help decarbonise an ammonia site owned by Abu Qir Fertilizers.

Tecnimont to begin work on Kima's nitrogen plant

Italian engineering firm Maire Tecnimont has received the first payment and authorisation to start engineering works on a nitric acid and ammonium nitrate plant for Egyptian Chemical Industries (Kima).

The go-ahead for engineering, procurement and construction (EPC) is anticipated by the end of June 2024.

The USD297mn plant is scheduled to become operational in mid-2027 and is expected to complement ammonia and urea production units at the Kima 2 facility. Kima 2 is designed to produce 1,200 t/d of ammonia and 1,575 t/d of urea. The facility, located in the Aswan governorship, began operations in 2020.

Kima's primary facility, Kima 1, has a production capacity of 300 t/d of pure ammonium nitrate and fertilizer, which will rise to 600 t/d of nitric acid and 665 t/d of pure ammonium nitrates by mid-2027 following the works.

Acwa eyes large scale green ammonia production in Egypt

Saudi energy firm Acwa Power plans to develop a large scale green ammonia project in Egypt's Suez Canal Economic Zone, with initial production capacity of 600,000 t/yr of ammonia and potential scale up.

The venture will require an investment of more than USD4bn, Acwa said.

The company has signed a framework agreement with Egyptian authorities, following an initial agreement announced a year ago. The project is Acwa's fifth venture in Egypt in advance development stage or already operating, the company said, but did not disclose a timeline for the project.

Authorities in Egypt said they will collaborate with the developer to ensure "speedy implementation" of the project, which they see as key to "maintain Egypt's lead in implementing green hydrogen projects, especially in light of the strong competition that now exists between countries in this field," Egypt's planning and economic development minister Hala al-Saeed said.

Quick and efficient project implementation rely on "efforts to localise the manufacture of electrolyser components in the region," al-Saeed said.

According to Egypt's hydrogen incentive package, approved by the cabinet in May, projects should use at least 20% of domestically produced components to qualify for benefits. Electrolyser factories have been announced in other North African countries such as Morocco, but not yet in Egypt.

ASIA

India's Torrent eyes green ammonia plant in Gujarat

Indian power utility Torrent plans to develop a renewable ammonia plant in the Indian state of Gujarat, with expected output of 100,000 t/yr by 2027.

The company plans to expand production to 400,000 t/yr at a later stage.

State-owned utility NTPC and vehicle manufacturer Erisha have also signed a deal with the Gujarat government for renewable hydrogen production, but details were not disclosed.

The agreements were part of a package of 58 preliminary deals signed between the state government and investors in various sectors ahead of the Vibrant Gujarat Global Summit, expected to start next week.

Gujarat is one of the leading states in India in terms of announced renewable hydrogen projects, along with Odisha.

Pakistan's Agven to start sales from new SOP plant

Pakistani fertilizer importer and producer Agven has started commercial production of a water-soluble SOP at its new plant in Gwadar, Pakistan, and will start selling the product to the domestic market in the second week of January.

The plant will have capacity of 1,500t of SOP in its first month of commercial operation, before reaching its targeted 20,000 t/yr capacity in February, which will be maintained over the following eight months. The producer will ramp up to the plant's full capacity of 40,000 t/yr by September.

Fellow Pakistani SOP producer Barket Fertilizers is expanding capacity by 12,000 t/yr from its current 22,500 t/yr. The expansion works are expected to be completed by the end of this month.

Red Sea attacks delay phosrock shipments to SE Asia

Tensions in the Red Sea region have led to delays and postponements of phosphate rock shipments to southeast Asia.

Several rock shipments from Egypt have been delayed by at least two weeks because of vessel reroutes, while other shipments have been postponed until further notice with no clarity on loading dates, according to buyers in Indonesia and Malaysia.

Most suppliers have withdrawn from the export market given continuing tensions, with no fresh offers emerging.

The actual volume of the delayed or postponed shipments is unknown, but some buyers in Malaysia noted that further delays in arrivals are likely to cause a supply shortage in the domestic market.

Indonesia and Malaysia are major phosphate rock importers in the region, taking in around 1.3mn t and 350,000t in 2022, respectively, GTT data show. Morocco, Jordan and Egypt are key suppliers of phosphate rock to southeast Asia, and deliveries from these suppliers all go through the Red Sea.

Supply disruptions from these key suppliers will likely push southeast Asian buyers to turn to alternative sources such as Christmas Island or Peru.

AUSTRALASIA

Australia shortlists six H2 projects for AUD2bn scheme

Australia's government has shortlisted six projects targeting large-scale production of renewable hydrogen and derivatives as part of its AUD2bn (USD1.35bn) Hydrogen Headstart subsidy scheme.

The shortlisted applicants, which include energy firms BP, Kepco and Origin, were invited to submit a full application to move to the next phase. Winners will be announced in the second half of 2024.

The six shortlisted projects have a combined electrolyser capacity of 3.5GW, according to the department of climate change, energy, the environment and water.

Winning ventures will be able to receive production credits for up to 10 years to cover the gap between production costs and market prices. The funding will be made available from 2026-27. Projects need to have minimum capacity of 50MW to qualify for the support. The government had previously said the initiative can support two to three "flagship projects" providing combined electrolyser capacity of 1GW by 2030.

Australia has the "largest pipeline of renewable hydrogen projects in the world," climate change and energy minister Chris Bowen said. The subsidy scheme aims to support "these projects to become a reality."

Projects from Australian developers Fortescue and Woodside were not featured on the shortlist. The first round of the scheme has prioritised enabling hydrogen deployment in hard-to-abate sectors, according to Australian Hydrogen Council chief executive Fiona Simon. Projects that were unsuccessful in this round "will be a in a better position to compete in future rounds," she said. ■

MARKET ANALYSIS ›

Commodity updates • Shipping news • Price watch

Soft commodities: China supports wheat in Chicago

Information from **Agritel** – ***An Argus Media company***

Wheat summary

The wheat market has two different faces. On the Chicago side, trade success is evident, with China buying 1.12mn t of US SRW wheat last week. This stimulated funds to buy back short positions and resulted in a 4.8% rise in SRW Mars 2024 wheat. In detail, it is the SRW wheat stock that is contracting the most and that alone still justifies a bullish potential towards USD7/bu on Chicago wheat.

On Euronext, the picture is more mixed. While Chicago's bullish momentum and the probable short-covering of funds have provided support, caution is still required. The weekly rise is limited, with only +0.65% for the March 2024 expiry. Note that sellers are rapidly returning to the market as soon as the top of the downtrend channel, which is still in place, approaches EUR235/t. French wheat, and European wheat in general, cannot afford to lose competitiveness, given that exports are still lagging considerably behind.

To continue on the upward path, further strong European export sales are needed, but this is far from certain. Egypt recently bought 540,000 t of Russian wheat and 60,000 t of Ukrainian wheat, neglecting European origin. The return of Algeria and Tunisia also looks set to be a tough one.

The surprise could come from China, which is continuing its buying tour of the major accredited wheat exporters, and may return to France. We believe that China still has 2mn t to buy, but for the time being, Australian wheat seems to be the most competitive.

The market's downward potential is limited by the continuing rise in Russian wheat prices to USD242/t Fob, a rise of almost USD20/t since the lows of late October. For the new marketing year, uncertainty over acreage and yield potential in Western Europe could limit the downward trend.

AGRITEL OPINION: *The upward momentum generated by Chinese purchases and fund buy-backs of wheat in Chicago is slow to be replicated in European wheat. The wheat market in Europe continues to be penalised by strong competition from Russia. The importers' return to buying and the upturn in Russian prices are providing support, but not enough to boost prices on Euronext and enable it to break through the strong resistance zone of EUR230-235/t for March 2024 futures.*

For the new marketing year, uncertainty over acreage and yield potential in Western Europe could limit the fall.

Corn summary

Corn prices took the opportunity offered by the upturn in wheat prices to climb back above the critical EUR200/t mark. Note that French grains regained some buying interest following the downturn at the end of the year. However, the recovery is still hesitant, with corn ending the week at around EUR201/t for March contract. There are a few adjustments on the part of financial operators, who are also taking time to digest the many reports. CONAB opened the week without touching Safrinha, despite the concerns of local analysts. By lowering the Safra by -0.6mn t, the country's total production was adjusted by the same amount to 118.53mn t. Shortly afterwards, it was the USDA's turn to publish its last monthly report of the year. Once again, the USDA remained conservative on South America, with Brazil's production renewed at 129mn t. The only notable change was the increase in the US export target by 0.63mn t to 53.34mn t, in line with the current good momentum. While the

Figure 1. Wheat price (USD/t)

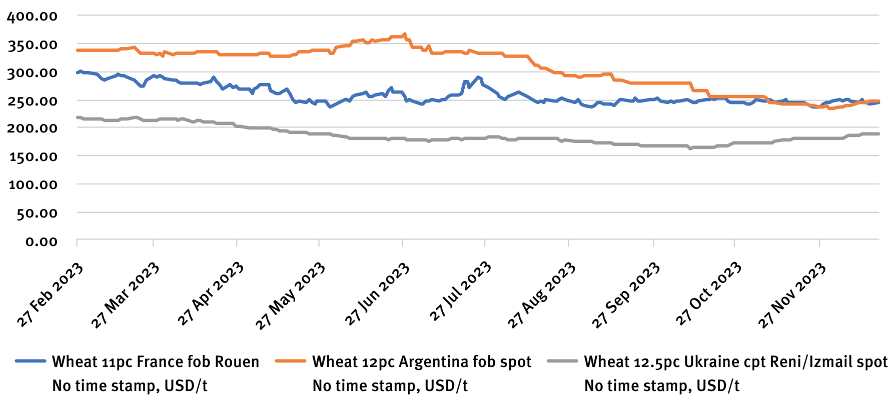


Figure 2. Corn price (USD/t)

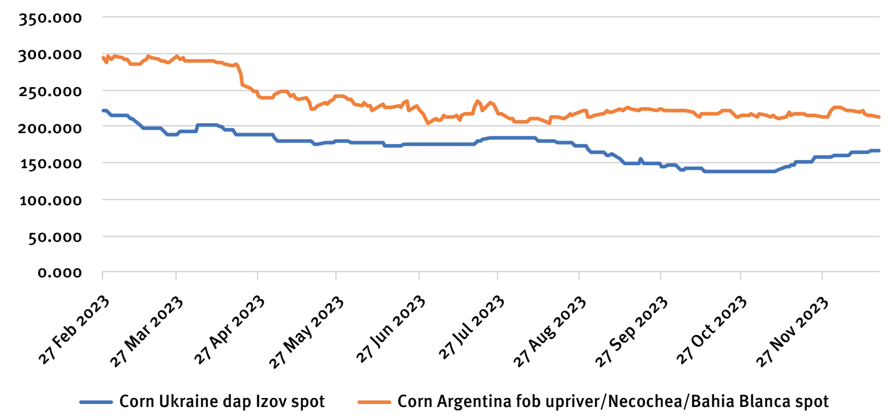
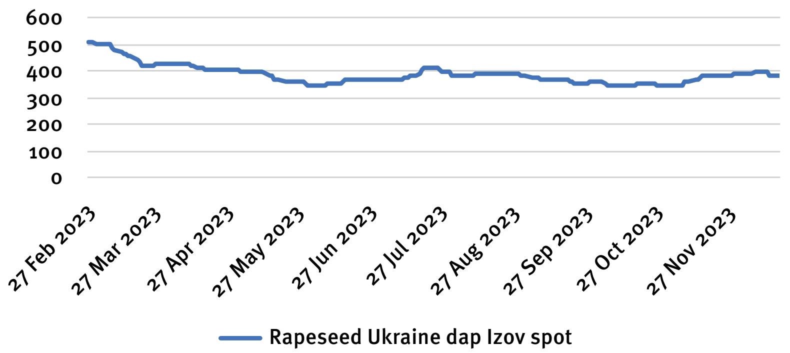


Figure 3. Rapeseed price (USD/t)



exceptional sales of wheat to China are the focus of attention, corn is not to be outdone, with another 165,000 t destined for an unknown destination. US prices remained unmoved, but managed to stay above USD4.85/bu.

European operators were focusing on their main supplier, Ukraine, and of the 2.5mn t of corn exported via the Black Sea since mid-September, more than 1mn t went to Spain. Moreover, the USDA has raised the export target by 1mn t to 21mn t, as has production, which has risen to 30.50mn t. The importance of shipments via Odesa is no longer in doubt. In the medium term, the main source of uncertainty for operators will be Brazil, where soybeans development is still behind schedule. The late harvest should reduce the optimum window for Safrinha sowing, leaving no room for the unexpected from next February onwards.

AGRITEL OPINION: *European corn tried to follow wheat's rebound, but the recovery was muted, with the March futures closing on Euronext at around EUR201/t on Friday. The different reports did not provide sufficiently strong elements to change the trend of the corn market. The market is now trying to get an idea of the situation in Brazil, as well as details of US farmers' sowing intentions.*

Rapeseed summary

European rapeseed prices have once again failed to make an upward breakthrough. European rapeseed prices are mirroring their own fundamentals: domestic supplies are sometimes difficult, leading crushers to firm up their bids in order to secure supplies, and Ukrainian imports are connected to alternative export routes: truck, rail and river. European rapeseed is nevertheless showing relative firmness in comparison with the rest of the complex, despite the upward revision of production in Canada and Australia by the USDA. Nevertheless, it will be necessary to ensure the continued supply of imports to Europe, mainly from Australia. By remaining relatively stable in the face of the downturn in the complex, rapeseed has managed to gradually improve its value, which should soon make it possible to import Australian canola, which is still too expensive to enter the EU for the time being. Soybean complex prices are falling on the back of a gradual return to rainfall in Brazil and low crude oil prices.

Soybeans retreated from the USD14/bu area and are now back at USD13.2/bu, forming a downtrend channel of USD12.7-14/bu. Any significant break in either direction would trigger a radical change in trend. In Brazil, the now regular rains have managed to stabilise the situation, but the first soybeans have suffered and the area initially targeted will not be reached. The USDA and CONAB revised their production estimates downwards by -2mn t last week, to 161mn t and 160.2mn t respectively. The consensus among local analysts is now between 150 and 160mn t. The production potential of the other South American countries looks promising for the time being, and should make it possible to avoid significant tension. The climatic risk premium is likely to persist in the near term, while the US is managing to position its soybean exports, notably to China, while awaiting the return of Brazil. While 48% of the export target has already been met, compared with the usual 45%, the USDA has not changed the US soybean balance sheet, with production and exports unchanged at 112.4mn t and 47.8mn t respectively.

AGRITEL OPINION: *Despite the upward revision of production estimates in Australia and Canada, European rapeseed has managed to test the EUR450/t resistance zone again on the Euronext near term contract. Import flows into Europe remain under watch, first from Ukraine and shortly from Australia. Rapeseed's upside potential will depend on the oilseed complex, with the weather still a risk for Brazilian soybeans.* ■

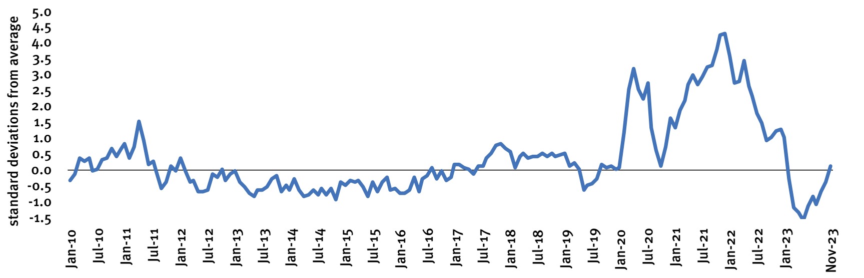
Hard commodities: Maritime disruptions threaten renewed supply chain pressures

Written by

David Fyfe, *Chief Economist,* ***Argus Media, UK***

Global supply chain bottlenecks show signs of worsening again after months of improvement. Disruptions to maritime commodity trade have played a part, with drought curtailing shipments via the Panama Canal and security concerns delaying transits via the Bab al-Mandeb Straits, Red Sea and Suez Canal. Meanwhile, the ongoing Russia-Ukraine conflict continues to affect Black Sea grain and fertilizer shipments, and any tighter restrictions imposed by the G7 nations on tanker movements of Russian oil could further impede regional trade in 2024.

Figure 1. Global supply chain pressures rising again



Source: Argus Media, Federal Reserve Bank of NY

Central Bankers at their final policy meetings in December were careful to avoid any sense of celebration or self-congratulation, but a clear message was that monetary tightening has for now come to an end, inflation has been contained and that markets should prepare for lower interest rates over the course of 2024. However, a glance at developments in the marine transportation markets suggests it may be premature to announce victory in the war on inflation, as the vagaries of climate and geopolitics combine to further disrupt shipping routes.

The New York Federal Reserve's Global Supply Chain Pressure Index, which spent much of 2022 normalising after the turbulence caused by the Covid-19 pandemic, has since early-2023 begun creeping higher once again. Clearly there is a risk that inflationary pressures could re-ignite in 2024, despite a widely-anticipated slow-down in economic growth and consumer demand, if shipping disruptions worsen, raising both delivery lead times and transportation costs. All this in a commodity market already buffeted by the aftermath of the Covid-19 pandemic and with traditional commodity supply chains turned upside down by sanctions imposed after Russia's invasion of Ukraine. Volatility in commodity freight rates is likely to persist into 2024 due to the combined impact of three key factors:

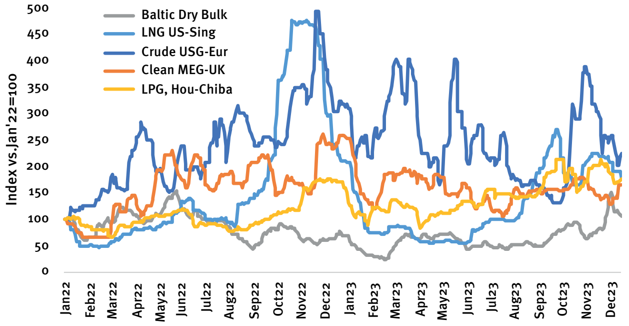
- Drought-related delays in transits via the Panama Canal, which have already in 2023 adversely affected dry bulk, container, LNG and LPG shipments
- Attacks on shipping near the Bab al-Mandeb Straits at the southern end of the Red Sea, affecting traffic headed to and from the Suez Canal
- A potential tightening by G7 governments on restrictions on the maritime movement of Russian oil exports under the terms of its price cap mechanism

Panama Canal

Low water levels since mid-year attributed to drought and the El Nino weather system have seen the Panama Canal Authority (ACP) reduce daily vessel transits from around 36 per day to 22 per day currently. An estimated 3% of total world trade crosses between the Atlantic and Pacific oceans via the canal. October was Panama's driest since 1950 and ACP originally planned to curb transits further to 18 per day by February (half normal levels). However, improved rains in November are now likely to allow a gradual increase in transits to 24 per day from mid-January. Nonetheless, waiting times for a southbound (Asia-bound) transit for both Panamax and Neopanamax locks are currently around 15 days, roughly double those evident in the first half of 2023.

