Fertilizer INTERNATIONAL

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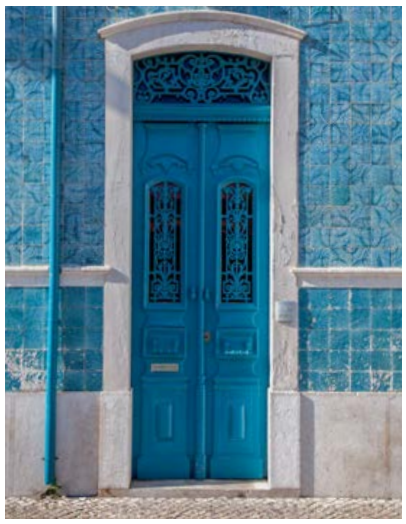
Argus Fertilizer Europe Conference, Lisbon

Nitrogen technology showcase

Unlocking the value of crop residues

Low-chloride crop nutrition



Cover: Charming wooden vintage door, Lisbon.
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Europe's NPK industry is in flux

The attractions of low-chloride fertilizers

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PHOSPHATES AND POTASH INSIGHT

REGULARS

Harvesting change


Antoine Hoxha.

PHOTO: FERTILIZERS EUROPE

Antoine Hoxha, the new Director General of Fertilizers Europe, looks ahead at the future of the EU fertilizer industry, setting out his vision of an industry transformed by decarbonisation, new energy markets, sustainable agriculture and the circular economy.

Living in our highly interconnected world has both strengths and weaknesses – as recent geopolitical events and global market developments have starkly revealed. For the European fertilizer industry, recent months have been particularly challenging, as we all know.

The sector's competitiveness has been negatively affected by volatile and high natural gas prices, for example. Broken supply chains have also disrupted the sector. More positively, however, the industry is now finally being recognised as essential for the continent's food security and autonomy.

Europe's strategic decision to move away from Russia is likely to speed up the greening of our industry. This is to be welcomed as now is definitely the time for the EU to step up efforts to deliver a low-carbon future for its domestic fertilizer sector.

A vision of the future

Fertilizers Europe has its own distinct vision of the future. It is a positive future in which fertilizers will increasingly be produced via renewable and low-carbon technologies. Water electrolysis, carbon capture and storage/usage, and biomethane feedstocks will all have a part to play.

In a major change, the ammonia industry also looks destined to become as essential for the energy and transport sectors as it currently is for agriculture. Many observers now expect decarbonised ammonia to become a driving force for the hydrogen economy, playing a key role in the energy transition, both as a carbon-free energy carrier and a fuel.

In future, precision farming methods and innovative fertilizer products – including inhibitors and biodegradable coatings – will become the bedrock of a productive, resilient, and sustainable EU agricultural system. Similarly, the nitrogen use efficiency (NUE) indicator and other scientific tools are also delivering improvements to farming practices. As a result, integrated plant nutrition, where organic and mineral fertilizers play mutually reinforcing and complementary roles, looks set to emerge as the cornerstone of EU agriculture. This more holistic approach to plant nutrition and soil fertility, as it becomes solidly embedded, will help Europe's farmers produce plentiful, high-quality crops.

Fertilizers will become a natural part of the circular economy too. Our industry's production processes are becoming increasingly circular by recovering nutrients from secondary sources to close the loop and minimise waste.

A decarbonisation roadmap

The European fertilizer industry, having done its homework, is moving from words to action with a concrete plan. A decarbonisation roadmap that lays out the pathways and milestones for our industry is now being finalised. This document reflects the collective ambition of Fertilizers Europe's members to steer the industry toward a sustainable future.

The roadmap foresees two scenarios capable of delivering CO_2 emissions reduction targets: firstly, a technology-neutral pathway that harnessies all low-carbon technologies; secondly, a green pathway based only on water electrolysis powered by renewable energy.

The eventual choice of decarbonisation technology will be determined by the unique needs and circumstances of each and every fertilizer production plant. While the pathway to the future is unique for each plant, the final destination is always the same: a carbon-neutral future.

The adoption of these technologies demands huge investments. Other regions and countries have already set up investment frameworks (such as the US Inflation Reduction Act, for example) to signal the importance of retaining domestic fertilizer production. Europe therefore also needs to provide substantial financial support and develop a favourable legislative framework – if it is to maintain the global competitiveness of the EU's fertilizer industry during the green transformation.

The pathway to the future for the EU fertilizer industry also requires making a viable business case for the green transition. Creating the necessary market demand for green and low-carbon products will undoubtedly requires incentives, as well as independent certification to differentiate them from their conventional equivalents.