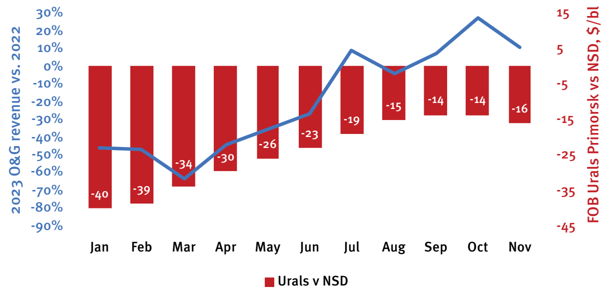
Around 290 mn t of cargo normally moves to market via the Panama Canal, comprising 105 mn t of dry bulk, 65 mn

Figure 2. Volatility shifts to the freight sector



Source: Argus Media

Figure 3. Russian oil & gas revenues now ahead of 2022



Source: Russia Finance Ministry, Argus Media

t of container traffic, 35 mn t of LPG, 20 mn t of crude and refined products and 12 mt of LNG. In terms of energy trade, shipments of propane, butane and liquified natural gas (LNG) from the US Gulf Coast to East Asia represent the key fragility caused by the ongoing delays. China, Japan and South Korea source between 40% and 90% of their LPG imports from the US. A typical Very Large Gas Carrier (VLGC) voyage from Houston to Chiba in Japan via Panama takes around 28 days, but potentially 15 days longer if routed eastwards via the Suez Canal or Cape of Good Hope. Not surprisingly freight rates have spiked as a result of Panama Canal delays, with LPG shipments on the Houston to Chiba route currently around double the cost seen in early-2023. An overhang of LPG and LNG supplies in the Atlantic Basin is also opening up substantial spot price discounts for those products versus comparable Asian prices.

Red Sea

Since October's outbreak of the Israel-Hamas conflict more than a dozen attacks have been made by Yemeni Houthi forces on commercial shipping passing through the Bab al-Mandeb strait. The Iran-backed Houthis have stated that vessels sailing to or from Israel will be targeted, although some recent attacks involved vessels destined for Europe. The Strait links the Gulf of Aden to the Red Sea and is the northward gateway for all seaborne energy shipments heading towards the Suez Canal. Over 9 mb/d of crude, condensate and refined products moved through the Suez Canal and associated SUMED pipeline in the first half of 2023, together with 116 million cu. metres per day of LNG, representing some 12% of seaborne oil trade and 9% of global LNG trade. As of mid-December, A.P. Moller-Maersk, MSC and CMA CGM had all temporarily suspended container shipments via Bab al-Mandeb with German container line Hapag Lloyd threatening to do the same. Oil major BP has also halted shipments via the Red Sea. Any prolonged disruption to Red Sea and Suez Canal shipments from the Middle East to northern Europe would involve sailing times of 8-10 days longer via the Cape of Good Hope.

The US Government is attempting to extend an existing naval military coalition for the protection of commercial shipping in the Middle East Gulf to the Red Sea, despite warnings from the Iranian Defence Minister that it would face "difficulties" if it tried to do so. Unsurprisingly, tanker operators in the region now face spiralling war risk insurance premia, which for the longer-running Russia-Ukraine conflict in the Black Sea have risen in excess of USD1/bl.

Russian oil shipments

The US and its G7 allies implemented a price cap mechanism for Russian crude oil and refined products exports in December 2022 and February 2023 respectively. The caps were designed to offset incoming EU embargoes which, in addition to banning imports of Russian oil into EU states, would have also prohibited sales into non-European countries using G7 country insurance, finance or shipping services. The price caps enabled the continued flow of Russian oil to the global market using G7 shipping and insurance services so long as oil was priced below specified price cap limits. Any cargoes transacted at prices above price caps would need to use non-G7 shipping and financial services.

In the first half of 2023, the price cap largely achieved its stated objectives, namely the continued flow of Russian oil to the global market but at the same time earning lower revenues for the Russian state. However, since July while Russian seaborne crude oil exports have been sustained in a 3.0-3.5 mb/d range, Russian revenues have moved above year-ago levels, partly due to rising benchmark crude prices and partly due to narrowing discounts for Russian crude oil. Russia has also successfully accessed an extensive "shadow fleet" of non-G7 vessels which does not rely on either G7 country financing or insurance services.

Now the US and EU are spearheading efforts to curtail Russian export revenues by tightening restrictions on the use of frequently un-insured "shadow fleet" vessels. Tighter enforcement mechanisms for vessels in breach of the price cap or even lowering price cap levels have also been discussed. However, the conundrum facing western policy makers is how to curtail Russian revenues without inadvertently reducing either overall global crude oil supply or broader tanker fleet availability. In an election year, resurgent energy costs due to surging crude prices or marine freight rates would be politically unwelcome. ■

Shipping and trade news

Sturdy OCP ammonia imports at risk from Red Sea route

A surge in Moroccan ammonia imports in the fourth quarter looks set to continue into 2024. But sole importer OCP will be partially reliant on deliveries from the Middle East for the first few months of the year, just as the viability of Red Sea voyages is being called into question.

Moroccan ammonia imports fell by 11% year-on-year to 1.6mn t despite increased finished fertilizer production, largely driven by pricing and delivery inconsistencies. But deliveries rose steeply in the fourth quarter.

Phosphate producer OCP imported on average 135,000t in 2023, down from 150,000t a month in 2022. Imports began to significantly ramp up from June onwards to an average of 156,400t/month, after prices dropped to USD320/t cfr. But when prices had averaged USD709.50/t in the first quarter, monthly deliveries were just 98,000t.

OCP's voracity for ammonia imports took on renewed fervour in the final quarter of the year as the producer was forced to step into the spot market searching for cargoes. Imports averaged nearly 190,000t/month in October-December after supply disruptions led to delayed shipments from contractual suppliers in Trinidad and Saudi Arabia for September.

So far, deliveries are showing no sign of slowing. The producer is already scheduled to receive 75,000t in the beginning of January — 50,000t from Saudi Arabia on vessels Seamaid and Marcella, and 25,000t from Egypt on Oceanic Star.

In total, OCP received 680,000t of Trinidadian product this year, and just over 600,000t from the Middle East — 430,000t of which came from Saudi Arabia.

But supply will likely shift to west of Suez sources next year, once the delayed 1.2mn t/yr Gulf Coast Ammonia (GCA) plant in Texas City, Texas, starts commercial production. It had originally been anticipated before the end of 2023, but is now slanted for start-up in the first quarter of next year, most likely by the end of March. OCP could be supplied with as much as 720,000t/yr from the plant, with contract volumes from other suppliers expected to be revised downwards to some extent as a result.

Shipments from the new and more efficient GCA plant could lessen volatility in deliveries for the producer in the new year — particularly as concerns mount over the viability and cost of voyages through the Red Sea. Some shipping firms have banned the route, while some very-large gas carriers have begun diverting around the Cape of Good Hope. And at least one major ammonia trader plans to avoid all near-term voyages through the area to minimise the threat. The situation remains uncertain, but with OCP unable to receive anticipated

FREIGHT RATES

POTASH	Price type	Units	Timing	Low	High	Date
Dry potash Vancouver - China 60-65kt	outright	USD/t	prompt	26	28	21-Dec-23
Dry potash Red Sea - WC India 25-30kt	outright	USD/t	prompt	33	35	21-Dec-23
Dry potash Baltic Sea - Brazil 30-40kt	outright	USD/t	prompt	37	75	21-Dec-23
Dry potash Baltic Sea - SE Asia 25-30kt	outright	USD/t	prompt	97	131	21-Dec-23
Dry potash Vancouver - SE Asia 25-30kt	outright	USD/t	prompt	72	74	21-Dec-23
Dry potash Baltic Sea - China 60-65kt	outright	USD/t	prompt	54	73	21-Dec-23
Dry potash Baltic Sea - US Nola 50-55kt	outright	USD/t	prompt	29	39	21-Dec-23
Dry potash Vancouver - Brazil 30-35kt	outright	USD/t	prompt	63	65	21-Dec-23
Dry potash Hamburg - Brazil 30-35kt	outright	USD/t	prompt	31	33	21-Dec-23

SULPHUR	Units	Low	High	Date
50-60kt – Vancouver-China	USD/t	29	33	21-Dec-23
Below all 30-35kt				
Mid East – EC India	USD/t	22	23	21-Dec-23
Mid east – North/River China	USD/t	32	34	21-Dec-23
Mid East – South China	USD/t	27	28	21-Dec-23
Mid East – Brazil	USD/t	29	30	21-Dec-23
Mid East – North Africa	USD/t	34	36	21-Dec-23
Mid East – South Africa	USD/t	20	22	21-Dec-23
Black Sea – North Africa	USD/t	55	65	21-Dec-23
Black Sea – Brazil	USD/t	65	70	21-Dec-23
Baltic – Brazil	USD/t	70	75	21-Dec-23
Baltic – North Africa	USD/t	55	65	21-Dec-23
35-40kt – US Gulf - Brazil	USD/t	30	32	21-Dec-23

deliveries from GCA for the first few months of 2024 and therefore reliant on its shipments from the Middle East, rising risks for Red Sea shipments and increased war premiums could prevent the stability the producer had sought.

Panama Canal dry bulk traffic down 75pc: Arrow

Panama Canal crossings for dry bulk vessels were 75% lower in the latest month from the same period in 2022, according to shipbroker Arrow.

The decline in passage through the crucial waterway from 20 November to 19 December from a year earlier is the result of a severe drought affecting water levels in Gatun Lake, where water levels are down by 7% from December 2022. Bottlenecks at the Panama Canal will likely persist into the first half of 2024, increasing dry bulk ton-mile demand by 1.0-1.5% as vessels take longer journeys through the Suez Canal or around the Cape of Good Hope, according to the shipbroker. Throughout the rest of 2023 and the first half of 2024, adjustments to slot distribution in the canal are expected according to future conditions. The Panama Canal Authority said on 15 December that its plan to raise transits to 24 from 22, starting 16 January, will "remain effective until conditions warrant changes." Of all the dry bulk segments, Supramaxes are the most affected by the bottlenecks. Panama Canal-transiting voyages account for 8% of the segment's ton-mile demand, more than that of any other dry bulk segment, according to Arrow.

Since 2 October, US Gulf coast-China Supramax rates have increased by 24% to USD67.05/t, while Panamax rates on the route have risen by 10% to USD55.80/t, according to Argus pricing.

Bulkers on the US Gulf-Asia Pacific route in particular have begun to reroute, foregoing the Panama Canal in favour of the Suez Canal. In November, 70% of Supramaxes along this route passed through the Suez Canal, compared with under 15% for any month in 2017-2022, according to data from Arrow.

"The restrictions at the Panama Canal are here to stay for many months, and this will likely increase average voyage distances, thereby tightening the market," said Arrow.

In addition, numerous attacks on commercial shipping in the Red Sea have caused several shippers to avoid the Suez Canal as well, but Arrow expects any blockages there to be temporary.

"However, if [an extended closure of the Red Sea] did materialize then the impacts on dry bulk shipping would be enormous, with ton-mile demand likely rising around 8% immediately," Arrow said.

Brazil auctions off five port terminals

Brazil's federal government and southern Parana state auctioned off concessions to operate five port terminals on 13 December to private bidders.

The National Waterway Transportation Agency (Antaq) and the Paranagua and Antonina port authority coordinated the process. Four terminals are in southern Rio Grande do Sul and Parana states and one is in northern Alagoas state.

In the port of Paranagua, the PAR09 terminal, dedicated to handling and storing solid bulk cargoes, mainly soybeans, corn and soy meal, was auctioned. Quadra Capital, through the Multiestrategia Equity Investment Fund (FIP Multiestrategia), won the concession for BFRL615,751 (USD124,190), under a 35-year contract and an expected investment of BRL910mn. The terminal was offered by the Parana port authority.

The other four terminals were auctioned off by Antaq. In the port of Rio Grande, in Rio Grande do Sul state, the RIG17 terminal, which is dedicated to handling and storage of solid vegetable bulk, was auctioned. AC Vita Serviços de Armazenagem won the concession, paying a BRL1mn fee, with a 10-year contract and planned investments of between BRL26-27mn.

Two terminals in the port of Porto Alegre, also in Rio Grande do Sul state, were auctioned off. POA02 was acquired by Serra Morena Corretora for BRL2,000. It is dedicated to domestic shipping and cabotage. The contract is for 10 years and investments are expected to be BRL16mn.

NITROGEN/UREA		Units	Low	High	Date
Middle East - US Gulf	45kt	USD/t	32	34	21-Dec-23
Middle East - Thailand	30kt	USD/t	20	22	21-Dec-23
Middle East - Brazil	40kt	USD/t	23	25	21-Dec-23
Baltic - Brazil	30kt	USD/t	55	65	21-Dec-23
China - India	60kt	USD/t	19	21	21-Dec-23
Algeria - Brazil	30kt	USD/t	32	34	21-Dec-23
Algeria - French bay	12kt	USD/t	27	29	21-Dec-23
Baltic - EC Mexico	30kt	USD/t	60	65	21-Dec-23
Baltic - WC Mexico	25kt	USD/t	92	96	21-Dec-23

PHOSPHATES		Units	Low	High	Date
Morocco – Brazil	30kt	USD/t	29	31	21-Dec-23
Tampa – Brazil	30kt	USD/t	42	44	21-Dec-23
Saudi Arabia – EC India	30kt	USD/t	19	21	21-Dec-23

AMMONIA	Units	Latest	Date
Ras al Khair - Ulsan, 23kt	USD/t	90	21-Dec-23
Ras al Khair - Kakinda, 23kt	USD/t	25	21-Dec-23
Ras al Khair - Kandla, 23kt	USD/t	48	21-Dec-23
Point Lisas - Ulsan, 23kt	USD/t	144	21-Dec-23
Point Lisas - Houston, 23kt	USD/t	38	21-Dec-23
Point Lisas - NW Europe, 23kt	USD/t	63	21-Dec-23
Bontang - Ulsan, 23kt	USD/t	39	21-Dec-23

Unifertil was the winner for the POA11 concession for BRL50,000. The investment forecast is BRL5mn over 10 years. The terminal handles solid bulk, especially fertilizers, cereals and salt.

In the port of Maceio, in Alagoas state, the MAC15 terminal, which handles and stores solid mineral bulk, mainly salt, was auctioned. Intermarítima Portos e Logística won the contract for BRL1mn. The contract is for a period of five years and involves planned investments of BRL7.2mn.

Mitsubishi, SKI to study hydrogen shipping potential

Japanese trading house Mitsubishi plans to work with South Korean energy firm SK Innovation and Norway-based ammonia firm Amogy to explore large-scale hydrogen shipping business.

The partners plan to carry liquefied ammonia and then use Amogy's technology to crack ammonia into hydrogen, Mitsubishi said on 20 December. Hydrogen is expected to be used for various industrial purposes including power generation, petroleum refining and steel production.

The companies aim to research the costs of hydrogen shipping, scaling up Amogy's ammonia cracking technology and the potential demand for hydrogen and ammonia in Japan and South Korea.

Japan and South Korea will co-operate on building global value chains for hydrogen and ammonia, Japanese premier Fumio Kishida previously announced on 17 November 2023. Japan, as a resource-poor country heavily dependent on imports of low-carbon fuels, is strengthening ties with similarly import-dependent South Korea to increase bargaining power and enhance energy security on its way to achieving net zero greenhouse gas emissions by 2050. ■

New Year viewpoints on the fertilizer nutrient market

Strong fall may trim spring US NH_3 demand

Another strong US fall application season will likely limit ammonia demand in the first half of 2024 and keep a ceiling on prices ahead of the spring.

A second consecutive prolonged fall application period in the Corn Belt — especially in Illinois and Iowa, where sources indicated record-high delivery volumes — is expected to trim initial interest in ammonia purchases for the spring. This could shift buying patterns to a hand-to-mouth dynamic for pre-planting applications, where farmers buy as little as possible and just before they need it.

Initial spring prepay offers by mid-December widely exceeded buyers' expectations, ranging from USD620-650/st for second quarter delivery. Sources say the offers so far have been met with minimum interest from buyers, potentially paving the way for demand and pricing dynamics to mimic those of the spring of 2023.

Producers and suppliers will have to announce more competitive offers for second-quarter ammonia volumes to capture commitments from buyers, or else risk another season of hand-to-mouth buying that could leave terminals with high inventories as applications wind down in the spring.

A successful fall application season, which is largely dependent on favourable weather and soil conditions, has historically reduced demand for end-users during the spring because some farmers will opt to skip seasons if they believe nitrogen content is adequate in their fields. Demand can be further reduced if weather and soil conditions do not meet requirements for anhydrous ammonia applications, or if prices are uneconomic relative to projected income.

Following spring 2023 applications, producers and suppliers announced the lowest fall ammonia prepay pricing since 2020, offering a significant discount after an unusual spring season in which a build-up of terminal inventories prompted nearly weekly in-season spot price declines. By the time fall applications began, some wholesalers estimated that up to 90% of volumes delivered during the fall in the east and west Corn Belt were purchased during prepay sales in the early third quarter.

But divergent weather and soil conditions between the east and west Corn Belt during the fall presented both challenges and opportunities to end-users, with record delivery volumes reported by sources in Iowa, Illinois and Indiana because of favourable conditions for much of the season. But widespread post-harvest fieldwork in Nebraska and Missouri was delayed, first by dry soil conditions and then by intermittent precipitation and warmer-than-usual temperatures.

Ammonia markets are expected to remain soft at the beginning of 2024

The relatively poor application conditions in the western Corn Belt, namely Nebraska and Missouri, could elevate inventories at terminals if prepaid volumes are not delivered, lifting carrying costs that would be difficult to recover if pricing does not recover by the spring.

Ammonia markets are expected to remain soft at the start of 2024, as price support declines amid slowing spot trade. The January Tampa settlement fell by USD100/t to its lowest point since September at USD525/t cfr, reflecting slowing demand that has weighed on sentiment in the first quarter.

Phosphate demand recovery likely to persist

Last year's recovery in US phosphate fertilizer demand will likely continue into 2024, but possible revisions to import duty cases on Moroccan and Russian product are clouding the supply outlook.

Phosphate supply would likely remain tight in 2024 if neither country exports any DAP or MAP to the US. Russia was the US' top source of imported MAP in the last fertilizer year (July-June). But a recent hike to Russian phosphate producer Phosagro's subsidy rate will probably curb its shipments to the US. Moroccan phosphate producer OCP's rate was lowered sharply, but the company has said it should face no import duties.

Supply concerns would ease if OCP were to resume DAP and MAP trade to the US. North American fertilizer producer Mosaic also indicated last month that it may increase phosphate production starting in the back half of 2024 to 2mn metric tonnes (t)/quarter from a recent average of 1.7mn t. That too would help loosen supply.

OCP used to be the US' biggest source of imported phosphate, but it ceased supplying the country with DAP and MAP when the US International Trade Commission (ITC) determined in 2021 that phosphate imports had materially injured the domestic fertilizer industry, and the US Department of Commerce levied import duties on Moroccan and Russian phosphate producers.

A slew of appeals followed in the months after, and in September, a US Court of International Trade judge said ITC's determination was not supported by sufficient evidence. The judge remanded the case back to ITC.

ITC has 120 days from the judge's decision to issue its remand redetermination. A subsequent comment period could last up to nearly 120 days.

Commerce on 29 April is set to release the preliminary results of its second administrative review of the countervailing duty order it issued in 2021 on Moroccan and Russian phosphate. The final results could take another six months to be released.

In November, Commerce issued the final results of its first administrative review. It lowered OCP's subsidy rate to 2.12% from 19.97% and raised Phosagro's to 28.5% from 9.19%.

US phosphate buyers will need to replenish depleted inventories

US phosphate buyers will need to replenish depleted inventories over the next few months in preparation for the spring application season. Market participants are mixed on whether demand for spring needs will outpace supply. Some are optimistic about securing enough phosphate from the usual domestic and import sources, as well as non-traditional ones, and they noted that DAP, which is higher in demand in the spring, is easier to source than MAP.

Others are less optimistic, citing the supply tightness and spot outages in the spring and fall 2023 that were exacerbated by poor conditions on the Mississippi River.

Winter fill demand has been stronger than expected during the past few weeks, bolstered by distributors taking product from Mosaic's allocation program.

Nola phosphate prices climbed as demand jumped. DAP prices rose to USD570-580/short ton (st) fob Nola last week from USD523-540/st fob in early November while MAP prices were up to USD615-620/st fob Nola from USD590/st fob a month earlier. Nola MAP and DAP were priced at a midpoint of USD610/st fob and USD612.50/st fob, respectively, in late December 2022.

The recent rise in Nola phosphate prices has not caused affordability concerns, and sources expect prices to soften some when demand cools.

To ensure sufficient spring supply, US phosphate consumers will need to compete with their global counterparts for imported DAP and MAP. Export restrictions in China, creating a global DAP deficit over the next four months, will likely make the market more competitive.

Southern Cone fertilizers activity remain muted

Import activity in the Southern Cone's fertilizer market is set to be minimal in early 2024, extending the trend of late 2023, as political uncertainty and alarming climate conditions hamper crop development.

Activity for the 2023-24 crop cycle has been reduced in Argentina, where January-November granular urea imports totalled nearly 732,500t, a 16% drop from a year earlier, while MAP imports were down by 6% to 725,500t.

Political and economic issues snarled import activity in Argentina, amid ongoing problems with the country's import system SIRA, such as difficulties accessing US dollars and, consequently, in paying suppliers amid a balance of payments crisis marked by surging inflation and sharp depreciation of the Argentinian currency. Imports were also further reduced because the country went through a presidential election period this year. In the weeks before and after primaries on 13 August and during the electoral period from 22 October to 19 November, market activity was scarce amid political uncertainty. President Javier Milei, a libertarian bent on reducing bureaucracy, took office on 10 December, but fertilizer activity may only intensify once there is more clarity on agricultural and economic reforms, according to market participants who operate in Argentina. Milei this week signed a resolution eliminating the SIRA and replacing it with a new import system, changes that took effect on 27 December.

In this context, Argentina commanded a higher-than-typical premium over Brazil this year. MAP/DAP prices usually have a USD10-20/t premium in Argentina relative to Brazil, but this year the average premium reached nearly USD30/t.

Waning demand from China has weighed on Vancouver sulphur pricing

Fertilizer deliveries in the Argentinian market totalled 2.4mn t in the first half of 2023, according to the country's civil fertilizer association Fertilizar. Nitrogen-based fertilizers accounted for nearly 61% of deliveries, followed by 32% for phosphate-based deliveries. That compares with 2.7mn t delivered in the same period a year earlier and with 3.3mn t delivered in the first half of 2021. Nitrogen and phosphates also accounted for most of the volumes in 2022, respectively, with 58% and 34%, Fertilizar data shows. Argentinian soil is rich in potash and the country buys higher volumes of nitrogen and phosphates.

Argentina is expected to have reduced fertilizer usage in 2023 — because of the country's ongoing balance of payments crisis — despite the expected increase in its 2023-24 production. The country is among the main global exporters of corn, soybeans and wheat. Corn production in Argentina is projected at 55mn t in the 2023-24 crop, compared with 34mn t in the previous cycle, according to the US Department of Agriculture (USDA).

In the third quarter of 2023, farmers in Argentina could opt to substitute soybeans for corn at the last minute in the 2023-24 crop, as soybeans' cost of production is lower than corn, according to market participants. Soybean planted area is estimated at 17.3mn hectares (ha), after the Buenos Aires Grain Exchange (Bage) increased the acreage by 200,000ha in its latest outlook in November at the expense of corn. Bage lowered expected corn planted area by 200,000ha to 7.1mn ha.

Soybean output should increase to 48mn t in 2023-24 from 25mn t in the previous crop, according to USDA. As for wheat, output is expected to reach 15mn t from nearly 13mn t in the 2022-23 crop.

Global softness to pressure North American sulphur

Increased sulphur output from US Gulf coast and Canadian producers helped balance the North American market in 2023, but a glut of sulphur will likely suppress export pricing heading into 2024 after a recent slowdown in global demand.

A slowdown of spot purchases by Chinese buyers has maintained downward pricing pressure on the global sulphur market, especially in the fourth quarter as Chinese port and river inventories reached their highest levels in around three years. Argus estimates phosphate fertilizer producers are operating well below capacity because of fertilizer export restrictions implemented by the Chinese government. The low demand from those producers combined with adequate stocks has required traders to place marginal volumes elsewhere and raised competition between suppliers.

Waning demand from China has weighed on Vancouver sulphur pricing, which has fallen by 25% since the beginning of the fourth quarter of 2023 to USD72/t fob on a midpoint basis on 14 December as suppliers compete to secure shipments and climbing freight rates trim fob values.

Sulphur output in Alberta is likely to reach record highs as bitumen and heavy, sour crude production bolsters sulphur production in the Canadian oil sands. According to the Alberta Energy Regulator (AER), sulphur production from January-October 2023 climbed by 386,000t, or more than 11% from the same time in 2022 to 3.78mn t.

Previously in 2023, suppliers were pulling tons from sulphur stockpiles, with market participants saying that suppliers were remelting, or preparing tons of solid sulphur inventory to shipment, to keep pace with demand from exporters. But as market sentiment has weakened, remelting operations may slow as falling prices squeeze high-cost tons out of the market.

In the US, increased shipments to Brazil, Morocco and Mexico have helped to balance the market amid higher output from refineries and natural gas processors. This trend will likely continue in 2024, but increased competition from other exporting regions to secure deals is expected to weigh on pricing in the first half of the year, despite relatively healthy margins for phosphate fertilizer producers.

A softening domestic sulphuric acid market and uncertainty surrounding domestic phosphate fertilizer production is expected to trim domestic sulphur consumption, which fell by about 6% in the first nine months of 2023 relative to the same time in 2022.

Sulphur production in the first nine months of 2023 has totalled just over 6mn t, according to the US Geological Survey (USGS), only 20,000t higher than during the same period in 2022. Sulphur output from each US region declined year over year except for in the Gulf coast, where production during January-September 2023 climbed by around 3% from 2022 to 3.57mn t, according to the USGS.

Abundant supply and lagging demand have kept sentiment relatively bearish for early 2024. Market participants expect the first quarter Tampa settlement to track recent spot price development in Vancouver and the US Gulf coast and decline by USD30-35/t into the mid-USD60s/t to low-USD70s/t delivered. ■

Price watch

*These market insights are provided by **Argus Fertilizer Analytics team***

AMMONIA

Downward price correction for ammonia marke

The global ammonia market has cooled after months of price accumulation fuelled by limited supply from several key merchant hubs. Most major outages have been resolved and a recovery in operating rates in the Middle East, in particular, has added some much-needed slack to the market. This, coupled with the winding down of peak fertilizer demand seasons in the northern hemisphere, has meant that nearly all ammonia benchmarks have started to register downward price corrections.

Buyers are happy to wait for market direction to become clear — a lack of spot trade given reduced availability from producers has clouded the outlook in recent weeks. Nost consumers are not looking to participate in spot trade anyway, instead wishing to draw on inventories. We expect demand to continue to wind down and most trade to be contract focused, particularly as key fertilizer demand periods wind down, before buying picks up towards the end of the first quarter of the new year.

Europe's TTF natural gas prices have so far been constrained to a level that does not place the majority of the continent's producers in jeopardy. But cracks might be starting to appear as Romania's Azomures announced a gas price-related curtailment and Yara has suspended operations at its Ferrara site for economic reasons. Unless there is a shock to gas market fundamentals that we cannot foresee and a resultant spike in European feedstock costs, production on the continent will remain on the right side of marginal for the next few months.

There is a slight difference in sentiment on either side of the Suez Canal — Asian markets are well supplied, and a slight softening is expected in the near-term, while the west is more balanced as buying continues with strength in some pockets and as buyers wait for output from the eagerly anticipated GCA unit on the US Gulf coast. Algerian producers are also thought to be facing production issues, although they managed to sustain typical export levels. Trinidadian producers as ever continue to face minor production outages.

A rollover in the Tampa contract settlement between Yara and Mosaic at USD625/t, after four months of consecutive gains, emphasises the balance now faced around the Atlantic and we expect to also see stable pricing in the key delivered benchmarks of northwest Europe and north Africa as a result.

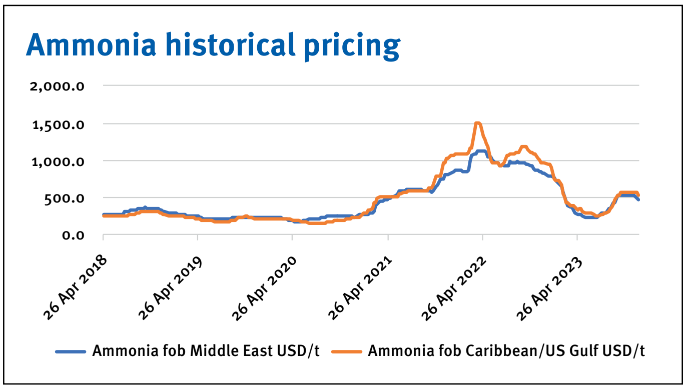
Looking to 2024, we expect a heavy shift to surplus as an additional 108,000 t/month is available from the US, assuming no issues occur during GCA's commissioning. The effect will be most keenly felt in Europe and Morocco, where most of the product is expected to go, but the fob Middle East benchmark will also experience downward pressure

as a result of having to compete on price to place cargoes to Morocco. Throughout 2022 and for most of 2023, fob benchmarks to the east of Suez have been priced at steep discounts to west of Suez benchmarks, allowing a price incentive to ship cargoes through the Suez Canal from east to west. But on account of a more balanced west of Suez market, we expect this spread to narrow from 2024.

There will be little support for any of our forecast benchmarks during the first quarter as supply outweighs demand, and month-on-month price decreases are anticipated over the period. Price depreciation will continue, particularly once applications finish in the spring in the US and Europe, and India's kharif application period draws to a close. Benchmarks are therefore expected to register the steepest declines from April to June, as any support provided by fertilizer demand drops away.

Added to the bearish tone for 2024 is the possibility of the start of operations at Uralchem's Taman export terminal on the Black Sea. The return of Russian supply would be the first out of the Black Sea since Russia's invasion of Ukraine in February 2022, and Uralchem plans to export as much as 80,000 t/month, although we take a more conservative view on expected volumes.

Prices will bottom out in July as they begin to squeeze some of the more marginal production centres, with European production perpetually at risk, before demand for the autumn application seasons brings about a tighter market and some strength to prices. But the new supply is expected to minimise subsequent price gains.



PHOSPHATES

US winter demand emerges

DAP and MAP markets east and west of Suez are still digesting a murky supply outlook over the coming months, which is largely being driven by the reintroduction of stringent export restrictions from China, to quell a jump in domestic prices. We have seen some fob levels drop, but this is largely being driven by rising spot fright rates, and suppliers are finding it difficult to pass on the rising rates at the cfr level, placing fob prices under pressure.

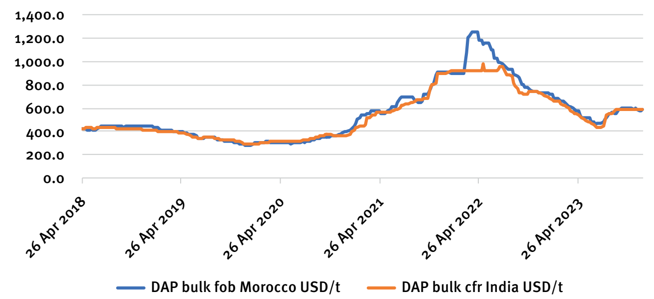
Overall, we expect DAP fob prices will remain broadly stable in the coming months as limited demand is expected to emerge in January and February. Despite it being evident that there is ample demand from the subcontinent to replenish inventories, there is hesitancy around importing until further clarity emerges on Chinese export availability in the first half of 2024.

It is clear that low inventory levels and healthy domestic offtake in the subcontinent will inevitably pull importers back into the market. But in the case of India, the recent subsidy cut has left imports and producers facing loss-making operations and this is preventing activity at current price levels. Producers appear content on waiting for further urgency to build up, especially as it would imply subcontinent, European, Australian and southeast Asian demand competing over a more narrow purchasing window.

As competing demand builds towards the end of the first quarter, we expect DAP fob prices will firm in March and April, following a global DAP deficit emerging. Export availability from China is muted and we expect this will remain the case across the majority of the first quarter, to ensure ample availability for the domestic season. DAP fob China has gained a premium over other markets but we expect it will quickly erode once exports resume at more typical levels. In the second half of the year we expect price movements in DAP and MAP markets to be more moderate, as overall stability improves and more typical seasonality is anticipated.

Looking west of Suez, European buying has slowed as it heads into the holiday season. We expect import volumes will return to more typical levels, particularly towards the end of the first quarter, and again in the fourth quarter of 2024.

Phosphates historical pricing



In the US, demand has picked up despite limited supply, particularly with MAP. This has caused prices at Tampa and US fob barge prices to rise. We expect the duties placed on Russian and Moroccan ammoniated phosphates will continue to create MAP supply concerns for the US domestic market, and this will sustain a premium, albeit less notable than earlier in 2023, which will support DAP prices as well, especially during deficit periods. We forecast US fob barge prices to fluctuate between stability and firming in the coming months until April.

Given the MAP market is more concentrated, we expect the market will retain a surplus over the bulk of the outlook period. And given Russia's outlets have shrunk since revised duties were imposed, we expect greater availability will be pushed into major importing regions such as Brazil and India, especially once China's export restrictions ease. This will place pressure on prices, gradually softening MAP fob and cfr levels over the outlook period.

POTASH

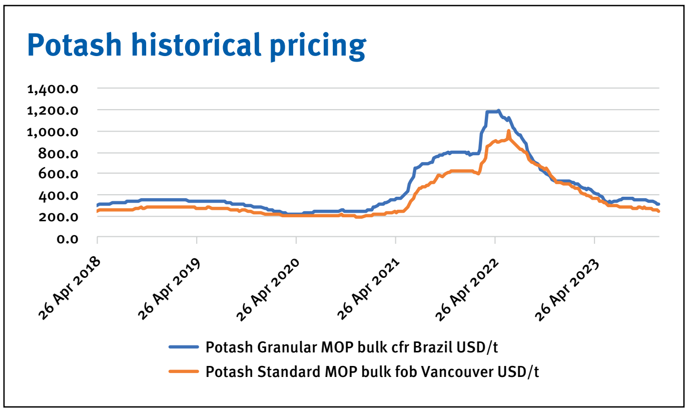
Weather and crop prices present downside risk

After a tumultuous two years, global potash prices were more stable in the last quarter of 2023. Buyers have been cautious despite improved affordability as weather concerns dominate sentiment but suppliers have been unwilling to drop prices without reason to believe that doing so would motivate buying. And there is little reason to expect prices to break out of their current trend in the near term as we are between main demand windows in many major markets and supply elsewhere is sufficient to meet requirements. The price direction later in 2024 depends on whether demand recovery outpaces the supply growth forecast from Russia, Belarus and Laos.

Buyers in Brazil are waiting on the sidelines as prices soften, with unfavourable weather conditions and logistical bottlenecks also contributing to cautious sentiment. Product availability remains high, as exports may exceed 13mn t in 2023 and product could be carried over if demand does not materialise. This is causing prices to soften in the US as the market receives offshore volumes from suppliers diverting away from the weaker Brazilian market. As the fall application season has passed, the only near-term demand is for rebuilding inventory over winter fill, which could see trading slow and stable to soft prices.

Softening prices in the Americas are guiding buyer sentiment in other granular markets, with Australia, South Africa, southeast Asia and Europe all facing negative sentiment as buyers look to move closer to Brazil's level.

The situation for standard MOP is not much different. China is gearing up for the spring application season by building stock thanks to higher imports from Laos and Belarus by



rail. China has sufficient product to meet near-term demand, even with restrictions likely for domestic producers, which makes a contract settlement for 2024 unlikely before midyear. Volumes newly contracted with Uralkali at USD319/t cfr will see more product flow to India in the near term but the government decision to slash the nutrient-based subsidy for potash for rabi 2023-24 limits demand upside from 2023, even with lower prices and a need for higher application after years of insufficient imports.

These contract markets have guided buyers in southeast Asia, where trading has been slow in recent months. Improving affordability as MOP prices fall and rice prices rise is finally seeing some buyers return. Plantations are looking to secure product for January-June delivery, suggesting market participants expect price stability to begin 2024. Demand recovery may be slowed by lower rainfall caused by El Nino, and increasing volumes from Laos and Belarus are expected to make supply competitive.