Learning from the past to shape the future

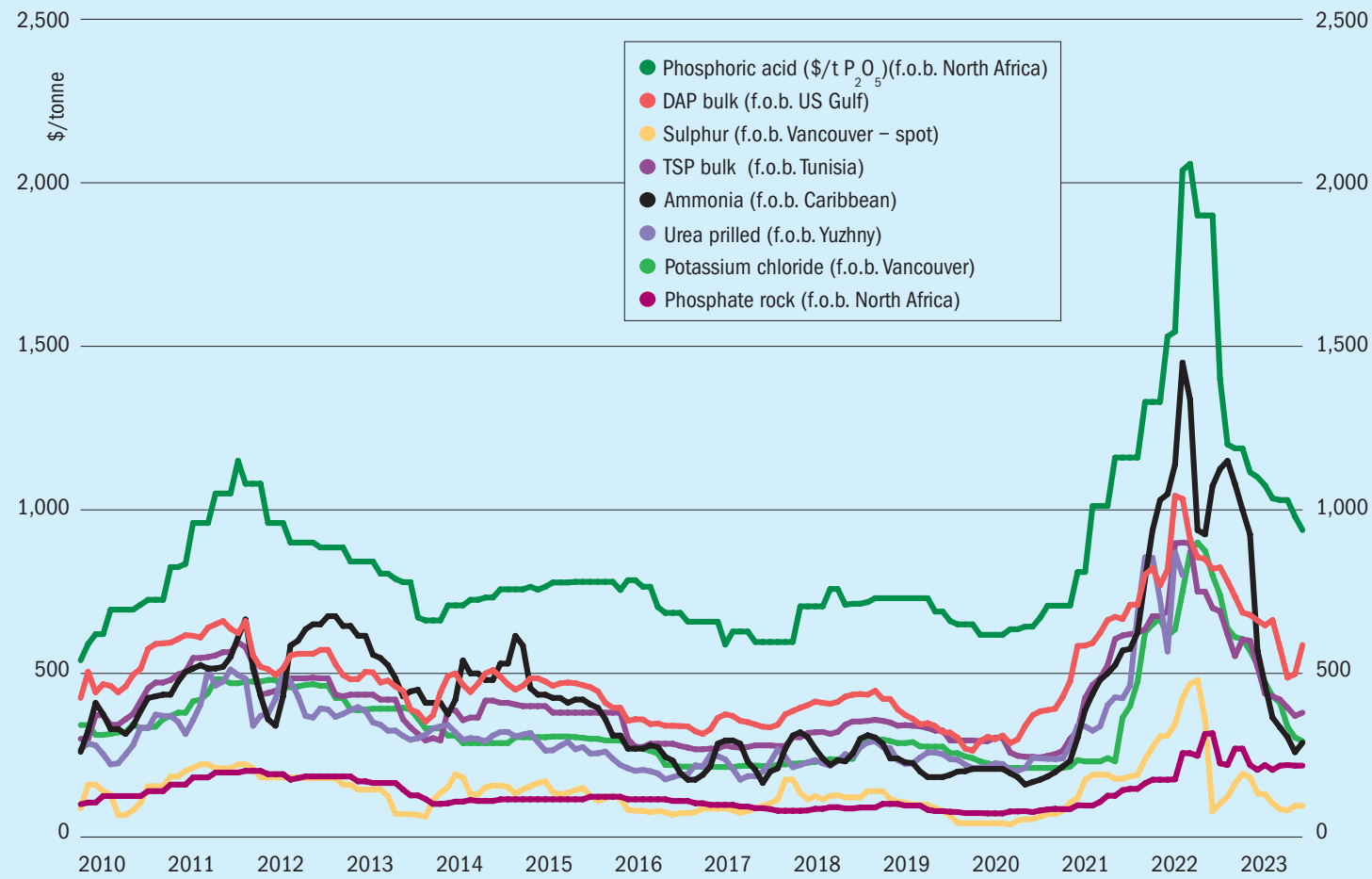
History always teaches invaluable lessons – with recent events being no different. The Covid-19 crisis and Russia's aggression towards Ukraine have rekindled concerns about food security and have underscored the strategic importance of the fertilizer sector.

EU governments are unlikely to repeat the mistake of over-relying on external countries for critical resources such as energy, fertilizers and food. Instead, the new geopolitical landscape makes it crystal clear that Europe now needs to come forward with a strong industrial strategy, one that aims to reduce external dependencies and boosts self-sufficiency in strategically important sectors.

This approach is necessary for Europe's citizens. It will also lay the foundation for a future-proof European fertilizer industry.

Market Insight

Historical price trends $/tonne



Source: BCInsight

Market Insight courtesy of Argus Media

PRICE TRENDS

Urea: While prices mostly fell in mid-August, the main development was the massive purchase of Chinese urea by Indian Potash Limited. IPL confirmed that, out of a total tender settlement of 1.759 million tonnes, one million tonnes will be met by Chinese exporters. This far exceeded expectations and added to the already bearish sentiment of most market players.

Market activity, otherwise, was generally slow, as many importers and traders awaited the settlement of the Indian urea tender before committing to new deals. Low demand prompted urea price falls in most markets – by $15/t in the US, $30/t in Brazil, $20/t in Europe and $20/t in southeast Asia.

Key market drivers: Chinese urea exports, by committing around one million tonnes to India's urea tender, surpassed expectations by around 80 percent. With production margins currently high in most regions, the market is expected to soften if Chinese exports continue at this pace. Market fundamentals remain weak – with neither grain nor energy markets providing much support in the short-term.

Ammonia: A rise in buying inquiries is supporting slightly firmer prices. Producers, meanwhile, are said to be sold out across most key supply regions. Trade has stalled due to limited spot f.o.b. availability with only one sale confirmed from Bangladesh to India during mid-August. Indian buyers are looking for prompt cargoes, yet most Middle East producers have nothing to offer. Although the supply outlook could improve in coming weeks, suppliers are in no rush to sell until a clearer picture of September demand emerges.

Key market drivers: Supply remains limited following the raft of production outages seen in recent months. European plants are weighing up production rates for the months ahead, with weak ammonia demand and high production costs creating a difficult decision for the region's producers.

Phosphates: Indian and Pakistan importers returned to the DAP market in mid-August, bolstering their line-ups ahead of the winter Rabi season. India purchased 150,000 tonnes of DAP in the low/mid $550s/t cfr, all sourced from Morocco via traders, up from $540/t cfr in early August. RCF also purchased a MAP 10-50 cargo and phosphate rock under its 10th August tender. Prices into Pakistan ranged between $565-580/t cfr, with at least two Moroccan cargoes and an Australian vessel concluded. Chinese DAP producers have raised offers, lifting mid-August's range to $550-560/t f.o.b. Saudi Arabia's Ma'aden concluded 40,000 tonnes of DAP for the US in the low $600s/t cfr for August.

West of Suez, MAP prices firmed to $530/t cfr Brazil. The US remains the premium destination market globally, with DAP barges at $530-545/st f.o.b. Nola. MAP barges also remain elevated at $635/st f.o.b. Mosaic, meanwhile, is offering Tampa DAP at $550/t f.o.b.

Market price summary $/tonne – Late August 2023

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	260-310	345-380**	f.o.b. E. Europe 140-190	f.o.b. US Gulf	573-600	-	-
f.o.b. Yuzhny	Port closed	Port closed	-	f.o.b. N. Africa	520-580	365-415	875-1,000
f.o.b. Middle East	290-320	346-400**	-	cfr India	540-560	-	850*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	260-325	-	cfr US Gulf	50-85	f.o.b. Vancouver	85-90	-
f.o.b. Middle East	285-429	-	-	-	f.o.b. Arab Gulf	80-93	-
f.o.b. Western Europe	-	530-650	-	-	cfr N. Africa	75-93	-
f.o.b. Baltic	245-323	-	-	-	cfr India	90-111+	-

Prices are on a bulk, spot basis, unless otherwise stated. (= contract ** = granular). Phosphoric acid is in terms of $/t P_2O_5 for merchant-grade (54% P_2O_5) product. Sulphur prices are for dry material. (+ Quotes for product ex-Arab Gulf). n.a. = not available.*

Key market drivers: The Ethiopian Agricultural Businesses Corporation (EABC) is seeking just under 1.36 million tonnes of NPS/NPSB in its annual fertilizer tender which closes on 22nd August. OCP will probably secure the full volume, as it has done in each of the four previous years.