Belaruskali has achieved shipment volumes in excess of 900,000 t/month in each of the past three months, with Russian Baltic ports dominating its export strategy. China has also proven a reliable trading partner, with exports to the country by rail rebounding to more than 130,000 t/month. We have raised our export expectations for Belarus as a result, and now forecast 8.7mn t in 2023 and 10.2mn t in 2024.

In Russia, Uralkali has returned to historical monthly export levels and should raise exports in 2024 to about 9mn t as a result. Russian exports will increase further as Eurochem continues to ramp up at its two mine sites, with about 3mn t of exports expected for the producer in 2023.

Laos is the other region where exports are rising, with 2mn t of MOP exported in January-October. Lao Kaiyuan has 1mn t/yr capacity and Asia Potash is on the way to 3mn t/yr by the end of 2023. Both producers are increasing granulation capacity to diversify sales options as output increases, with sales so far almost exclusively in China or southeast Asia.

Canadian producers are expected to have a strong fourth quarter and how far their sales increase in 2024 depends on the scale of demand growth.

Production in Europe and the Middle East is forecast flat year on year for 2024, with some downside risk, although ICL production and export from Israel has so far been unaffected by the Israel-Gaza conflict.

Fob potash prices may be pressured by rising freight rates. Delays at the Panama Canal have worsened, with rainfall needed to alleviate drought conditions unlikely before April at the earliest. With ships tied up waiting at the canal or switching to longer routes to avoid the higher costs incurred, bulk shipping rates should be firm in the near term.

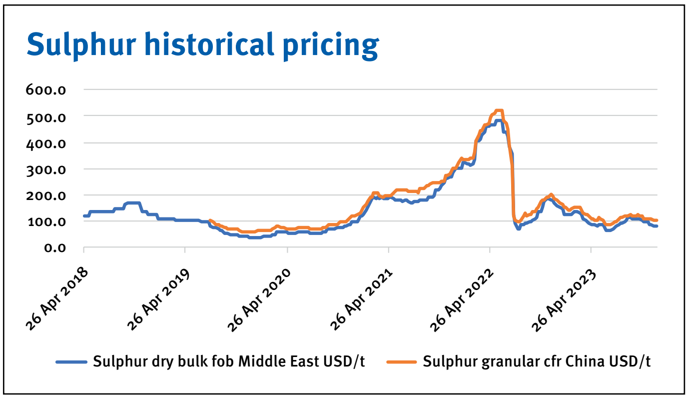
The SOP market is currently tighter than the MOP market as demand is returning in Europe but suppliers have been slow to respond, or are already sold out well into 2024. China's continued near-absence from the traded market is contributing to this tightness that should see SOP prices firm in early 2024 until producers take advantage of lower MOP costs to raise operating rates.

SULPHUR

Slow price erosion set to continue

We continue to forecast sulphur prices will be weighted by low import demand from China because of elevated stock levels and lacklustre demand, as processed phosphate exports continue to be restricted. Clarity on first quarter 2024 export allowances for Chinese phosphate producers is still lacking, but we are continuing to forecast exports will be strictly limited until at least March/April, and that in turn will limit appetite for imported sulphur. Also, in the most part, buyers outside of China are covered until the end of 2023, if not the early parts of 2024, and this is adding to the bearish sentiment in the spot market.

There are still a few pockets of demand for 2024 showing however, with Indonesia's PT Huayue looking for 2-3 cargoes for January arrival and Brazil's CMOC expected to seek a February arriving, January-loading cargo. But this demand is not sufficient enough to make up for the sluggish demand in China and elsewhere, and prices are still set to ease. December cargoes remain unsold, and this is forcing suppliers to offer lower prices. Buyers are more than happy to add further pressure under cutting these bids, as it is clear that softening is set to continue.



But current price levels are already nearing a price point which will likely halt sales and exports of higher-cost tonnes. Turkmenistan origin product and crushed lumps will be the first to be removed from the market, as logistics costs for Turkmen tonnes and production costs for lumps keep fobs at higher levels. And there is also a risk to Russian loading cargoes becoming constrained beyond that of the usual winter season cutbacks as, if prices slide further for mainstream tonnes, it is likely the handful of buyers still taking Russian cargoes will add further downwards pressure on Black Sea and Baltic fobs, which are already at a discount to other benchmarks, making exports of some product unworkable. Curbed availability of these cheaper tonnes will slow down some softening and prevent a steep price correction in 2024. Also we cannot forget that freight rates are firming, notably on many routes, which is adding further pressure to fob prices. And notably for Black and Baltic Sea loading cargoes as the weather gets colder ice breaker vessels will be required, which will further boost freight rates which are already elevated because of premiums already in place for those routes, a continuing fallout of the conflict in Ukraine.

Lastly, when it comes to first quarter contracts, negotiations are in the very early stages, but it has already been reported that buyers and sellers, at least on a Middle East fob basis, are at least USD10/t apart following initial offers. As is the tradition, key buyers such as Morocco's OCP are now on the sidelines which is adding to the bearish sentiment in the market. But, once they are concluded, it is more than likely some more spot demand will emerge, which will further support a slow erosion of prices in the first quarter, rather than a dramatic correction.

We also should remember because of Chinese export restrictions, downstream fertilizer prices are on a firm footing into the first quarter, which should support raw material affordability and, in turn, put a floor in place for sulphur suppliers.

NITROGEN/UREA

Urea prices down sharper than expected.

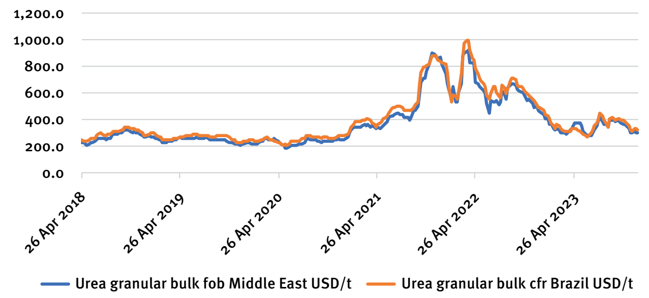
A sharp drop in urea pricing recently was mainly on account of buyer resistance to perceived high prices.

India bought large amounts of urea for November shipment — close to 1.7mn t — but increased output at new plants in the country means there has been no additional tender scheduled.

In Brazil, delayed planting and unfavourable corn prices because of the exchange rate restricted demand, while suppliers tried to push close to 1mn t of urea into the market.

European buyers have largely stayed out of the market over the past few weeks, watching prices in Egypt fall from USD400/t fob to less than USD350/t fob and mindful of the huge midseason fall in prices in 2022.

Urea historical pricing



Import statistics for 13 of the largest markets worldwide, which account for more than 70% of world trade, show that there was a 900,000t fall in demand in January-September in 2023, compared with the same period of 2022. This demand decrease is likely to have widened in the fourth quarter. But export supply is being maintained.

With a few exceptions, urea prices have not yet fallen to levels at which cost pressures will force plants to close. Ammonia plants are being closed, probably permanently, in Lithuania, Poland and Romania, and Norway-based producer Yara has announced a two-month closure at a plant in Italy. But these are not large enough in aggregate to alter the market outlook for urea, which remains weak.

Attempts by the Chinese government to micro-manage the market have further discouraged urea exports. Authorities have instigated lengthy customs inspections and voluntary quotas in their efforts to push down prices in the local market. China's exports are likely to approach 4mn t in 2023, up from 2.8mn t in 2022. Production is expected to total 61mn t, with domestic use rising to 55mn-56mn t. Exports could be sustained at this level in 2024, if the government permits.

For the time being, China is a sideshow in the urea market. Prices are well above those from competing origins and India has stepped out of the market, so there is no need for large quantities of prilled urea.

Fob prices may come under pressure from a sharp increase in freight rates for dry bulk goods. This is unlikely to be absorbed in higher cfr prices, suggesting that producers will have to cut their prices.

Our trade balance shows that there will be a significant supply surplus because of an absence of additional buying from India. But a rapid fall in prices suggests that the market is approaching a floor, and should be prevented from falling much further by short covering.

The supply surplus is expected to be smaller in January and February, suggesting that prices should stabilise rather than rebound rapidly. But there are two caveats — firstly, prices tend to overshoot on the downside and, secondly, some of the lost demand from the fourth quarter could resurface early in the new year, altering the balance supply and demand. ■

People and events

Novaphos names Navy Vice-Admiral Andrew Lewis (Ret.) as Chief Development Officer

Leadership team continues expansion to drive deployment of revolutionary process for producing high-quality phosphoric acid

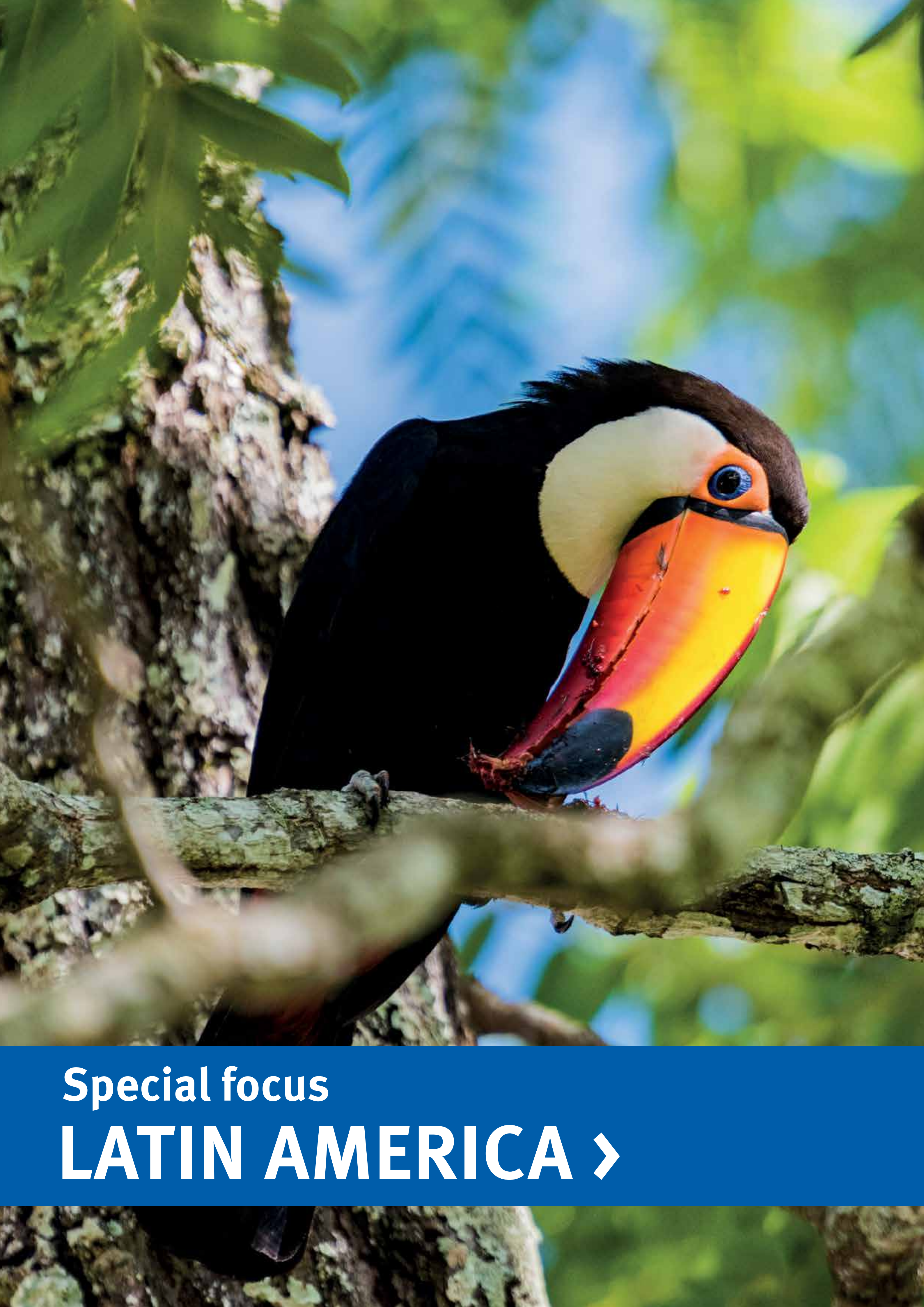
Novaphos has announced the appointment of Navy Vice-Admiral Andrew "Woody" Lewis (ret.) as Chief Development Officer (CDO), a newly created senior executive position responsible for managing and directing the company's relationships and engagement with strategic partners, including policymakers, regulators and industry. In his role, Mr. Lewis will develop and lead the advancement of Novaphos' commercial interests, showcase its value position within the global marketplace, and build relationships with key government officials and industry stakeholders. Mr. Lewis has a long and distinguished 36-year military career as a 3-star senior officer, serving in the United States Navy, where he cultivated deeply unique leadership experiences and has built impactful relationships and networks with senior leadership inside the United States and with foreign governments and allies. He most recently served as Commander of the U.S. 2nd Fleet and NATO Joint Force Command in Norfolk, Virginia. Mr. Lewis will report to Novaphos' Chief Executive Officer, Timothy Cotton.

During the last ten years, Novaphos has developed a revolutionary process for producing high-quality phosphoric acid, one of the most valuable resources on the planet and a vital ingredient in manufacturing fertilizers, lithium-ion batteries, and many other essential products. Through Novaphos' series of patents and proprietary technological innovations, the company will look to begin processing phosphate at lower cost and higher margins without the environmental damage associated with the current phosphate industry.

"Phosphate is one of the most valuable minerals in the world, yet the way it is produced is broken, outdated, and has seen minimal technical change. The result is that current production processes are dangerously wasteful and destructive to the environment," stated Timothy Cotton, Novaphos' Chief Executive Officer. "Through significant investment and research, Novaphos has built a modern and powerful method that is now ready to begin scaling in 2024. We anticipate this paradigm-changing operation to potentially impact national security, food security, and the supply chain. Woody brings to Novaphos deep strategic experience and executive leadership in global operations management that will be imperative to our success and ultimately ensure that one of the most valuable resources on the planet remains available and can be produced sustainably. Like our other recent leadership additions, Woody's appointment shows that Novaphos is ready to enter a new stage of operations and production. The team we are building provides us and our community of partners great confidence during this important moment for the company."

"When we talk about the formative changes that could take place with Novaphos production innovations, it is clear there is a tremendous opportunity to better the lives of tens of millions of people, and specifically the ability to improve food and energy security, production efficiencies, and environmental stewardship. As a stand-alone, each of these elements is deeply significant, but when combined together, this is a moment to address far-reaching global security challenges, and there must be a plan to build partnerships, develop consensus, and ensure transparency at the state, federal, and international levels," stated Lewis. "For over three decades, my family and I have dedicated ourselves to our great country, and the driving force of my military and professional experience has been the oath I have taken. I view this new role at Novaphos as an extension of our service. Novaphos has undertaken this consequential project for the right reasons and goals, and I am proud to now be a part of this great team."

This announcement is the second of significant senior additions to the Novaphos team in the last few months. The company previously announced the appointment of Evgeny Fedoseev as its Chief Operating Officer, who served in the same capacity for the fertilizer division at EuroChem Group and is an internationally recognized operations leader with deep experience in engineering and managing the construction, modernization, and operation of plants that have produced compounds such as ammonia, methanol, phosphoric acid, and their derived products. ■



Special focus

LATIN AMERICA ›

A profile of fertilizer logistics in Brazil

Written by

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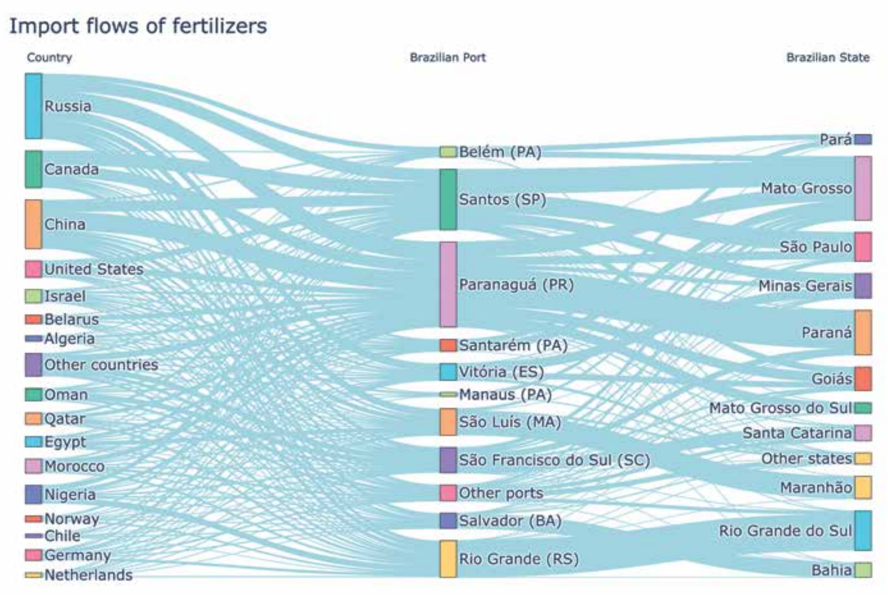
Brazil, a significant global player in agribusiness, stands out as an exporter of various products. However, it relies heavily on the international fertilizer market and is one of the largest importers. For instance, in 2022, Brazil imported about 38 mn t of fertilizers, while its national production was approximately 7.4 mn t.

Figure 1 illustrates the import flows of fertilizers from supplying countries to Brazil, passing through Brazilian ports to the consuming states in 2022. The six leading suppliers account for 61% of Brazilian imports. Specifically, the most prominent suppliers are Russia (21%), China (16%), Canada (12%), Nigeria (6%), and the United States (6%). The five states that import the most fertilizers, representing 65% of the national total, are Mato Grosso (20%), Paraná (14%), Rio Grande do Sul (13%), São Paulo (10%), and Minas Gerais (8%). It is important to note that the largest importing states are not always the largest consumers due to the significant role of the blending industries in the final product formulation. The five main import ports, responsible for 77% of fertilizer imports, are Paranaguá (28%), Santos (20%), Rio Grande (12%), São Luís (9%), and São Francisco do Sul (8%).

Brazil, a country of continental dimensions, relies predominantly on road transport for its large agricultural production, especially for exports involving long distances. This characteristic impacts the logistics of fertilizers - shippers and carriers view fertilizers as return loads. It is common in the country for trucks carrying grains to the export ports to seek opportunities with cargoes returning to their region of origin. The longer the route distance, the greater the transporter's interest

Figure 1. Logistical flows of fertilizer imports from countries, Brazilian ports and Brazilian states



Source: ESALQ-LOG (2023)

Figure 2. Logistic Indicators of fertilizers in Brazil

Source: ESALQ-LOG and SIFRECA (2023)

Brazil, a country of continental dimensions, relies predominantly on road transport for its large agricultural production

in finding return loads. Notably, due to the country's grain exports exceeding fertilizer imports, there is an oversupply of trucks in port regions, contributing to a reduction in fertilizer freight costs – which can be around 20-40% cheaper than the main outbound freight. In general terms, in 2022, Brazil exported about 140 mn t of grains and derivatives (55% of this volume was soybeans, 30% corn, and 14% soybean meal) and imported 38 mn t. Therefore, a ratio of 3.71 t of grains and derivatives were exported for every 1 t of fertilizer imported.

Figure 2 presents a series of indicators to demonstrate the profile of fertilizer logistics in the country.

Growth of logistics corridors

In 2010, Brazil imported around 15 mn t of fertilizers, and the national industry produced 9 mn t, making up a supply of 24 mn t (and a 62% dependence on imports). From 2019, the country drastically increased its dependence on imports to meet its

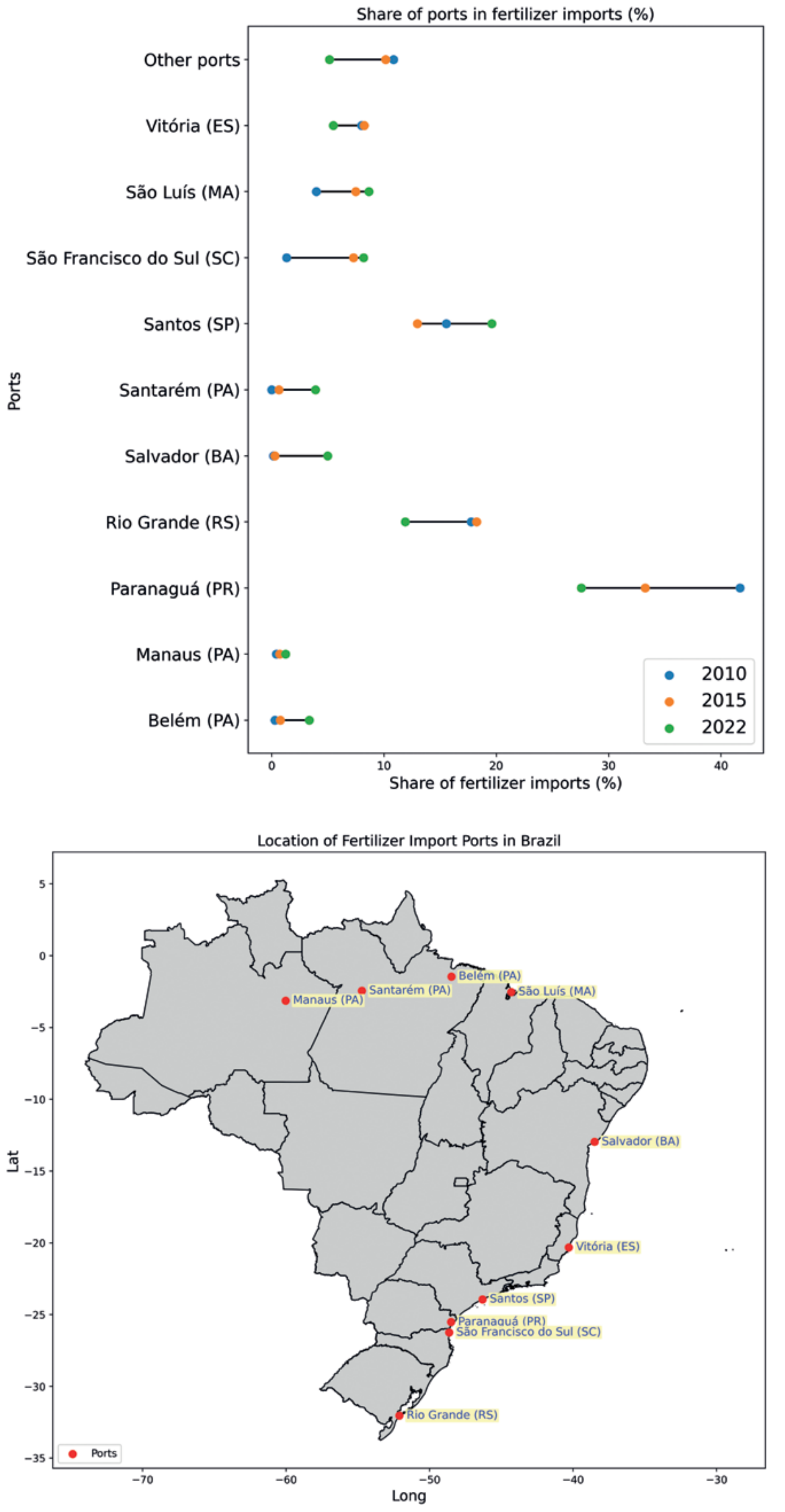
Brazil has seen significant changes in logistics infrastructure

input demand, exceeding 80%, until reaching a peak in 2021, with 86% of imports relative to the total consumed. This effect was derived from two major drivers: (i) increased demand from the international market for Brazilian agricultural products, fostering national fertilizer demand. And (ii) a drop in national supply by Brazilian industries; for instance, in 2022, national production was at 7.5 mn t, a 20% decrease compared with 2010. Such information can be observed in figure 2 in the indicator "Evolution of fertilizer demand and the share of imports."

Brazil has undergone significant changes in logistics infrastructure over the last decade, particularly involving the expansion of rail and waterway transport and the growth of new logistics corridors for export and import, primarily to support the significant growth of the country's grain exports. However, recent changes in logistics infrastructure have not reduced the logistical cost of supplying fertilizers in the country and have not resulted in an effective difference in the mode of transport. In 2010, for example, 80% of fertilizer movements in the country occurred by trucks and 20% by railways. In 2022, 86% of movements occurred by trucks, 13% by railways, and 1% by cabotage and waterways (as visualized in the figure 2 indicator "Fertilizer Modal-Share in Brazil"). In other words, Brazil has increased its dependence on trucks in fertilizer logistics.

Reflection of such change can be observed in the country's road freight prices (see figure 2 indicator "ESALQ-

Figure 3. Share of ports in fertilizer imports



Source: ESALQ-LOG (2023)

Rail movements of fertilizers in the country from 2010 to 2022 increased by 23%

LOG Fertilizer Truck Freight Index"), which shows a 21% increase in the ESALQ-LOG Group's fertilizer road freight price index in 2022 compared with 2010, for a deflated series. The freight price indicator (USD per 100 ton-kilometre) represents the average freight price of the sixteen highest volume road routes, with their weightings. In real terms, Brazil has recently presented record prices for fertilizer freight, mainly due to increased fuel prices and transport demand, derived from increased fertilizer consumption and imports. The country's fuel price follows international market parity pricing and depends on the exchange rate's effect. The average transport distance for fertilizers in the country is 800 kilometres. Hence, significant fuel price increases greatly impact the truck transport cost structure, which is a vehicle of low energy efficiency. The truck freight price for fertilizer is quite seasonal. Typically, freight price peaks occur during the periods of highest fertilizer importation - in the months of September and October. The dips in freight prices happen between the months of February and April, which are times of significant grain exportation. Exceptions may occur in the event of crop failures.

Regulatory changes

Rail movements of fertilizers in the country from 2010 to 2022 increased by 23%, reaching 6 mn t. However, this increase was not sufficient to significantly reduce the dependence on road transport due to the demand for fertilizers in the country having increased by more than 80%. In 2010, rail movement represented around 32% of the total imported fertilizers, and this ratio had halved by 2022.

Meanwhile, the port sector has undergone significant changes in the last decade that have led to a reduction in the concentration of fertilizer import ports, with new logistics corridors. In 2013, a regulatory change in the country allowed for the creation of private port terminals for service provision without the need to operate its own cargo. Such measures brought investments that propelled a diversification of corridors, mainly in the country's northern region. The ports of Manaus (AM), Santarém (PA), Belém (PA), São Luís (MA), and Salvador (BA) make up the so-called Brazilian Northern Arc (see the location in figure 3). In 2010, for example, fertilizer imports at these ports represented 4.8% and increased to 22% in 2022 (see the annual evolution in the indicator "Northern Arc share in imports" in figure 2).

The detailed temporal cuts of 2010, 2015, and 2022 of the market share of fertilizer imports by ports can be visualized in figure 3. The ports that gained the most market share in the period were Salvador (increasing from 0.2% in 2010 to 5% in 2022), Belém (increasing from 0.2% to 3.3%), São Francisco do Sul (increasing from 1.3% to 8.1%), and São Luís (increasing from 4% to 8.6%). On the other hand, Paranaguá lost market share from 41% to 28%, although it continues in a hegemonic position. Rio Grande port also decreased from 17.7% to 12% during the same period.

Santos success

An important detail is that unlike its larger peers, the port of Santos did not lose share; on the contrary, it gained a 4-percentage point share.

Several reasons can explain this fact:

(i) The port received a new terminal that imports fertilizers and connects directly to the railway
(ii) New railway terminals began to receive fertilizers from Santos
(iii) There is a park of fertilizer mixers near Santos, which increased imports due to the increased demand for fertilizers during the period

Improving logistics in the country is fundamental for the sustainable growth of the Brazilian economy, particularly the agricultural sector. The country has continuously increased agricultural production as well as demand for inputs, such as fertilizers. Between 2010-2022, many changes in transport and port infrastructure reflected changes in fertilizer logistics. However, these were required to reduce the overall logistical costs. In terms of trends, growth in fertilizer imports through the Brazilian Northern-Arc region is expected for the coming years. Several important railway projects can also be built to increase the competitiveness of Brazilian logistics for fertilizer importation.

Recently, Brazil has created a new opportunity: the construction of railways by authorization (private railways), which could usher in a cycle of investments for the sector. Additionally, there are several promising projects for federal government concessions that could contribute to enhancing economic and environmental sustainability – and better efficiency in logistics contributes to better food security.

Reference notes:
ESALQ-LOG – Group of research and extension in agro-industrial logistics.
SIFRECA – Freight information system. ■

Argentina: Fertilizer demand and El Niño

Written by

Dr. Marcos Gallacher, *Professor of Economics and Organizations,* ***University of CEMA, Argentina***

The importance of the El Niño Southern Oscillation (ENSO) phenomenon has long been recognized. As a result, a substantial amount of information has been produced regarding the impact of changes in temperatures in the Southern Pacific Ocean on weather-related variables.

Rainfall, in particular, is of importance for the extensive agricultural producing areas of the American continent, southeast Asia and Australia. In relation to the impact of ENSO on South America, three different cycles are identified: “Niño” (above-average rainfall years), “Niña” (below-average) and “Neutral” (no impact). ENSO impacts not only crop output but also worldwide commodity prices. The linkages of ENSO to farmer decision-making are thus both complex and important aspects to be studied.

This article focuses on Argentina, specifically on the demand for fertilizers influenced by the occurrence of ENSO events. The key point is as follows: from the farmer’s perspective, fertilizer use constitutes a significant investment. Moreover, this investment is 'ploughed under', resulting in returns contingent upon factors beyond the farmer’s control, particularly those linked to climate variability. This prompts the following questions: To what extent does climate variability influence fertilizer-use decisions? What decision-making processes do farmers employ to adapt fertilizer use to unpredictable climate shocks? How can the risk associated with investing in fertilizers be mitigated?

Errors in fertilizer use decision-making

The most important crops grown in Argentina (corn, wheat, soybeans, sunflower and grain sorghum) are produced under rain-fed conditions, irrigation accounts for less than 5% of the total planted area. The main producing area (the “Pradera Pampeana”, or Pampean Prairie) is comparable to the main producing areas of the U.S., in particular the corn and wheat producing areas of the Mid-West. Generally favourable weather conditions prevail, but variations in rainfall and temperatures result in significant year-to-year changes in crop yields.

Table 1 presents a crude overview of crop variability patterns in two important production areas of the country. A four-decade series (1980-2023) was used for calculations. Production shortfalls are calculated in percentage terms, with the yield in a given year divided by the average of the previous three-year yields. This metric therefore represents the “negative surprise” a producer may experience. As shown, yield shortfalls of 10% or more can be expected in 10% of the years in Area 1, and 12% in Area 2. Shortfalls greater than 20% occur approximately with a 3% probability in Area 1, but with 8% probability in Area 2. The largest three shortfalls range from 25-42% in Area 1, and 35-70% in Area 2.

Two additional points are worth mentioning. First, production variability faced by individual producers is significantly greater than those reported above: these are calculated from aggregate data and not individual farms (“Law of Large Numbers”). Secondly, production shortfalls associated with the 'risk' in using fertilizers result from the expectation that the response to this

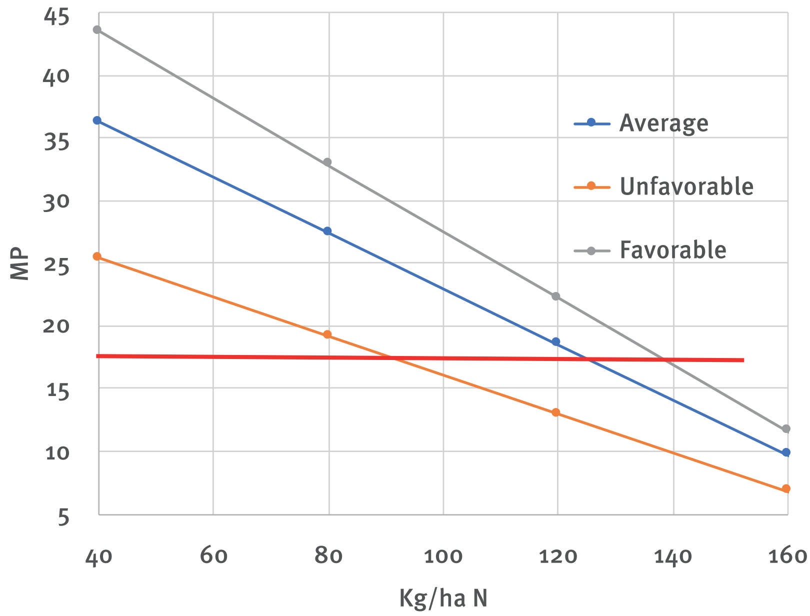
Table 1. Argentina: Production variability

Yield Shortfall (%)	Area 1 (Province of Buenos Aires)	Area 2 (Province of Córdoba)
Greater than 10 %	10 % of years	12 % of years
Greater than 20 %	3 % of years	8 % of years
Three largest shortfalls (range)	25 – 42 %	41 – 70 %
Years with “optimum” conditions	17 %	27 %

Source: Authors calculations based on MINAGRI data input will be lower in years of shortfall compared to those experiencing 'normal' conditions. The farmer with access to a "perfect prediction" of climate conditions, would adjust fertilizer use accordingly, decreasing dosage in years with "water stress" conditions while increasing use in years with optimum conditions.

In summary, when planning fertilizer use based on the expectation of 'average' conditions, errors can manifest in two ways: (i) overuse if climate is unfavourable, and (ii) underuse if the opposite occurs. Both of these errors result in costs: the first excess expenses in fertilizers, the second opportunity loss due to lower than optimum crop output.

Chart 1. Fertilizer Marginal Productivity (MP)



Source: Adapted from a production function reported in Fernando O.García "Criterios para la fertilización en el cultivo de maíz" (Maíz 2005 meeting, Córdoba)

ENSO forecasts and farmer adaptation

The recent severe drought (2022/23) that affected Argentine agriculture emphasizes the crucial need for an enhanced understanding of climate variability and its interactions with farmer decision-making. During this crop year, the output of principal crops was approximately half of the preceding three-year average due to the presence of an ENSO 'Niña' cycle. Consequently, fertilizer use was impacted: the total demand for the 2022/23 crop year was 17% lower than the previous year; however, when compared to the expected fertilizer trend, the reduction was likely in the range of 20-25%.

While the 2022/23 drought was extreme, it was not the sole period of significant yield shortfalls. Over the last two decades, Argentina experienced at least one additional severe drought event on a nationwide scale.

The timing of a drought's onset is crucial concerning demand. In Argentina's 2022/23 crop year, the early identification of drought conditions in fall, persisting through winter and summer, led to fewer 'errors' in fertilizer use compared with what might have occurred if a severe drought had started in spring, after crucial decisions related to fertilizer use were made. During the 2022/23 crop year, farmers were forewarned about challenging conditions on the horizon and adjusted input levels accordingly.

In Argentina, summer crops - especially corn and to a lesser extent soybean - are particularly sensitive to rainfall variability. Climate forecasts can be beneficial if they prompt changes in crop mix (e.g. increasing land allocation from summer to winter crops), altering planting schedules (shifting from early- to late-season corn), or adjusting input levels or the timing of applications (e.g. fertilizer). Analysis of ENSO patterns enables forecasts, albeit with a margin of error.

For illustrative purposes, a simple example of the impact of climate variability on fertilizer use is shown in chart 1. The X-axis depicts nitrogen use, the Y-axis reporting marginal productivity of the added nitrogen (extra kg of corn per kg of nitrogen). The three curves depict expected productivity under three climate conditions: 'favourable,' 'average,' and 'unfavourable.' The 'favourable' and 'unfavourable' scenarios were simulated by respectively increasing or decreasing the average productivity of the 'average' scenario by 30%. This represents substantial variability concerning 'average' production conditions.

The horizontal (red) line represents the nitrogen/corn price ratio perceived by the farmer. It is calculated dividing the price of nitrogen by the price of corn (including transport and application costs for fertilizer, and harvest plus marketing costs for corn). A 30% "required" rate of return in investment (or risk premium) is also included in the input/output price ratio. For profit-maximizing, marginal productivity should be equated with the nitrogen/cost price ratio. Optimum fertilizer use ranges from 93kg/ha under "unfavourable"

Climate variability – probably enhanced by climate change – is an extremely important aspect of dryland agricultural production

conditions, to 144 kg/ha if conditions are "favourable". Under "average" conditions optimum dose is 126 kg/ha.

The results in chart 1 allow a rough estimate be obtained on the value of growing-season climate forecasts (e.g. those resulting from the ENSO trends). Table 2 (A) shows profit levels resulting from the use of nitrogen fertilizer for a 300-hectare corn farm. "Profit" is defined here as corn output resulting from the fertilizer dose minus fertilizer cost adjusted for a risk-premium factor of 30%. In Table 2 (B) results for each fertilizer dose are shown by subtracting from the "best" profit for the given scenario the profit resulting from the dose under that scenario. A "regret" table results: how much less profit was obtained than the maximum achievable given that the given scenario occurred.