Potash: Overall market sentiment is firm, largely due to tight granular MOP supply. In the US, granular MOP prices (f.o.b. Nola) rose amid strong demand for product through to October. Although Brazilian granular MOP prices also rose again in mid-August, demand has slowed compared with previous weeks as soybean requirements have largely been fulfilled. In Europe, granular MOP prices increased slightly with buyers looking to secure volumes amid concerns over shortages and price rises. In southeast Asia, standard MOP prices have started to creep upwards.

Key market drivers: Australian Potash has pulled out of the Lake Wells SOP project, having failed to find an investor, adding to the country's recent string of failed SOP projects. In Indonesia, BPC has been awarded three cargoes – around 75,000 tonnes – at $306/t cfr under Pupuk's standard MOP buying tender.

NPKs: The market has remained generally firm. Some NPK prices moved upwards in mid-August, thanks to ongoing downtime in some regions, while others remained flat. In major news from the Horn of Africa, the Ethiopian Agricultural Businesses Corporation (EABC) is seeking just under 1.36 million tonnes of NPS/NPSB in its annual fertilizer tender, as well as 980,000 tonnes of urea. OCP will probably secure the full volume, as it has done in each of the four previous years.

In India, NPK tenders have yet to garner offers, despite market firming and expectations of higher prices to come. Although one trading firm has offered RCF Indonesian 20-20-0+13S, the price has yet to be revealed.

Key market drivers: Russian exports of nitrogen-containing complex fertilizers rose by 96,000 tonnes year-on-year to total 440,000 tonnes in July. Exports were mainly boosted by shipments to India although deliveries to EU states also climbed significantly. Globally, phosphate market prices continued to rise in mid-August, across products and locations.

Sulphur: Demand and prices have risen in recent weeks, with a combination of phosphate fertilizer prices and demand lifting producer operating rates. Demand has been led by China's building of stock levels to 2.45 million tonnes. This stock level is nudging the record three million tonnes reached last year, even with increasing domestic production contributing to inventory.

Much of August demand is committed, with tonnes lifting during the month similarly sold, while the September price level is not yet clear. This has led to a lack of spot offers from Middle East offtakers.

Key market drivers: Two factors are at play. Firstly, offers above previously concluded business in the $120s-130s/t cfr range. Secondly, a lack of liquidity while the market remains in wait-and-see mode for the Middle East spot tender for September lifting.

OUTLOOK

Urea: The market is trending back towards surplus as normal supply from Nigeria and southeast Asia resumes and exports from China build. Demand is looking unexceptional, with both traders and importers appearing generally bearish.

Ammonia: While there is some short-term firming of sentiment, the market remains in a very cautious state. Neither buy- or sell-side players want to instigate a price spike which could cause further demand destruction.

Phosphates: Prices for cargoes loading in September and October are firm. India, Pakistan and Bangladesh all still need to add to their import line-ups for October-November arrival. Importers, by paying up now, are starting to ease some of this pressure.

Potash: Suppliers are comfortable going into the fourth quarter and granular prices will continue to be supported by healthy demand from the US and Brazil.

NPKs: Firmness in raw materials markets and increasing demand for complex fertilizers are set to keep NPK prices on a rising trend. NP and NPK prices could, however, eventually come under pressure as urea enters its weak demand period, this placing downward pressure on nitrogen prices in general.

Sulphur: Prices are expected to continue to firm while support from rising demand and prices in the phosphate fertilizer markets is sustained. Nonetheless, sulphur prices are expected to soften eventually due to growing sulphur stock levels in China and the end of the fertilizer production season in the northern hemisphere, with good availability likely to erode prices once again.

UK

Billingham ammonia plant to close

Ammonia production at Billingham in Teesside looks set to end, bringing to a close a history of production that dates back almost a century.

The proposal to permanently close Billingham's ammonia plant was announced by owners CF Fertilisers UK on 25th July. In a statement, the company said this was necessary "to secure the long-term sustainability of its business in the United Kingdom and more efficiently serve its customers in the country".

The move follows CF's closure of its large-scale fertilizer production complex at Ince in north west England in 2022 (*Fertilizer International* 509, p8). The Ince site was the UK's largest producer of compound fertilizers and also manufactured large volumes of ammonium nitrate for agriculture.

Billingham is the UK's largest ammonia, ammonium nitrate (AN) and carbon dioxide producer. The Teesside complex in north east England combines a 595,000 t/a capacity ammonia plant with 625,000 t/a of ammonium nitrate and 410,000 t/a of nitric acid capacity.

CF Fertilisers UK, a wholly-owned subsidiary of US-headquartered CF Industries, says it will continue producing AN fertilizer and nitric acid at the Billingham site using imported ammonia – as it has done since idling the site's ammonia plant in August 2022.

"[Ammonia production at] Billingham will not be cost-competitive for the long-term compared to importing ammonia due primarily to projected high natural gas prices in the United Kingdom relative to other regions and the impact of carbon costs," CF said in a statement.

In future, the company believes that imported ammonia, including imports from its North American operations, will enable more cost-competitive and efficient production of nitric acid and AN fertilizer in the UK for its agricultural and chemical customers.

CF's planned closure of Billingham's ammonia plant, which follows its closure of the Ince fertilizer production complex last year, is the latest in a series of shutdowns and consolidations that have marked the long decline of the once mighty UK ammonia industry (*Fertilizer International* 509, p4). British production of this basic chemical has a proud history and – under former corporate giant Imperial Chemical Industries (ICI) – the UK also became a leading global centre for innovation in ammonia technology and catalysis.

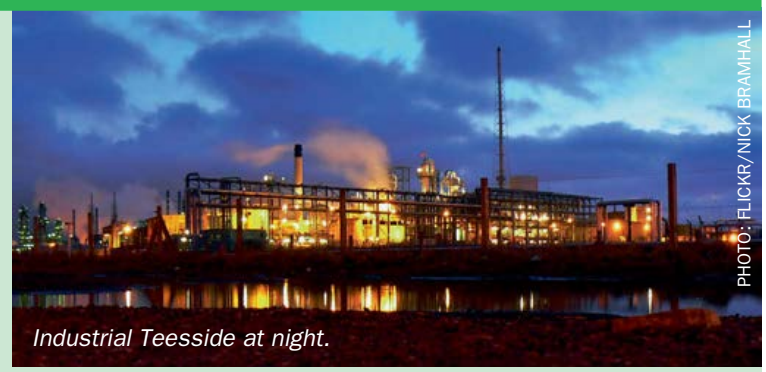


PHOTO: FLICKR/NICK BRAMHALL

Industrial Teesside at night.

Commercial ammonia production began at Billingham in 1924 under Brunner, Mond & Co, the predecessor to ICI. By the 1960s, when ICI was the world's largest producer, ammonia was being produced at Billingham, Heysham, Wilton, Severnside and Immingham in the UK.