Maximum per-farm losses due to "incorrect" fertilizer dose are USD16,000 (dose 93 kg/ha), USD4,000 (dose 126 kg /ha) and USD9,000 (dose 144 kg/ha). For the conditions analysed here, it appears a priori that it is better to err on the side of higher fertilizer doses rather than lower ones. A "perfect" forecast would result in optimum dose given each of the climate scenarios. Loss as to optimum dose would therefore be zero. This result can be compared, for example, with the expected loss that would result if the farmer – in the absence of a climate prediction - used the fertilizer dose corresponding to "average" conditions. Given that losses for the "average" dose of 126 kg/ha are (USD0, USD4,000 and USD2,000, and assuming probabilities of these scenarios of 0.2, 0.4 and 0.2, a weighted average of these losses results in USD2,000 per farm.

Table 2 (A). Returns over fertilizer cost (USD '000, 300-hectare farm)

Fertilizer dose (kg/ha)	Climate		
	Average	Unfavourable	Favourable
93	307	195	419
126	312	191	433
144	310	186	435

Table 2 (B). Losses due to "wrong" fertilizer dose (USD '000, 300-hectare farm)

Fertilizer dose (kg/ha)	Climate		
	Average	Unfavourable	Favourable
93	5	0	16
126	0	4	2
144	2	9	0

Adapting behaviour

Climate variability – probably enhanced by climate change – is an extremely important aspect of dryland agricultural production. We have discussed here some aspects related to the potential impacts of the ENSO phenomenon on fertilizer use. Substantial research exists linking ENSO phases to above- and below-average rainfall conditions in the Southern American continent. Farmers can be expected to adapt behaviour in response to ENSO cycles.

The simple example provided here focuses on fertilizer use in corn (Argentina). While real-world data is utilized, the example serves only an illustrative purpose. However, certain insights can be gleaned. Firstly, in the analysed case, a high response to nitrogen fertilizer and a relatively gradual decline in response with increased dosage lead to moderate climate shocks not significantly affecting the fertilizer use decision. For Argentine farmers in these production areas and considering the doses examined, climate does not appear to severely impact the decision on fertilizer use. A different conclusion might arise in areas where climate shocks are more pronounced and/or fertilizer response is lower.

Secondly, it is anticipated that the value of ENSO forecasts will be considerably higher for the entire range of decision alternatives than for the singular 'fertilizer dose' decision analysed in this basic model. In this simplistic model, a 'perfect' ENSO forecast results in improved decisions valued at USD2000 for a 300-hectare farm. This amount is relatively modest, especially considering the assumption of a 'no-error' forecast. ■

The potential of Brazilian agribusiness following COP 28

Written by

Deise Dallanor, *Head of Brazil and Latin America,* ***Varda, Brazil***

The 28th United Nations Climate Change Conference, held in Dubai in the United Arab Emirates, resulted in a global commitment to end the era of fossil fuels and begin a more sustainable energy transition. The assessment recognizes that global greenhouse gas emissions need to be reduced by 43% by 2030, compared to 2019 levels, to limit global warming to 1.5°C.

Brazil stands out not only because it already operates with renewable energy bases but also due to its national agri-food system and sustainable practices, such as combating deforestation, recovering degraded pastures, intercropping, and others. However, discussing climate change is impossible without addressing the impact that extreme weather has had on global agriculture. Such changes have already caused a series of losses and damages along the entire food chain, as well as social and economic harm. According to the latest Grain Crop Survey published by Conab (Brazil's National Supply Company) in November 2023, it is predicted that Brazilian grain production for 2023/24 will likely see a reduction of 4.7 mn t, representing a 1.5% decrease compared to the crop yield of 2022/23.

According to this agency, climate issues attributed to El Niño are the primary causes of the forecasted crop loss. As widely known, extreme climate phenomena such as prolonged droughts, heavy flooding, and unpredictable climate changes have become more frequent and intense worldwide due to climate change. Such severe conditions jeopardize the stability of farming systems, leading to substantial damage to food production.

Low-carbon agriculture

Prolonged droughts and high temperatures have a detrimental effect on the water availability necessary for crops to grow, resulting in significant impacts on the harvest and reduced productivity. Similarly, sudden flooding can submerge fields and affect soil quality, exacerbating the challenges that farmers already face.

In seeking alternatives to reverse this scenario, Brazil has increasingly focused its efforts on combating deforestation to promote low-carbon agriculture. Brazil ranks second among countries that reduce the most greenhouse gas emissions during crop production processes, trailing only behind Argentina. This finding stems from a study published by the Institute for Applied Economic Research (Ipea) in 2022, based on projections from the Food and Agriculture Organization of the United Nations (FAO).

According to Ipea's findings, advancements in farming technologies have helped the country maintain low emission levels while significantly increasing production. Over ten years, Brazilian agribusiness doubled its production but increased inputs by only 2.1%.

In this context, monitoring Brazil's land to identify threats to environmental protection, prevent deforestation, and, most importantly, validate, certify, and reward sustainable and effective practices already in use in the field are crucial to advancing this green agenda.

Accelerating traceability

Tracking the food production chain—from seed planting to crop transportation, storage units, and shipments at ports—is a complex task requiring collaboration among various agents and intermediaries. Certifying the sustainable origin of these products necessitates the collection and analysis of a significant amount of information. Consequently, data standardization and infrastructure are pivotal for accelerating traceability. This foundational infrastructure enables all links in the production chain to contribute crop-related data, fostering interoperability across the entire chain.

To achieve this goal, it is essential to uniquely manage each field plot by adopting a universal identifier for every planted area. This identifier would integrate all crop-related data from that field, thereby enhancing transparency throughout the entire process. Such an approach facilitates data unification and simplifies information exchange among diverse stakeholders along the supply chain.

Undoubtedly, sustainable agriculture stands as the solution to foster a nature-positive future for food production. Brazil holds the potential to shed light on this issue and spearhead initiatives aligned with the goals of COP-28. This is why it's imperative to advance the promotion of basic infrastructure, making traceability a cornerstone in protecting and restoring deforested areas, while substantiating sustainable agricultural practices. This progress will drive the development of a greener and more responsible economy. ■

Nutrient use efficiency in agricultural systems:

A Brazilian perspective

Written by

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Most Brazilian soils are deep, highly weathered, acidic, and of low natural fertility. Many strategies have been developed for building soil fertility using lime and mineral fertilizers, particularly phosphorus (P), potassium (K), and micronutrients to attain higher yields. Brazil currently uses 8% of all the fertilizer produced in the world. The country is fourth among the largest consumers, behind only China, India and the United States. However, there is a big problem: national production is minimal. More than 85% of nutrient sources are imported to meet agricultural demand.

Furthermore, the efficiency of fertilizer use is often low and nutrient inputs can represent more than 40% of the production costs of some crops.

The tremendous external dependence on the supply of nutrients makes the country's position quite fragile and heavily dependent on the national variation in input prices. Variations in prices and the uncertainty in supply have been the primary concern for Brazilian producers. Currently, Brazil finds itself in a highly complex situation where costly inputs are imported and often underutilized. Nevertheless, it's crucial to acknowledge the various methods available to enhance nutrient utilization efficiency in the agricultural field. Numerous technologies exist for producers, offering avenues to improve this aspect.

Technological innovation stands as a cornerstone for the success of Brazilian agribusiness, given that its growth has historically relied on the creation and adoption of innovative technologies. The advancements in agricultural productivity have been deeply rooted in technological innovation. Consequently, a consistent influx of technical knowledge becomes imperative for the sector's sustainability.

Below, several technological solutions are outlined, aimed at enhancing the implementation of optimal agricultural practices. These solutions can significantly contribute to achieving high yields within the framework of rational and sustainable Brazilian agriculture.

Soil analysis

Soil chemical analysis is essential to assess soil fertility. By interpreting the results, it is possible to carry out chemical soil management efficiently and economically. By integrating physical analyses such as density and soil texture with more accessible biological analyses such as enzyme activities, it becomes possible to conduct a comprehensive and highly informative assessment of soil conditions. The results of chemical analyses determine the nutrient stock and levels of growth-limiting chemical elements before planting. This enables precise recommendations for liming and fertilization, as well as ongoing monitoring and evaluation of nutrient balance in the soil.

Moreover, maintaining a balanced nutrient profile within the soil-plant system can be viewed as an indicator of the sustainability of agricultural land use. For optimal results, all recommendations regarding liming and fertilization should stem from chemical analyses performed on samples representing various production systems. This approach avoids the use of fixed amounts of limestone and fertilizer formulations, which, when applied indiscriminately, can result in imbalances, either through underdosing or excessive application.

Enhanced efficiency fertilizers (EEF)

One of the options for reducing the environmental impacts and increasing nutrient availability to crops is using nutrient sources with increased efficiency, such as enhanced efficiency fertilizers (EEFs). Examples of this include slow release and controlled release fertilizers. Both feature technologies that alter release patterns and delay the solubilization of nutrients.

Various fertilizer technologies exist to enhance efficiency, such as coatings (which involve applying a material to serve as a physical barrier around

(left) Soil liming in a crop-livestock-forest integrated system in São Carlos-SP, Brazil; *(right)* No-till corn sowing in a crop-livestock-forest integrated system in São Carlos-SP, Brazil

the fertilizer), composite fertilizers (fertilizers processed with particles within their structure), chemical surface modification (involving the mixture or deposition of molecular compounds), or interaction with biological agents. These innovative methods aim to improve nutrient utilization efficiency by minimizing losses caused by leaching (N and K), volatilization (N), denitrification (N), and fixation (P), thereby enhancing plant uptake through a gradual supply aligned with crop demand.

Ideally, the release of nutrients should be controlled and synchronized with the plant's growth rate to adequately address its changing nutritional requirements throughout the growth and production cycle.

Precision Agriculture (PA)

Research results and the practical experience of farmers have indicated that combining agronomic knowledge with digital technologies, such as precision agriculture (PA), can also help improve fertilizer use efficiency. Neglecting spatial variation within production areas can significantly impact both yield and environmental quality when managing soil fertility. Hence, understanding the spatial variability of soil chemical and physical properties becomes crucial for establishing uniform management zones. This knowledge facilitates the application of lime and fertilizers at varying rates and locations, promoting the judicious utilization of resources.

Precision agriculture (PA) begins with data collection, analysis, and interpretation to generate recommendations for field interventions and harvesting. It involves an integrated knowledge chain, combining machinery, equipment, and sensors with information technologies to support agricultural management. Thus, creating thematic maps becomes pivotal in defining highly effective management strategies, particularly in optimizing input usage.

The utilization of georeferenced soil sampling and variable-rate input applications has been prevalent in expansive production areas, notably in soybean, corn, sugar cane, and cotton crops. Results are evident across various perennial crops and pastures, showcasing the potential to map and assess the spatial variability of soil properties, subsequently recommending lime and fertilizer application based on these maps.

PA technologies play a vital role in enhancing resource efficiency by precisely applying the appropriate dosage at the right location and time.

However, for further advancements in PA, there is a need to reduce mapping costs while enhancing robustness and accuracy. Ongoing developments involve testing and employing new methods, sensors, and equipment in the field to achieve this objective. PA is increasingly driven by the rapid evolution of the Internet of Things (IoT), big data, cloud computing, and artificial intelligence (AI). These technologies, when integrated with interfaces, are expected to converge, encompassing PA within agriculture's management information systems.

Integrated systems

Conservation agriculture includes a set of management practices based on no-tillage, which means direct planting without soil harrowing or ploughing, maintaining permanent soil covered with inter-season crops, and crop diversification. Adopting these conservation practices increases the input of organic matter into the soil and changes its decomposition rates, favouring the aggregation of particles and promoting soil structure. Crop rotation and soil cover play a pivotal role in enhancing soil quality, affecting various aspects such as water infiltration and retention, temperature regulation, stimulation of biological activity, and reduction of pressure from weeds and diseases. By minimizing soil disturbance and preserving its structure, there's a notable increase in water-conducting pores. Consequently, this reversal of the erosion process leads to heightened water retention capacity and improved nutrient availability for plants. The increase in the amount of soil organic matter (SOM) also leads to higher nutrient retention, lower emissions of greenhouse gases (mainly CO_2, CH_4, and N_2O) into the atmosphere, and a reduction in global warming.

Crop-livestock and forest integrated systems (ICLF) are options for conservation agriculture, which enable the recovery of degraded pasture areas, lead to improvements in the physical, chemical, and biological properties of the soil, increase the competitiveness of rural enterprises and diversify and stabilize income on rural property. Furthermore, crop rotation with legumes contributes to biological N fixation. ■

Addressing the fertilizer industry's impact on nitrate pollution

Written by

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In the quest to balance increasing global food demand with environmental sustainability, the role of the fertilizer industry in nitrate pollution has come under scrutiny. Fertilizers provide huge benefits for agriculture, but are also known to pose significant environmental risks, and these must be balanced and properly addressed if we aim to develop sustainable solutions to these crises.

It cannot be disputed that the agricultural industry has contributed significantly to global nitrate pollution issues, the effects of which are becoming more widely seen in all sectors in a way that has made the need for a solution more urgent. The industry has a responsibility to deal with this legacy, and find ways to better optimize and monitor fertilizer use, with assistance from the latest methodological advances, to tackle the challenges of pollution.

As governments and industry stakeholders navigate these challenges, the need for sustainable and economically viable solutions becomes paramount. The interplay of technological innovation, efficient resource management, and environmental stewardship is crucial in shaping a future where food security and environmental health coexist harmoniously.

Groundwater contamination by nitrates is a major environmental challenge

How do fertilizers damage the environment?

Although fertilizers are pivotal in modern agricultural practices, they also play a significant role in environmental nitrogen pollution. The primary environmental impacts of fertilizers can be summarized into two major concerns: groundwater contamination and eutrophication of surface waters.

Groundwater contamination by nitrates is a major environmental challenge. Nitrate ranks as the second most prevalent contaminant in global water sources, preceded only by coliforms and other bacteria. This widespread contamination primarily stems from diffuse sources such as agricultural runoff, where nitrates used in farming seep into groundwater systems. Additionally, point sources like sewage treatment plants or manure waste piles significantly contribute to this problem. The infiltration of nitrate into shallow groundwaters across various regions underscores the severity of this issue, as the trend has been linked to public health concerns such as cancer and birth defects.

The second major concern involves the effect of fertilizers on surface waters, including rivers and lakes. Nitrate, being a nutrient, is rapidly assimilated by aquatic plants and algae. Excessive fertilizer runoff into these water bodies can trigger overstimulation of algae and plant growth, a phenomenon known as cultural eutrophication. This process can lead to significant ecological disruptions, and potentially cause toxic blue-green algal blooms and the accumulation of organic matter at the bottoms of lakes and ponds. In turn, this results in rapid decomposition and leads to anoxic conditions, killing fish and causing a drastic reduction in aquatic biodiversity.

Both groundwater contamination and eutrophication of surface waters have far-reaching and lasting impacts on the environment, which is why many governments are taking action. In 2023, the UK government outlined an Environmental Improvement Plan, setting binding targets to reduce nitrogen, phosphorus and sediment pollution in water from agricultural sources by at least 10% by 2028, and by 40% by 2038; similarly, the Netherlands has set a target of a 70% reduction in nitrogen pollution by 2030.

Rising global demand for fertilizer is leading to a growing environmental impact, particularly in terms of nitrate pollution of water

The growing impact of fertilizer production

Any efforts to tackle this problem will be challenging due to the evolution of fertilizer production in agricultural practices over the last half-century. This development can be traced back to the early 20th century, with the discovery of the Haber-Bosch process. This groundbreaking method enabled the synthesis of inorganic nitrate fertilizers from atmospheric air, revolutionizing agriculture by reacting air with methane derived from fossil fuels to produce ammonium fertilizers.

Before this era, agriculture predominantly relied on manure, which lacks the potency of concentrated inorganic fertilizers. As such, this innovation catalyzed an agricultural revolution, with the increasing global population necessitating a surge in food production, and therefore an escalated use of fertilizers.

The impact of this shift became increasingly apparent in the latter half of the 20th century. The widespread application of fertilizers, beginning in the 1950s and 1960s, introduced large quantities of these substances into the landscape. Over time, a significant portion of these fertilizers seeped into waterways and groundwater systems, leading to an insidious form of pollution.

One of the most daunting aspects of this issue lies in the treatment of contaminated groundwater. Groundwater, characterized by long residence times that range from decades to millennia, becomes virtually impossible to clean once polluted. Natural remediation processes, such as denitrification, are rare and insufficient to counteract the extensive pollution.

As a result, many shallow groundwater systems are now heavily contaminated with nitrate, a pollutant with limited treatment options. The most effective method, reverse osmosis, remains economically unfeasible for widespread application. Consequently, contaminated groundwater often makes its way into municipal supply systems, presenting a significant challenge for water quality management.

As the world's population continues to grow, the demand for food and consequently, fertilizers, also increases. As such, the need for sustainable practices and innovative solutions in fertilizer production and agricultural management has never been more pronounced.

What can be done to address these pollution trends?

Improving the efficiency of fertilizer use is crucial in the context of global agriculture, especially considering that approximately half of the fertilizers applied worldwide are lost. This inefficiency not only represents a substantial economic cost, but also contributes significantly to environmental issues. There are several strategies and techniques that can be employed to optimize fertilizer use, each with varying applicability depending on the agricultural context and resources available.

One such technique is drip fertigation. This method involves running small tubes through fields, particularly effective in certain fruit crops, to deliver a precise amount of water mixed with fertilizer directly to the root zone of plants. Drip fertigation is a significant advancement in efficiency over traditional methods like broadcasting manure or granular fertilizer, which often result in a considerable portion of the fertilizer being applied to non-target areas like crop rows, where it benefits weeds or grasses rather than the intended crops.

By localizing fertilizer application to the root zone, drip fertigation not only reduces the amount of fertilizer needed but also enhances its effectiveness. This targeted approach minimizes waste and ensures that the nutrients are delivered precisely where they are most beneficial for plant growth.

Combining efficient nutrient delivery with optimized water usage is a primary goal in agricultural management, even beyond the direct benefits to plant nutrition. Reducing both fertilizer and water use not only cuts costs, but also lessens the environmental impact of farming practices.

However, the feasibility of these advanced techniques varies significantly across different regions of the world. While wealthier countries may have the resources to implement such efficient systems, developing countries often face constraints due to the high costs associated with advanced technologies. In these regions, farmers may have to rely on more traditional, less efficient methods such as spreading manure or using lower-cost fertilizers.