UK ammonia production reached its zenith under ICI in the 1980s. However, with profits from basic chemicals dwindling, the company subsequently sold off its ammonia and nitrogen fertilizer production assets in the 1990s as part of a divestment programme.

The long-term decline in North Sea gas output has been a factor in the contraction of the UK ammonia industry. Although British industry and power generators once benefitted from a glut of cheap North Sea natural gas during the 1980s and 1990s, this is no longer the case. UK natural gas production peaked at 115 bcm in 2000 but has declined to below 40 bcm in the two decades since.

The announcement from CF now looks set to end large-scale ammonia production in the UK for good. However, the industry's lack of competitiveness is a regional issue and not unique to UK.

Europe's ammonia producers in general are struggling to compete on price with ammonia imports (*Fertilizer International* 515, p7). The elevated price of natural gas, a key feedstock, has badly affected regional production costs during the last two years. The Dutch TTF price, Europe's main gas price benchmark, having fallen back from an all-time high of €319/MWh in August last year, remains historically high compared to pre-pandemic price levels. ■

UK

Fertiberia supplies M&S dairy farms with green fertilizer

Spain's Fertiberia is to supply Marks & Spencer (M&S) with green fertilizers to help the British supermarket reduce the carbon footprint of its 27 dairy farms.

The company will supply M&S farms with Impact Zero fertilizers, a new emissions-free product range manufactured in Spain. The supermarket's UK distributor, Bartholomews Agri Food, signed an exclusive supply agreement with Fertiberia for these innovative fertilizers on 12th July.

Fertiberia, by substituting green hydrogen for natural gas, has managed to drastically reduce the production emissions of its Impact Zero product range. The emissions associated with these have been cut by as much as three tonnes of CO_2 for every tonne of ammonia generated, according to the company.

M&S dairy farmers will use an Impact Zero fertilizer called Tech Nergetic. This product should improve nitrogen use efficiency by 22 percent, compared to a standard fertilizer, helping to reduce the amount of nitrogen applied to the land. Its properties will also cut the amount of nitrogen lost to leaching.

"Decarbonisation of the food chain requires cooperation between all links in the chain, and this alliance shows the way forward. Fertiberia brings its Impact Zero crop nutrition solutions and R&D&I know-how, Bartholomews guarantees the best application of these solutions thanks to its extensive knowledge of UK growers and livestock farmers, and M&S is leading the initiative to bring food that drastically reduces its emissions to the end consumer," said Javier Goñi, Fertiberia's CEO:

M&S farms will be the first to adopt Impact Zero products from spring 2024 onwards.

"M&S has set important targets to reduce our carbon footprint and become net zero emissions across our value chain by 2040. 72 percent of M&S Food's emissions come from agriculture and around half of these come from livestock, mainly ruminants. It is therefore essential that we work with our farmers to make a significant change. We believe the use of these fertilisers will enable our farmers to maintain productivity while playing a vital role in helping to decarbonise milk production," said Steve McLean, head of agriculture and fisheries at M&S.

The first Impact Zero green fertilizer shipment, imported from Spain by Bartholomews Agri Food, arrived in the country via Southampton in the last week of July. The amount imported has not been disclosed.

SPAIN

Fertiberia and PepsiCo to jointly cut agricultural emissions

PepsiCo and Fertiberia are collaborating on new ways to reduce the carbon emissions of potato growing.

The two companies are trialling a new approach to cutting agricultural emissions as part of a joint pilot programme launched at the end of June. This will combine the use of low-carbon fertilizers with precision agriculture.

The pilot programme is being carried out by the Garlan cooperative, PepsiCo's potato supplier for the last 30 years, in Spain's Álava, La Rioja and Burgos provinces. Growers in these regions will trial Fertiberia's new Impact Zero fertilizers. Their use is expected to reduce the emissions from potato cultivation by about 15 percent, according to Fertiberia.

Potatoes will be sown on 400 hectares of land initially. The trial will then be scaled-up over the next two years and is expected to reach 1,500 hectares by 2025. The potatoes will be grown using efficient precision farming methods. These tightly control fertilizer applications and prevent overuse by monitoring the nutrient status of crops and soils.

The Impact Zero fertilizers used in the potato growing pilot will be made from green ammonia at Fertiberia's Puertollano production site. Green ammonia is manufactured at Puertollano using green hydrogen generated on-site by a solar-powered plant, the largest of its type in Europe.

"Fertiberia is changing the paradigm in the agri-food sector with the development of Impact Zero," said Alfredo Segura, Fertiberia's commercial director. "The agreement with PepsiCo confirms the potential of green hydrogen to achieve a fully sustainable agriculture."

PepsiCo plans to increase its use of regenerative agriculture in Spain to 77,000 hectares by 2030.

"We are very proud to announce this green fertiliser pilot programme together with Fertiberia to reduce the emissions associated with fertilisers and, consequently, emissions from agriculture which account for a high percentage of our total emissions," said Ángel Alonso, PepsiCo's agricultural director for Southwest Europe. "This initiative complements others that we are already carrying out to regenerate the land and make it more fertile through regenerative agriculture practices."

Fertiberia has pledged to reduce its emissions to net zero by 2035. The switch to fertilizer production using renewable energy will be the key to achieving this ambitious goal. Fertiberia has already decarbonised its Puertollano production centre (see box) and plans to follow this up by decarbonising its other Spanish

production plants (Palos de la Frontera, Avilés and Sagunto) in future.

GERMANY

Yara supplies green fertilizers to cereal growers

Yara Germany has launched a joint pilot project to reduce the carbon footprint of cereal production.

In August, the company signed an agreement with two of Germany's leading food industry players, the flour milling company Bindewald & Gutting Milling Group and bakers Harry-Brot, to supply their cereal growers with green fertilizers.

The nitrate-based fertilizers, produced at Yara's Rostock site in Germany, will have an 80-90 percent lower carbon footprint than normal. They will be supplied to Bindewald & Gutting's contract farmers and used to grow around 1,600 hectares of cereals in Germany from the 2023/24 growing season.

Yara Germany says the fertilizers will be made using Norwegian green ammonia. Yara manufactures this from green hydrogen generated via water electrolysis using renewable electricity.

Yara's Rostock production complex in Germany features two nitric acid plants, two nitrate fertiliser plants, one urea ammonium nitrate (UAN) plant and two plants making technical ammonium nitrate.