The challenge, therefore, lies in finding and implementing strategies that are both economically viable and environmentally sustainable across diverse agricultural contexts. This requires a multifaceted approach, with a combination of technological innovation, education in best practices, and investment in infrastructure to support more efficient fertilizer usage worldwide.

Stable isotope analysis can be used to identify nitrate sources in water samples, making it easier to identify pollution sources and develop solutions

The role of stable isotope analysis in addressing nitrate pollution

Another crucial tool for tackling nitrate pollution associated with fertilizers is stable isotope analysis, which has emerged as a pivotal tool in identifying the sources of nitrate in water samples.

This analytical method makes it easier to determine where pollution is coming from, thereby facilitating the implementation of solutions and potentially informing regulatory penalties. It has long been recognized by researchers for its value in monitoring environmental pollutants, but traditional methods have presented several challenges that hindered consistent access to this vital data.

Historically, determining the rise in nitrate levels in watercourses was complex due to the natural occurrence and the number of potential pollution sources of nitrate, including sewage, wastewater treatment and emissions from combustion engines, in addition to fertilizer runoff. The most prevalent method for stable isotope analysis involved using specific bacterial strains to convert nitrate samples into nitrous oxide (N_2O), a process demanding a combination of specialized skills and resources that made it both costly and time-consuming. An alternative method employed toxic chemicals such as cadmium and sodium azide, necessitating stringent safety procedures and specialized equipment available to only a few laboratories worldwide.

In 2019, a breakthrough was achieved by Dr Leonard Wassenaar and Dr Mark Altabet, who introduced a new, more accessible method for stable isotope analysis of dissolved nitrate. This method uses affordable titanium (III) chloride to convert samples, and has been shown to be highly cost-effective, while simplifying sample preparation, and utilizing commonly available laboratory equipment and materials. This innovation holds the potential for widespread adoption in laboratories globally.

Dr Wassenaar explained to Elementar: “With the titanium technique, you only use microliters of titanium, meaning the materials cost is less than USD6 per sample, compared to over USD100 for the microbial and cadmium techniques. That opens up a completely new horizon. Now you can start to think about collecting 250 samples from a single watershed, instead of only 10, or do a more frequent seasonal analysis.”

With the increased availability of stable isotope analysis, more laboratories worldwide are expected to develop the capacity for this testing. This advancement presents an opportunity for the fertilizer industry to help to combat nitrate pollution. Insights from isotope analysis can aid in incorporating nitrification inhibitors into fertilizers and monitoring their effectiveness.

Dr Wassenaar also envisions integrating stable isotope analysis into national water monitoring programmes, offering a comprehensive understanding of nitrate sources and their transformation in various water systems. Such integration could significantly enhance governmental oversight over fertilizer usage and its environmental impacts.

While the context-specific solutions to nitrate pollution will vary, the role of stable isotope analysis in informing and guiding these solutions is indisputable. Only by making use of all the available tools will the agricultural sector succeed in maximising the upsides of fertilizers while keeping the environmental impact to a minimum. ■

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Daily Fertilizer Price Assessments

Nitrogen

- **Prilled:**
  - China fob
- **Granular:**
  - Egypt fob
  - Brazil cfr
  - Nola (US Gulf) fob $/st

Ammonia

- East Asia cfr *(excluding Taiwan)*
- Middle East fob

Phosphates

- DAP fob China
- DAP cfr India
- MAP cfr Brazil
- DAP barges fob Nola
- MAP barges fob Nola

Sulphur

- China cfr granular $/t
- China domestic (ex works) Yn/t

Work smarter with groundbreaking daily fertilizer price assessments from Argus

Argus daily price assessments provide you with unique benefits, including

Greater certainty

Increased price frequency gives you immediate clarity for volatile markets.

Lower risk

Additional data points ensure your business calculations are more robust.

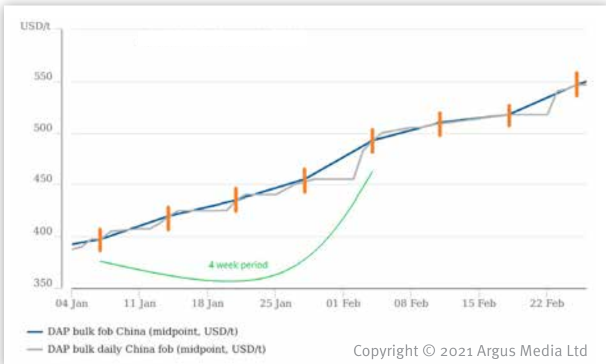
Smarter outcomes

Daily data powers the most sophisticated data analysis and algorithmic trading tools.

Increased confidence

Access editorial staff in key global fertilizer hubs: Widest geographical reach and rigorous methodological adherence.

Sharp price action captured earlier with daily assessment



Over the highlighted 4 week period (7 Jan to 4 Feb 2021) the price of DAP fob China grew from $397.50/t to $492.50/t, an increase of 24%. The blue line on the graph, marked by the 5 weekly prices over this period (orange) clearly highlights this price growth. However, the 21 daily prices over this same period (grey line) provide greater detail on how this price growth was achieved.

For more information please contact us: fertilizer-m@argusmedia.com www.argusmedia.com/fertilizer

Market Reporting
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Fertilizer
illuminating the markets

Real-time measure of soil health on your smart phone

Written by

Rachel Holdsworth, *Director,* ***Holdsworth Associates, UK***

Real-time measurement of nitrogen under a growing crop could provide invaluable information about bioavailability of this nutrient. This was one of a number of emerging approaches for measuring soil health discussed at the recent Agri-TechE REAP conference.

The important synergistic role of the soil microbiome on crop nutrition, and the impact of the roots of cover crops and legumes on nitrate levels, is being increasingly recognised by researchers. But monitoring and measuring soil dynamics in the field, in real-time, is still problematic.

Three different approaches were presented at REAP:

1. PlentySense uses solid-state sensors to provide insights into nutrient cycling
2. University of Warwick's approach uses bioacoustics to assess the sound of soil life
3. PES Technologies method uses an electronic nose to identify the soil fingerprint

Optimising soil biological processes

The rhizosphere is the region where plant roots influence the biological, chemical, and physical features of the soil. Roots exude sugars to feed a network of fungi and other microbes that in turn scavenge mineral nutrients such as nitrates and phosphates from the soil water and make this accessible for the plant. The microbial action also improves the soil health and water-holding capacity.

Monitoring soil dynamics in the field, in real-time, is problematic

Researchers have found over 15,000 microbial species in the rhizosphere and they are looking at how compounds produced by roots can shape the composition and functions of these communities.

The aim of the WISH-ROOTS project is to identify root traits that can improve soil structure and optimise soil biological processes. It was while working on this project that Professor Tony Miller of the John Innes Centre, an expert in ion-selective membranes, realised that the technology he was using to measure nitrates in the cells of the plants could also be used in the soil.

Nitrogen (N) is present in the soil in different forms, but it is nitrates dissolved in soil water that are most available to the crop. So, Prof Miller and his team designed sensors using screen printed electrodes combined with an ion-selective membrane. This enables precise measurement of the activity of a given ion, in an aqueous solution containing many ions.

He explains: "We found it was difficult to gain measurements of nitrate in the soil, so we designed the sensors to give us accurate information. The initial studies were in soil columns and provided proof of concept, we then moved to field trials with Agrii."

Prof. Miller explains that to improve efficiency it is important to know how N is being cycled in the soil. "Traditional soil testing requires removing a core of soil for mineral analysis in a laboratory, but this can impact the soil structure and characteristics.

"By reviewing the real-time usage of nitrates under a growing crop, combined with environmental measurements such as soil moisture, we are gaining valuable information about the dynamic system that can be used by farmers and agronomists to inform their decision-making."

Improved decision-making

The sensors can measure the amount of nitrate taken up by the crop and the reserve available in the soil, thereby optimising fertilizer usage.

In 2023 the team studied bioavailable nitrate under commercial wheat, potato, and onion crops and gained some interesting results.

It is thought that around 50% of nitrogen applied to crops is not taken up and can leach into the environment before crop roots can acquire it. This is particularly problematic if there is rain after fertilizer is applied.

However, in Prof. Miller's trials there was evidence that even after heavy rain, the nitrate remained in the soil, showing that a second application was not always required.

The sensors are deployed in sets of three, at 10/20/40 cm depths, to measure nitrate levels through the soil profile. Wheat has deep roots so nitrates washed down and stored at lower levels can be used later in the year.

Additionally, the research showed that N stored in the plant's lower leaves is mobilised later in the season and moves to the wheat ear. This negates the need for a later N application to increase the protein value of the grain.

Reusable sensors offer real-time information

The sensors can be positioned across the field at the start of the season using the farmer's yield maps, which can indicate where more information would be valuable. They communicate across a LoRaWan (Low Power Wide Area Network) providing data in real-time, direct to the farmer's phone throughout the growing season. The sensors are also reusable for further seasons.

Nicole Sadd (Rothamsted Enterprises) *(centre)* with the presenters from the REAP 2023 Start-Up Showcase *(left-right)*: Robyn Sands (Autopickr), Nima Eskandari (Agtelligence), Martin Stocks (HotHouse Therapeutics), Tony Miller (PlentySense), Matthew Dobbs (HerdVision) and Jim Bailey (PES Technologies) (not pictured is Cian Duggan from Resurrect Bio, who appeared via video). *Photo credit: Agri-TechE / StillVision Photography*

Presenters at REAP 22023: *(top left)* Jackie Stroud discusses her research; *(top right)* Tony Miller from PlentySense; *(bottom left)* Jim Bailey from PES Technologies; *(bottom right)* Jackie Stroud. *Photo credits: Agri-TechE / StillVision Photography*

(left) PlentySense Trials 2023, *Photo credit: PlentySense*; *(right)* PES Technologies' 'electronic nose', *Photo credit: PES Technologies*

He says that the sensors give early actionable insights: "If aerial or satellite imaging used to measure the health of the crop indicates a yellowing of the leaves, then it is too late – yield has already been affected.

"Our sensors enable action to be taken that will ensure that the plant has the right amount of nutrition throughout the year without waste or yield penalty; this will have a huge financial and environmental benefit."

The first sensors from spinout PlentySense are designed to measure nitrate, but the team is working on adjusting the sensor chemistry to quantity other nutrients, including potassium (K) and phosphate (P).

Listening to soil life

Soil fauna also has an impact on soil health and cultivation impacts below-ground biodiversity, but measuring soil animals is very challenging. Soil scientist Jackie Stroud, from the University of Warwick, is working on a new strategy.

She explains that "earthworms and mesofauna make sounds which can be detected. The initial data suggests that a noisy soil is a healthy soil, and this could be used as a measure of ecosystem health."

The team are developing prototypes of hand-held soil acoustic probes to generate an acoustic library to help to interpret soil noise.

Sniffing out soil health

An alternative method for monitoring organic content in the soil is an 'electronic nose' being developed by PES Technologies to sniff out soil health. It aims to deliver results to a farmer's phone in five minutes.

Microbes are essential for making nutrients available to plants, but current biological lab tests are expensive and take ten weeks to provide results. The company creates an aroma fingerprint from gas released by microbes in the soil to indicate the amount of organic matter in the soil.

CTO Jim Bailey says "Our machine learning algorithm has been trained using soils of various types from across the UK, and results provide soil quality indicators for the specific soil sample. The whole process, from loading the soil sample to receiving results to your phone takes a little over five minutes."

Informing precision agriculture

Dr Belinda Clarke of Agri-TechE curated the technologies at REAP; she says optimising conditions on the seedbed are vital for the establishment of the crop and can determine of future yield.

"With precision agriculture it is increasingly possible to target fertilizer or seed rate according to the conditions, but the farmer has a small window of opportunity to do this, and soil composition and health can vary across the field.

"This new generation of real-time soil quality sensors will not only provide the information required to inform these decisions, but also provide invaluable insights into how the nutrients are being used within the soil ecosystem. This could be a game-changer." ■

About Agri-TechE
Agri-TechE is a business focused membership organisation that supports the growth of a world-leading network of innovative farmers, producers, scientists, technologists, and entrepreneurs who share a vision of increasing the productivity, profitability, and sustainability of agriculture. *For more information:*

Agri-TechE: agri-tech-e.co.uk *WISH-ROOTS project: jic.ac.uk/wish-roots-wheat-roots-in-soil-health/*
PlentySense: plentysense.io *PES Technologies: pestechnologies.com* *REAP Report: reapconference.co.uk*

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Fertilizer
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Conference preview:

Argus Fertilizer Africa

19-21 February 2024 • Movenpick Marrakech, Marrakech, Morocco

The African fertilizer market's key industry meeting point for trade and insight returns to Morocco.

The Argus Fertilizer Africa Conference is returning to Morocco, the continent's top fertilizer producing country, for the first time since 2018.

The conference will gather delegates from across Africa, along with international suppliers, service providers and investors. All participants will meet, discuss and sign deals with the purpose of strengthening domestic production, improving trade through investment, and digitalisation and helping the African fertilizer market thrive.

Networking opportunities:

Access new customers and suppliers across the African fertilizer supply chain

All sections of the African fertilizer supply chain, from across the continent, will be represented at the conference. The event is structured to enable you to target those individuals that are most relevant to you and your business.

NEW African regional market meet-ups:

A more efficient way to network
Tuesday 20 February 12:15-13:30

Navigate the vast and varied continent of Africa through our new African regional market meet-ups. This feature will break the continent into north, south, east and west, with content and networking tailored to each region. Participants will be able to focus their attention and time on the regions that really matter to their business in an efficient learning and networking format.

Conference networking platform:

Access five weeks before the event

The conference networking platform enables you to identify, communicate with and meet your high-priority targets from the delegate list in the most efficient way possible. Gain access to the conference networking app

Categories include:

- Woman of the year in fertilizers award
- Africa First: Outstanding contribution to food security award
- Made in Africa: SME business award
- The last mile: African supply chain integrity award
- Agri-tech innovator of the year award

before the conference begins, so you can start setting up meetings with other participants and plan your schedule across the three days.

Exhibition and networking zones

Our fully integrated exhibition hall and networking zones are designed to maximise your meeting opportunities in a range of different formats, whether organic or prearranged. The conference has been designed to ensure your networking experience is as smooth and as comfortable as possible, with plenty of areas set aside for you to host meetings with clients, as well as various networking zones offering different amenities.

To find out how a tailored sponsorship package could meet your business objectives, please contact:

George Ade-onojobi
Direct: ***+86 13 2627 83062***
Email: ***sponsorship@argusmedia.com***

2024 Agenda:

Written in collaboration with the industry, for the industry
Specific national, regional and continental-level discussions will enable you to tailor your company strategy for the African continent, wherever you operate.

Standout themes include:

Tuesday, 20 February
- The Sustain Africa Programme's market resilience initiatives supporting food security and affordability.
- Investment and port infrastructure as the solution to long-term trade efficiency.
- Digitalisation of trade as a connector of African markets.

Wednesday, 21 February
- How is Africa building resilient phosphates value chain?
- Creating customizable crop programmes to cater to specific soil types and regions.
- Traceability and certification as an enabler of inter-African trade.

Argus Fertilizer Africa Awards:

Celebrating achievements in the industry
Tuesday 20 February 16:45-18:30
Celebrate the outstanding achievements and innovations of your peers and clients across the African fertilizer industry at the Argus Fertilizer Africa Awards. A panel of industry leaders and pioneers will vote on all nominations to recognise who is driving access, affordability and sustainability in the African fertilizer industry.

Get involved in the leading African fertilizer trading event

Registration enquiries: ***Zubair Kahn***
Direct: ***+44 208 158 8888***
Email: ***zubair.khan@argusmedia.com***

Sponsorship and exhibition enquiries: ***George Ade-onojobi***
Direct: ***+86 13 2627 83062***
Email: ***sponsorship@argusmedia.com*** ■

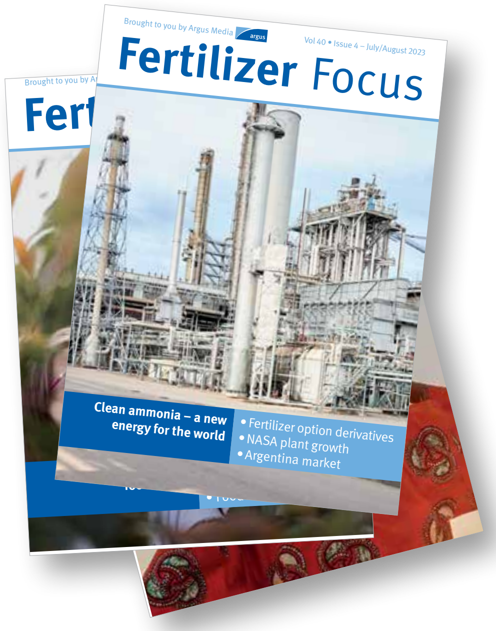
Fertilizer Focus

Media pack 2024

Fertilizer Focus heritage

Argus produces the most comprehensive suite of pricing and market intelligence services available to the fertilizer industry

First published in February 1984 by FMB Consultants, Argus' Fertilizer Focus is the world's leading bi-monthly journal serving the international fertilizer industry. It covers the key developments influencing fertilizer and related markets, such as production economics, technology, plant and project news, and product logistics.



Drawing on Argus's unrivalled expertise and wealth of contacts from our market reporting, consulting and conferences, the editorial content in Fertilizer Focus covers the issues which are top-of-mind for senior executives in the industry. As an advertiser, your message reaches decision makers throughout the world and positions you as a thought-leader on the cutting edge topics which will define the future of the industry. The magazine features a unique blend of news, features, interviews and analysis of all aspects of the fertilizer industry, including:

- Spotlight on hot new trends and growth areas - including clean ammonia and low carbon/ sustainable fertilizers
- New product developments – fertilizer blends, enhanced efficiency ingredients, micronutrients, liquid fertilizers
- Fertilizer production technology across all products
- Port logistics and shipping
- Company strategy, industry developments and emerging markets
- Agronomic analysis and changes in agricultural practice impacting fertilizers

Editorial schedule

January/February issue

Advertising due date - **8 December 2023**

Special Focus - CLEAN AMMONIA

- Key global clean ammonia production hubs
- Market expansion
- Unlocking the hydrogen economy

SUPPLEMENT - LATIN AMERICA

- Infrastructure & logistics in Brazil
- Policies and regulations in Latin America
- The impact of El Nino

March/April issue

Advertising due date - **9 February 2024**

Special Focus - Added Value fertilizers

- Micronutrients as adjusters for plant growth
- Investments in biostimulants
- Adapting strategies to adopt AVFs

SUPPLEMENT - Asia

- Future growth in India
- Phosphate protectionalism policies in Asia
- Laos' emergence as a potash power in southeast Asia.
- What happened to Australia's SOP wave?