"Yara Germany, all nine locations of the Bindewald & Gutting Milling Group, and Harry-Brot signed a cooperation agreement with the shared goal of reducing CO_2 emissions in cereal production. The partnership will help in reducing carbon footprint along the entire food value chain, starting from fertilizers to sales and ultimately reaching end consumers," Yara said in a statement.

The use of green fertilizers can reduce the CO_2 footprint of cereals by up to 30 percent, according to Yara. The project partners plan to drive down cereal emissions even further by combining green fertilizers with precision farming and site-specific fertilization.

"Our partnership with the Bindewald & Gutting Milling Group and Harry-Brot is a crucial first step to decarbonize German agriculture. It is a concrete example of how food production can be transformed in a sustainable way," said Marco Fleischmann, Yara Germany's managing director.

"The avoidance and reduction of greenhouse gas emissions in all scopes is at the core of our sustainability strategy. While we are continuously working on reducing Scopes 1 and 2 CO_2 emissions, with short delivery and transport routes and efficient production, we are still dependent on agriculture and our suppliers when it comes to Scope 3 emissions. If we succeed, starting with fertilization, we can reduce emissions precisely where a large proportion of our supply chain emissions has always occurred. This is why we are proud to be part of this innovative project," said Norbert Lötz, Harry-Brot's managing director for production and technology.

Yara says the new project will offer consumers "a sustainable food choice" and support "climate-friendly [fertilizer] production".

Nearly three-quarters of German consumers would like to see the CO_2 footprint of products displayed on packaging, according to an IPSOS study commissioned by Yara. More than half of German consumers are also willing to pay extra for food with a smaller carbon footprint, the study suggested.

SAUDI ARABIA

FLSmidth wins major Ma'aden beneficiation order

FLSmidth has secured a DKK 530 million contract for Ma'aden's 'Phosphate 3' project.

The Danish mining equipment company will provide major items and critical services for the construction of a large-scale phosphate beneficiation plant at the project's mine site in the Northern Province of Saudi Arabia.

FLSmidth has agreed to supply Ma'aden with key equipment for the beneficiation plant, as well as support services covering its design, construction, commissioning and ramp-up. The order includes: primary and secondary sizers, apron and HAB feeders, cone crushers, screens, cyclone clusters, ball mills, paste and high-rate thickeners, horizontal belt filter, slurry pumps, knife-gate valves and flotation columns.

FLSmidth has booked the order for the third-quarter of this year. It expects all the beneficiation equipment to be fully integrated on-site in Saudi Arabia during 2025.

"We are pleased to collaborate with Ma'aden on this expansion, as this order sets another strong standard for our MissionZero agenda," said Mikko Keto, FLSmidth's CEO. "In particular the incorporation of our paste thickening and dewatering technology at this important mine site plays a key role in reducing emissions and water spend from the beneficiation process."

FLSmidth's partnership with Ma'aden on its latest phosphate mine project began in 2019 with the laboratory testing of samples collected from the ore body. The company subsequently carried out pilot-scale tests and developed the beneficiation flowsheet.

Ma'aden renews fertilizer supply deal with Bangladesh

Ma'aden has renewed its agreement to supply the Bangladesh Agricultural Development Corporation (BADC) with 600,000 tonnes of fertilizers. The agreement was signed during a visit to Ma'aden's headquarters by a BADC delegation in mid-August.

The agreement means Ma'aden will continue to supply approximately 42 percent of Bangladesh's diammonium phosphate (DAP) requirements.

"We are pleased that we are able to continue working with BADC to ensure a reliable supply of high-quality fertilizer products to the Bangladesh market. We are excited to extend our near-decade-long relationship with BADC and playing a role in helping support food security efforts in the region," said Hassan Al Ali, Ma'aden's EVP for its phosphate business unit.

Ma'aden is planning to increase its phosphate fertilizer production by 50 percent to nine million tonnes p.a. by implementing its 'Phosphates 3' mega project. The company is the world's second-largest exporter of phosphate fertilizers currently.

SABIC Agri-Nutrients ships low-carbon urea to New Zealand

SABIC Agri-Nutrients Company's (SABIC AN) has made its first ever global shipment of low-carbon urea.

The 2,700-tonne urea consignment was successfully delivered to Ravensdown, the farmer-owned agricultural co-operative, at Timaru, New Zealand on 21st July

"Our collaboration with Ravensdown is a major step in this direction and a strong indicator of SABIC's overall commitment to delivering low-carbon solutions to customers and helping them achieve their net-zero targets," said Abdulrahman Shamsaddin, SABIC AN's CEO.

"This collaboration with SABIC AN is key to ensuring we meet our commitment

SPAIN

Briefing: Fertiberia pioneers Europe's green ammonia market

Puertollano green hydrogen plant, Spain.

Fertiberia's Puertollano green hydrogen plant was officially inaugurated by His Majesty Felipe VI, the King of Spain, in mid-May.

The large-scale plant will produce up to 3,000 tonnes of renewable hydrogen annually. It incorporates one of the world's largest water electrolysis systems and is powered using renewable electricity from an integrated 100 MW photovoltaic solar array. The plant, the largest of its type in Europe, will supply the company's nearby fertilizer complex, enabling Fertiberia to produce green ammonia at Puertollano, using green hydrogen instead of natural gas.

This major project was successfully developed in partnership with the Spanish electrical utility Iberdrola. It forms the centrepiece of Fertiberia's net zero strategy and the company's ambitions to become carbon-neutral by 2035.

With Puertollano's inauguration, Fertiberia says it has become the world's first major crop nutrient company to begin carbon-free ammonia and fertilizer production on an industrial scale.

The inauguration was attended by the Javier Goñi, Fertiberia's CEO, and Ignacio Sánchez Galán, president of Iberdrola. Major Spanish civic and government leaders, both regional and national, were also in attendance.

Javier Goñi said Fertiberia's investment in Puertollano marked the first step towards pioneering the green ammonia market in Europe.

"The milestone … makes us the first company in the world to manufacture green ammonia and CO_2-free crop nutrition solutions on an industrial scale. The project is unique in the sector due to its sheer size. This initiative is part of our Net Zero strategy which, thanks to the support of our owner Triton, will make us the first major European company in our sector to reduce emissions to zero by 2035," Goñi said.

Fertiberia "is moving forward in the decarbonisation of the essential agriculture sector", added David Herrero, the company's industrial director. "By replacing natural gas with indigenous resources … we are helping to move towards food and energy independence in the EU," he said. ■

to reduce carbon emissions by 50 percent by 2030. As pressure mounts for New Zealand farmers to lower greenhouse gas emissions from behind the farm gate, it is important we pull our weight across all facets of our supply chain too," said Garry Diack, Ravensdown's CEO.

SABIC AN produced the urea using blue ammonia. The company's low-carbon ammonia production has been independently certified by TÜV Rheinland, a leading independent testing, inspection, and certification agency. This guarantees that a significant part of the CO_2 associated with the manufacturing process has been captured and used downstream.

UNITED STATES

Nutrien shelves Geismar project

Nutrien has decided not to proceed with a large-scale blue ammonia project in Geismar, Louisiana.

The Canadian fertilizer giant halted the project on 3rd August, Argus reported, because of rising capital costs and "continued uncertainty on the timing of emerging uses for clean ammonia".

The company said it will now prioritise other capital allocations instead.

Nutrien first announced plans to construct what had been called the world's largest blue ammonia plant at Geismar in May 2022 at an estimated cost of around $2 billion. However, the project's projected costs have since increased by around 15-20 percent, according to Ken Seitz, the company's president and CEO.

A final investment decision (FID) for Geismar had been expected this year with the project moving to construction in 2024 and potentially becoming fully operational in 2027. The decision to shelve the project for now will mean a delay of "at least 24 months", said Trevor Williams, Nutrien's president for nitrogen and phosphate.

The tax credits offered for sequestering carbon dioxide by the US Inflation Reduction Act provided "a big improvement in terms of being able to try and justify" projects like Geismar, Williams said. But these incentives still "didn't get [Nutrien] over the hurdle in terms of the economics of the project at this point", he said.

"[While] there will be an opportunity in the clean ammonia business in the future, the timing of the evolution of that demand is unknown," said Seitz.

"Today, the evidence wouldn't be sufficient to justify the assumption of a premium – at least not in the near term – emerging for clean ammonia," added Mark Thompson, Nutrien's chief commercial officer.

BRAZIL

Unigel indefinitely halts Laranjeiras plant

Unigel indefinitely suspended operations at its Laranjeiras nitrogen fertilizer plant in the state of Sergipe on 11th August, ICIS has reported.

The shutdown is due to high natural gas costs and follows Unigel's announcement to temporarily idle the plant for 90 days from 1st June.

"The company continues to make every effort to make the production of nitrogen fertilizers feasible," Unigel said." [It] continues to establish dialogues with public agents and authorities and negotiate conditions with the main gas suppliers, in favour of solutions for the challenging situation that surrounds the chemical industry and the production of national fertilizers [in Brazil]."

The Laranjeiras plant is Brazil's largest nitrogen fertilizer manufacturing site with a production capacity of 650,000 t/a for urea, 450,000 t/a for ammonia and 320,000 t/a for ammonium sulphate. Urea production at Unigel's other fertilizer plant at Camacari in the state of Bahia also remains offline currently.

AFRICA

Stamicarbon to build two sub-Saharan African urea plants

Stamicarbon has secured a second contract for a 4,000 t/d urea melt and granulation plant in sub-Saharan Africa.

It follows the award of a license and process design package for an identical plant at the same location by the same customer last year. Neither the customer or the location have been disclosed.

Combined, the two contracts cover the delivery of high-pressure equipment and fluid bed granulation units for two urea production trains at a world-scale integrated ammonia and urea complex. This will have a total capacity of 4,600 t/d for ammonia and 8,000 t/d for urea.

Stamicarbon's pool condenser with MP Flash design offers significant reductions in energy consumption, while the granulation plant will use Stamicarbon's fluid bed granulation technology. An integrated off-gas acidic scrubbing system, meanwhile, will cut ammonia emissions to a minimum. The system also eliminates waste water by incorporating innovative salts reworking technology. The high-pressure equipment for the synthesis sections will be in durable Safurex® duplex stainless steel.

The ammonia-urea production complex is expected to become operational in 2026. The complex has a strategic location and is well placed to meet growing regional and global demand for high-quality fertilizers, according to Stamicarbon.

"We are glad to have secured this licensing and proprietary equipment contracts for this grassroots complex that will support agriculture, create local jobs and address the growing demand for high-quality fertilizers across the Sub-Saharan region and other parts of the world," said Pejman Djavdan, Stamicarbon's CEO. "We look forward to building a long-term relationship with our new customer over the coming years and watching this exciting project grow."

CAMEROON

Yara Cameroon acquired by NJS Group

Yara has agreed to sell its 65 percent stake in Yara Cameroon to NJS Group, its local partner in the country.

NJS Group, founded by the late Jean Samuel Noutchogouin, will become Yara Cameroon's sole shareholder, once the transaction is completed, having held a minority stake in the business since its inception in 1995. Yara said the sale of its majority stake, owned by Yara International France, was a natural and strategic development.

"Yara International ASA and the Noutchogouin family have been partners for over 25 years," Yara said in a statement. "This complete takeover of the company by its local historical minority shareholder paves the way for ambitious expansion projects."

Yara and NJS Group will strengthen their collaboration, despite the divestment, having concluded an exclusive distribution agreement for the premium NPK fertilizers, YaraMila, and YaraLiva Nitrabor Calcium Nitrate. This will ensure Cameroon's farmers and agricultural retailers continue to receive a supply of these products in future. Yara has also agreed to provide NJS Group with technical and operational support.

AUSTRALIA

Pupuk Kaltim in talks to buy Incitec Pivot Fertilizers

Indonesia's Pupuk Kaltim has emerged as the frontrunner to buy Incitec Pivot Fertilisers, according to the Australian Financial Review (AFR).

Incitec Pivot Limited (IPL) have turned away other suitors, AFR reported in early August, in favour of negotiating a bilateral deal for its fertilizer business unit with state-owned Pupuk Kaltim.

Incitec Pivot Fertilisers is Australia's biggest fertilizer manufacturer and distributor, with a market share of about 50 per cent in eastern Australia. The business unit is valued at around AUD 1.5 billion ($989 million). It typically generates annual revenues in the region of AUD two billion and earnings of around AUD 200 million.

IPL's Gibson Island plant near Brisbane ceased production in January, having failed to secure a new gas supply contract (*Fertilizer International* 506, p10). IPL and its partner Fortescue Future Industries are, however, looking at the feasibility of converting Gibson Island to green ammonia production (*Fertilizer International* 511, p8).

IPL also owns a major phosphate production complex at Phosphate Hill, Queensland, and a superphosphate plant at Geelong, Victoria. The company recently sold its 880,000 t/a capacity Waggaman ammonia plant in Louisiana in the United States to CF Industries for $1.7 billion (*Fertilizer International* 514, p10).

In Indonesia, Pupuk Kaltim operates five ammonia plants with a combined capacity of 2.7 million t/a and five urea plants with a combined capacity of 3.4 million t/a. Any sell-off to an overseas company would require the approval of Australia's Foreign Investment Review Board.