May/June issue

Advertising due date - **12 April 2024**

Special Focus - Technological advancements

- Innovations in packing and material handling
- Next generation of plant nutrition
- Digital applications for the fertilizer industry

SUPPLEMENT - AFRICA

- Infrastructure investments
- Copper demand supporting sulphur imports to S Africa
- North Africa: the new price driver for sulphur
- The growth prospects for specialty fertilizers in East Africa

July/August issue

Advertising due date - **7 July 2024**

Special Focus - The fertilizer economy

- Funding new projects
- Hedging tools to de-risk project development
- Fertilizer affordability
- Market opportunities for investors

SUPPLEMENT - Middle-East

- The changing nature of regional nitrogen investment
- Market impact from conflicts
- Rising sulphur production fin the Middle-East

September/October issue

Advertising due date - **9 August 2024**

Special Focus - Fertilizer sustainability

- Decarbonisation progression
- Sustainability investments in Africa
- Revitalizing soil fertility

SUPPLEMENT - Europe

- East Europe capacities
- Importing fertilizers
- European policy update

November/December issue

Advertising due date - **11 October 2024**

Special Focus - FEnhanced efficiency fertilizers

- Advancements for additives and coatings
- NPK processing technology
- New methods for increasing yields

SUPPLEMENT - North America

- Mexico: market overview
- Canada's rail network and the risk of bottlenecks
- Lithium and the increasing in sulphur consumption in North America
- US Inflation Reduction Act impact on nitrogen plant investments

Distribution

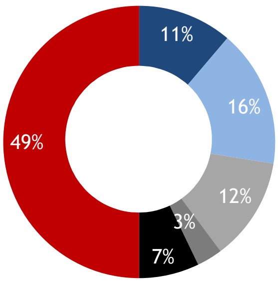
Sector leading digital and hard copy distribution

Published six times a year, the magazine is read by subscribers in over 90 countries. Fertilizer Focus has a unique, best in class distribution, benefiting from Argus' unrivaled presence in the fertilizer sector - **the digital circulation of the magazine in late 2023 was nearly 15,000 - and is growing substantially each month.** Around two thirds of our digital recipients are paying subscribers of Argus fertilizer price reporting and outlook services. This encompasses executives and decision makers in all of the major fertilizer producers, traders, importers and buyers, as well as sector focused financial institutions, shippers, engineering companies, plant contractors, government agencies and trade associations. Our key magazine features are promoted on leading social media platforms (LinkedIn, Twitter, Facebook)

Reader profile

Our unique and unrivaled circulation means your messages reach the industry's most important decision makers.

% of all Fertilizer Focus recipients with the following in their job title



- Executive, President, Director, Vice President
- Manager, Head, Consultant, Advisor
- Sales, Commercial, Marketing, Supply
- Procurement, Buyer, Purchaser, Sourcing, Business Development
- Analyst, Intelligence, Strategy, Accountant, Finance, Investor Relations, Economics
- Other

Unique event distribution

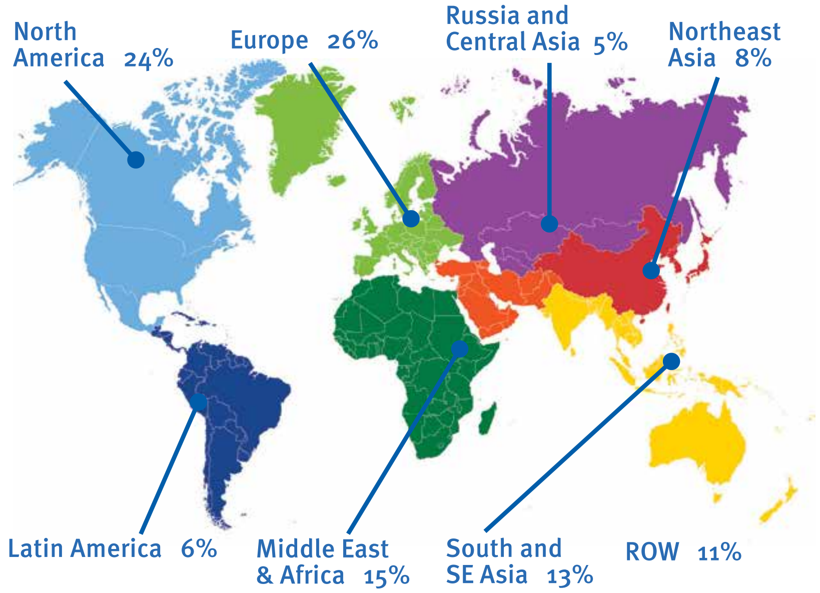
Fertilizer Focus is distributed to every one of the thousands of delegates attending Argus' fertilizer conferences around the world, and available at all of the major global and regional industry events.

Fertilizer Focus will continue to give you unrivaled events positioning. The pandemic temporarily restricted the ability of Argus and other events organizers to deliver physical events, but this is changing. Argus' industry leading conferences are returning in their traditional physical format and our magazine will be delivered to registrants at both physical and digital conferences.

Global distribution breakdown

Our geographic distribution is aligned with the broader Argus fertilizer customer base.

Regional distribution of Fertilizer Focus recipients



Argus events

- Fertilizer Latino Americano (FLA)
- Argus Asia Fertilizer
- Argus East Europe Fertilizer
- Argus Europe Fertilizer
- Argus Clean Ammonia
- Argus Vehicle Emissions and DEF Summit USA
- Argus Paris Grain Conference
- Argus Green Marine Fuels Conference

Global and regional industry events

- AFA Annual Fertilizer Forum & Exhibition, Egypt
- FAI Annual Seminar, India
- IFA Annual Conference
- IFA Crossroads
- Southwest Fertilizer, USA
- TFI Annual Meeting, USA
- TFI World Fertilizer, USA

Advertising rates 2024

Cover rates	
	USD
Outside front package	6,000
Inside front cover	3,740
Inside back cover	3,530
Outside back cover	4,080

Run of press rates	1 Issue	2 Issues (10% discount)	3 -5 Issues (20% discount)	6 Issues (30% discount)
	USD	USD	USD	USD
Double page	6,460	5,748	5,100	4,464
Full page	3,120	2,808	2,496	2,184
Half page	2,640	2,376	2,112	1,848
Third page	1,860	1,674	1,488	1,302
Quarter page	1,740	1,566	1,392	1,218

For more details or to discuss our requirements please contact
Stefan Worsley: stefan.worsley@argusmedia.com

Advertising specifications

Editorial & advertising schedule 2024	
Edition	**Due date**
January/February	8 December
March/April	9 February
Maj/June	12 April
July/August	7 July
September/October	9 August
November/December	11 October

SIZE & POSITION

Once you have booked your advertisement please ensure you supply the artwork at the correct size, as below. Please note: 'Trim size' is the actual size that the advertisement will appear in the publication. 'Bleed size' is the size your advertisement needs to be supplied to us including the required 3mm bleed (if full page). 'Type area' is the suggested area that any text or important information should sit within to ensure details have some clear space around them for clarity.

TECHNICAL SPECIFICATION

Please ensure your advertisement is produced professionally, and in accordance with the following criteria:

- All artwork should be CMYK colour (No Pantone/Spot colours)
- All fonts should be embedded or outlined
- All images within the artwork must be at least 300dpi resolution and in CMYK colour
- For Full Page adverts please include 3mm bleed and crop marks

FILE FORMAT & SUPPLY

Our preferred file type is a high resolution PDF to the the following specification when exported from Adobe InDesign:

- Adobe PDF Preset: PDF/X-4:2008
- Colour Profile: Coated FOGRA39 (ISO 12647-2:2004)

The above will ensure your advertisement appears in the best possible quality, however if you are unable to supply as a PDF we will accept a 300dpi JPEG or TIFF file in CMYK colour format.

Full page

Trim size:
297mm(h) x 210mm(w)
Bleed size:
303mm(h) x 216mm(w)
Type area:
275mm(h) x 185mm(w)

HALF PAGE (Horizontal)

Trim size:
128mm(h) x 180mm(w)
Type area:
118mm(h) x 170mm(w)

HALF PAGE (Vertical)

Trim size:
250mm(h) x 86mm(w)
Type area:
240mm(h) x 76mm(w)

THIRD PAGE (Horizontal)

Trim size:
62mm(h) x 180mm(w)
Type area:
54mm(h) x 172mm(w)

THIRD PAGE (Vertical)

Trim size:
122mm(h) x 112mm(w)
Type area:
114mm(h) x 104mm(w)

Please note: Bleed is not required for Half Page and Third Page advertisements as these formats sit within the page, however we do recommend your advertisement includes a keyline/border if it has a white background.

If you have any queries regarding our specifications or to send us your files, please contact: Kate.Shanley@argusmedia.com

Fertilizer Focus

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IN THE NEXT ISSUE...

SUPPLEMENT: ASIA

- Future growth in India
- Phosphate protectionalism policies in Asia
- Laos' emergence as a potash power in southeast Asia
- What happened to Australia's SOP wave?

SPECIAL FOCUS: ADDED VALUE FERTILIZERS

- Micronutrients as adjusters for plant growth
- Investments in biostimulants
- Adapting strategies to adopt AVFs

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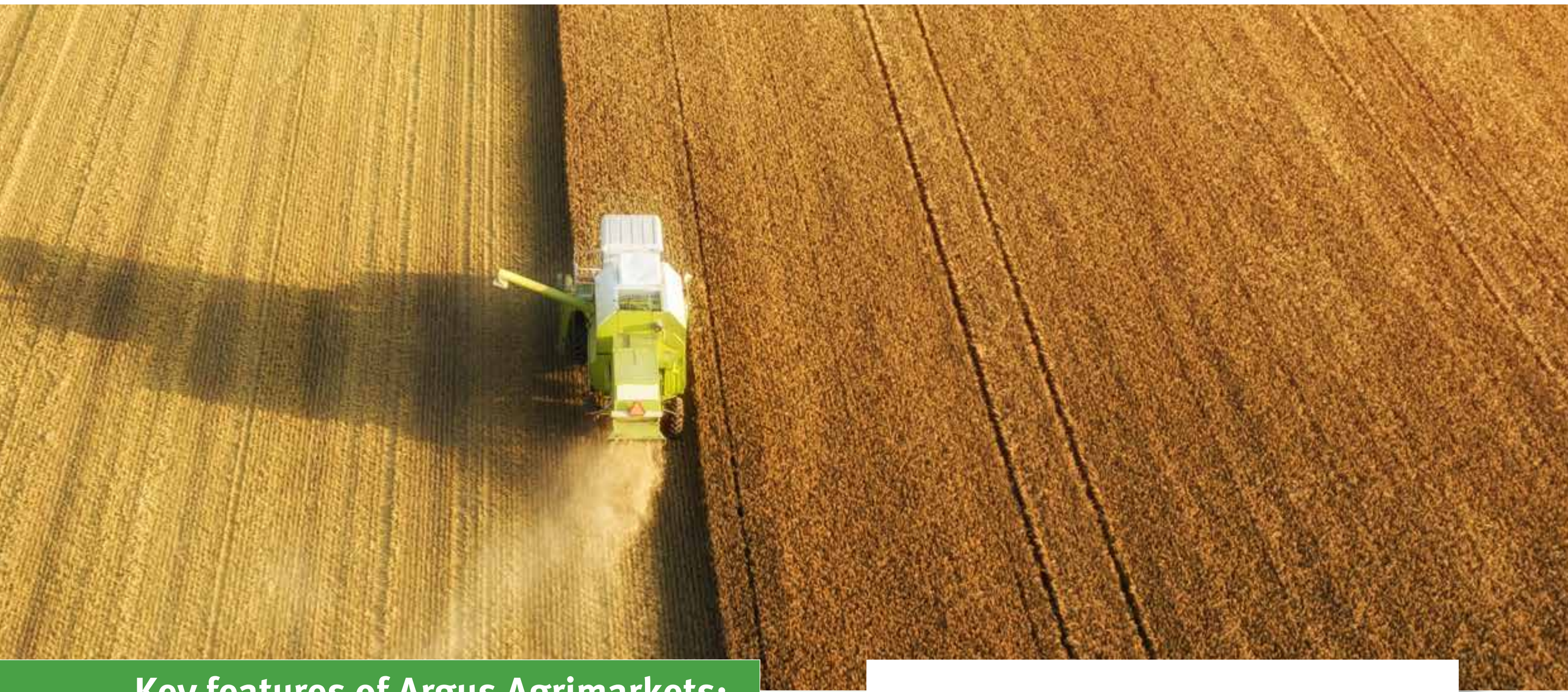
Timely, accurate and dependable price assessments, news and analysis for the agriculture markets



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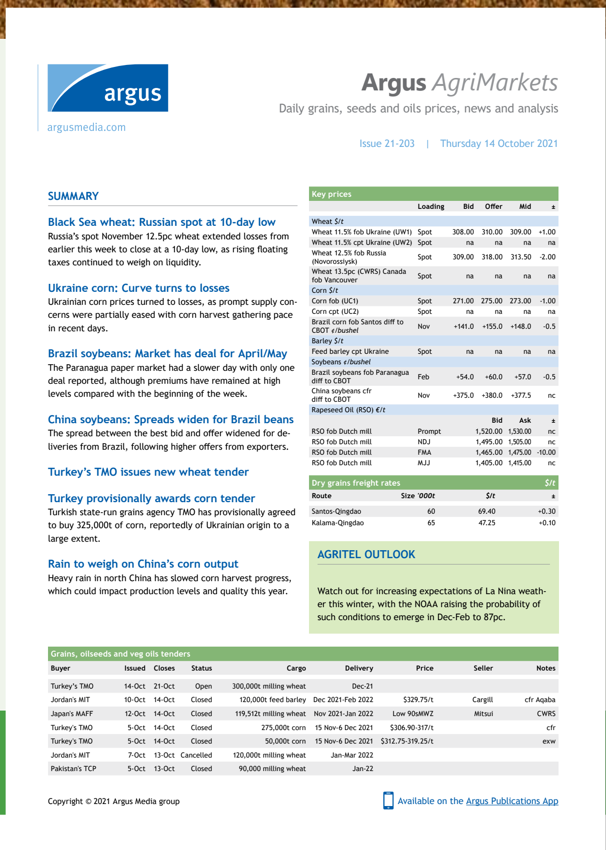
  - Ukraine wheat market
  - Ukraine corn market
  - Ukraine Barley Market
  - Russia wheat market (spot prices only)
- **Brazil soybean and corn - news, insights and prices**
- **China soybeans market**
- **Global news and key market developments**

For more information visit:
www.argusmedia.com/agriculture



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Argus *AgriMarkets*

Daily grains, seeds and oils prices, news and analysis

Issue 21-203 | Thursday 14 October 2021

SUMMARY

Black Sea wheat: Russian spot at 10-day low
Russia's spot November 12.5pc wheat extended losses from earlier this week to close at a 10-day low, as rising floating taxes continued to weigh on liquidity.

Ukraine corn: Curve turns to losses
Ukrainian corn prices turned to losses, as prompt supply concerns were partially eased with corn harvest gathering pace in recent days.

Brazil soybeans: Market has deal for April/May
The Paranagua paper market had a slower day with only one deal reported, although premiums have remained at high levels compared with the beginning of the week.

China soybeans: Spreads widen for Brazil beans
The spread between the best bid and offer widened for deliveries from Brazil, following higher offers from exporters.

Turkey's TMO issues new wheat tender

Turkey provisionally awards corn tender
Turkish state-run grains agency TMO has provisionally agreed to buy 325,000t of corn, reportedly of Ukrainian origin to a large extent.

Rain to weigh on China's corn output
Heavy rain in north China has slowed corn harvest progress, which could impact production levels and quality this year.

Key prices

	Loading	Bid	Offer	Mid	±
Wheat *$/t*					
Wheat 11.5% fob Ukraine (UW1)	Spot	308.00	310.00	309.00	+1.00
Wheat 11.5% cpt Ukraine (UW2)	Spot	na	na	na	na
Wheat 12.5% fob Russia (Novorossiysk)	Spot	309.00	318.00	313.50	-2.00
Wheat 13.5pc (CWRS) Canada fob Vancouver	Spot	na	na	na	na
Corn *$/t*					
Corn fob (UC1)	Spot	271.00	275.00	273.00	-1.00
Corn cpt (UC2)	Spot	na	na	na	na
Brazil corn fob Santos diff to CBOT *¢/bushel*	Nov	+141.0	+155.0	+148.0	-0.5
Barley *$/t*					
Feed barley cpt Ukraine	Spot	na	na	na	na
Soybeans *¢/bushel*					
Brazil soybeans fob Paranagua diff to CBOT	Feb	+54.0	+60.0	+57.0	-0.5
China soybeans cfr diff to CBOT	Nov	+375.0	+380.0	+377.5	nc
Rapeseed Oil (RSO) *€/t*					
			Bid	Ask	±
RSO fob Dutch mill	Prompt		1,520.00	1,530.00	nc
RSO fob Dutch mill	NDJ		1,495.00	1,505.00	nc
RSO fob Dutch mill	FMA		1,465.00	1,475.00	-10.00
RSO fob Dutch mill	MJJ		1,405.00	1,415.00	nc

Dry grains freight rates *$/t*

Route	Size *'000t*	$/t	±
Santos-Qingdao	60	69.40	+0.30
Kalama-Qingdao	65	47.25	+0.10

AGRITEL OUTLOOK

Watch out for increasing expectations of La Nina weather this winter, with the NOAA raising the probability of such conditions to emerge in Dec-Feb to 87pc.

Grains, oilseeds and veg oils tenders

Buyer	Issued	Closes	Status	Cargo	Delivery	Price	Seller	Notes
Turkey's TMO	14-Oct	21-Oct	Open	300,000t milling wheat	Dec-21			
Jordan's MIT	10-Oct	14-Oct	Closed	120,000t feed barley	Dec 2021-Feb 2022	$329.75/t	Cargill	cfr Aqaba
Japan's MAFF	12-Oct	14-Oct	Closed	119,512t milling wheat	Nov 2021-Jan 2022	Low 90sMWZ	Mitsui	CWRS
Turkey's TMO	5-Oct	14-Oct	Closed	275,000t corn	15 Nov-6 Dec 2021	$306.90-317/t		cfr
Turkey's TMO	5-Oct	14-Oct	Closed	50,000t corn	15 Nov-6 Dec 2021	$312.75-319.25/t		exw
Jordan's MIT	7-Oct	13-Oct	Cancelled	120,000t milling wheat	Jan-Mar 2022			
Pakistan's TCP	5-Oct	13-Oct	Closed	90,000 milling wheat	Jan-22			

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