IPL's former CEO Jeanne Johns and Christine Corbett, the head of its fertilizer business unit, have left the company in recent months. Both were associated with plans to demerge IPL into separate fertilizer and explosives companies.

UZBEKISTAN

$100 million investment in phosphate rock mining

The ramp up of the new NEOFOS mine in Uzbekistan's Navoi region looks set to increase the country's phosphate rock production to 2-2.5 million tonnes annually.

The $100 million mine is owned by investment company Ferkensco Management Limited. More than 30 large-scale excavators (including diesel-hydraulic excavators, a milling combine, dump trucks, bulldozers and graders) are being used to extract phosphate rock from a 50-metre-deep opencast mine over a large area (45.7 km^2).

NEOFOS will also produce phosphate rock concentrate as part of the project's second phase. A dedicated processing plant, scheduled to open by the end of 2023, will supply concentrate to the under-construction Samarqandkimyo fertilizer plant, another Ferkensco investment project.

"Samarqandkimyo chemical complex will become the largest producer of phosphorus-containing fertilizers in Uzbekistan. The enterprise will annually produce up to 910,000 tonnes of high-quality products, which will not only cover the needs of local farmers, but will also enter the export market, competing with foreign manufacturers. Own raw materials produced in NEOFOS will reduce dependence on third-party suppliers and make the operation of the complex uninterrupted," said Timur Zhuraev, the head of Ferkensco Management Limited in Uzbekistan.

People

PHOTO: EUROCHEM

Gustavo Horbach, EuroChem Group's new Head of South America.

Gustavo Horbach is EuroChem Group's new Head of South America with responsibility for operations and strategic business development in the region. Gustavo was previously EuroChem's VP for upstream production and investment projects in South America. He has been with the company since 2021.

In his new role, Horbach will lead on EuroChem's assets and operations across the region. He will also ensure delivery of the company's strategic growth plan. EuroChem claims to be the fastest growing fertilizer company in South America, having invested over $1.5 billion in the region since 2016.

One of Gustavo's major priorities will be to complete and commission the large-scale Salitre project, a phosphate mining and production complex located in Minas Gerais, Brazil, in the first quarter of 2024. Salitre is expected to meet 15 percent of total Brazilian phosphate fertilizer demand when it is completed.

"Brazil is the food basket of the world, and key to global food production and security. I'm pleased to be taking the lead in EuroChem's South America operations and am committed to the Group's vision of growth in the region. We will seek to efficiently consolidate the assets we already own, not losing sight of potential market opportunities and ensuring that our capital investments – notably Serra do Salitre – come into operation in a solid and reliable manner," Gustavo Horbach said.

Horbach is a civil engineer with post-graduate degrees in business administration and project management. He brings to EuroChem more than 20 years of leadership experience at global organisations. His past responsibilities have included industrial operations and complex capital projects in the petrochemicals, oil and gas, fertilizers, mining and energy sectors.

Welcoming the appointment, Don Lambert, EuroChem's CEO for the Americas, said: "The scale of EuroChem's investment in South America, clearly demonstrates our commitment to supporting Brazil and the agricultural sector in the region. Gustavo has delivered some significant achievements in his time in EuroChem, leading the mining and production project in Serra do Salitre, which – at 75 percent completion – is ahead of schedule, and achieved with outstanding safety records. Gustavo shares our vision and is the right choice to lead our South America business which will enable us to expand our strategic focus on the region and accelerate our growth plans."

Magnus Krogh Ankarstrand is Yara International's new EVP for corporate development. Magnus was previously the CEO of Yara Clean Ammonia and will retain this responsibility until his successor is appointed. Prior to 2021, Ankarstrand held various other company roles, including SVP Yara North America and CFO of the industrial segment. He was also Yara's director of strategy and business development. Before joining Yara, Magnus worked for The Boston Consulting Group and served in the Royal Norwegian Navy. He holds a degree from The Norwegian School of Economics.

Yara has also named **Jorge Noval** as EVP & CEO Yara Industrial Solutions. He joins the company's executive board alongside Magnus Krogh Ankarstrand. Jorge was previously President, Yara Industrial Solutions.

"Magnus and Jorge both bring extensive experience to the Group Executive Board and represent areas which are key in our strategy execution. I am delighted to welcome them both onto the team," said Svein Tore Holsether, Yara International's president & CEO.

Eriez has appointed **Richard Murray** as its global flotation service director. He will be responsible for overseeing and expanding the company's global flotation aftermarket and service business. Mr Murray brings to Eriez a wealth of international expertise from his previous experience at Metso Outotec.

"Richard's career contributions have had a tangible impact in Australia, South America, South Africa, the Middle East, China, India, and North America, highlighting his outstanding ability to navigate and thrive in diverse regions," said Eric Wasmund, Eriez Vice President-Flotation. ■

Calendar 2023/2024

SEPTEMBER

17-19
13th GPCA Agri-nutrients Conference, DOHA, Qatar
Contact: Jovelyn Sadoguio
Tel: +971 4 451 0666, ext. 153
Email: jovelyn@gpca.org.ae

OCTOBER

2-3
TFI World Fertilizer Conference, WASHINGTON DC, USA
Contact: Valerie Sutton
Tel: +1 202 962 0490
Email: vsutton@tfi.org

10-12
IFA Crossroads Asia Pacific, BANGKOK, Thailand
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

17-19
Argus Fertilizer Europe Conference, LISBON, Portugal
Contact: Argus Media
Tel: +44 (0)20 3923 0741
Email: conferencesupport@argusmedia.com

DECEMBER

6-8
IFS 2023 Conference, CAMBRIDGE, UK
Contact: Steve Hallam, International Fertiliser Society
Tel : +44 (0)1206 851819
Email: secretary@fertiliser-society.org

FEBRUARY 2024

5-7
Argus/CRU Fertilizer Latino Americano 2024, MIAMI, Florida, USA
Contact: Argus Media
Tel: +44 (0)20 3923 0741
Email: conferencesupport@argusmedia.com

26-28
CRU Phosphates 2024 Conference & Exhibition, WARSAW, Poland
Contact: CRU Events
Tel: +44 (0) 20 7903 2444
Email: conferences@crugroup.com

Argus Fertilizer Europe welcomes you to Lisbon!

This year's Argus Fertilizer Europe Conference is taking place at the EPIC SANA Lisboa Hotel, Lisbon, Portugal, 17-19 October 2023.

Argus Fertilizer Europe is the sector's number one networking event in the region.

PHOTO: ARGUS

Argus Fertilizer Europe is making a welcome return to Lisbon this October. Taking place in Portugal's trade and agriculture centre, Europe's largest fertilizer event will offer three days of exclusive insights and unparalleled networking.

Access new customers and suppliers

Argus Fertilizer Europe is the number one networking event for senior representatives across the European fertilizer supply chain, including producers, traders and distributors. Now in its 35th year, the conference typically attracts 650+ delegates from more than 300 companies and 50 countries, and guarantees access to new customers and suppliers, as well as existing contacts. In 2023, there will also be opportunities to meet new delegates from the energy, shipping and AgTech sectors attracted by this year's vibrant agenda and large exhibition.

Exhibition and networking boost

This year's larger-than-ever exhibition has already successfully sold out. The expanded floor area available in Lisbon will ensure there are plenty of places to host client meetings. A wide range of different amenities (food, drink, charging points etc) will also make your networking experiences as smooth and as comfortable as possible.

The addition of a **start-up pavilion** to the exhibition area – new for 2023 – provides access to leading innovators who are helping to decarbonise the fertilizer sector and transform the industry with biostimulants and circular economy business models.

The conference is delighted to host the following exhibitors, all of whom will showcase products and services dedicated to the European fertilizer market: **ADM**, **AGI**, **Agripower**, **Argus**, **BioAnalysis**, **Bluestone**, **Eirich**, **EMT Blending and Bagging**, **CFC-Evergrow The Global Alliance**, **GoudenKorrel**, **ISG**, **Koppern**, **MCFP**, **Quest Group**, **RS Trading**, **Saviolife**, **Sinomagchem** and **Yunnan Yingfu**.

A topical agenda

The prolonged heatwaves and widespread wildfires that enveloped southern Europe this summer have brought home the need to prepare for the effects of climate change. This clearly has serious implications for agriculture – and consequently for fertilizer demand and production too. This year's conference agenda is therefore shining a spotlight on new products and innovations that will help tackle climate change, and mitigate its impacts on fertilizer trade, production and use.

Alongside traditional market outlooks, the agenda will also explore the future of energy and food production, two themes that are very much interlinked. Insights will be provided on the dynamics of natural gas and agricultural markets, for example, and how these sectors could work in harmony.

Agenda highlights include ministerial and C-suite level presentations:

- Keynote speech delivered by **Maria do ceu Antunes, Minister of Agriculture, Portugal**.
- Creating a sustainable production complex. **OCI**, **Fertiberia**, **Arab Potash Company**, **IFA** and others.
- What is a decarbonised fertilizer and what value-add does it bring to the fertilizer consumer? **Heineken**, **Yara**, **ADM Plant Health**, **Herogra** and others.
- Market synergies: How will gas markets affect fertilizer pricing. **Axpo Iberia**, **RWE**, **Uniper** and **Cheniere**.
- Exploring markets beyond Europe: where can Europe import fertilizers from? **Apex Brazil**, **SML**.

Fertilizer Fast Track

Fertilizer Fast Track is specifically designed for industry newcomers or those seeking a refresher on market essentials. The session will cover the fundamentals of key market products, clean ammonia pricing and more. Pass holders will have exclusive access to Argus experts and can participate in interactive discussions on raw materials (NPKs) and finished products (phosphates, potash and clean ammonia).

Join the European fertilizer community in Lisbon

Maximise this opportunity to meet with senior decision-makers across the European bulk and specialty fertilizer supply chain all under one roof. Secure your place in advance of the conference and benefit from early access to the event networking app which launches in September. This allows you to plan your schedule ahead of the crowd and start setting up meetings straightaway.

Visit the website at: www.argusmedia.com/fertilizer-europe to see the latest list of registered attendees and the current agenda. ■

Europe's NPK industry

The Moustier NPK production plant in Belgium. This was acquired by Yilfert Holdings in September 2022 as part of its purchase of Rosier.

PHOTO: ROSIER/BOREALIS

We profile leading European NPK fertilizer producers. Major ownership changes have taken place within the EU during the last three years. Europe's NPK producers have also needed to adjust their raw material sourcing in response to the Russia-Ukraine conflict.

The term 'NPK' is a catch-all phrase given to any fertilizer containing the primary crop nutrients nitrogen, phosphorus and potassium.

For growers, one of the main advantages of NPK fertilizers is that they can be specifically formulated, according to crop and/or soil type, to address nutrient needs and deficiencies. NPKs are typically applied to crops such as sugar beet, sunflower, and buckwheat during the autumn and to corn, wheat, barley, and vegetable crops during the spring.

NPKs are supplied to the market as either physical blends – of granular urea, diammonium phosphate (DAP) and muriate of potash (MOP), for example – or as compound NPKs produced using steam or chemical granulation (*Fertilizer International* 513, p46).

The manufacturing of compound NPK fertilizers via chemical granulation is often favoured due to quality considerations, as it produces hard, spherical, evenly sized granules of uniform composition. In this NPK production route, phosphoric acid and sulphuric acid are reacted with ammonia to produce a slurry. This is introduced as a spray into a granulator alongside solid raw materials such as potash (*Fertilizer International* 513, p46).

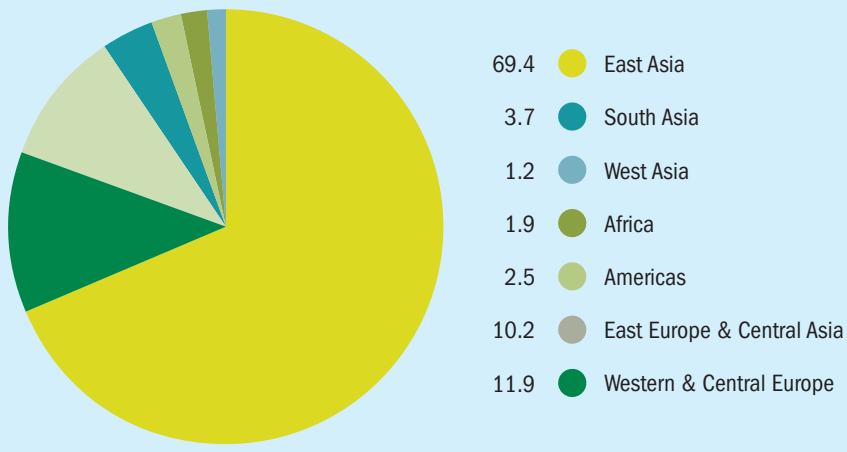
NPK products make up a sizable share of the overall fertilizer market. In 2020, for example, NPKs on a product basis accounted for a:

- 36 percent share of the 40 million tonne global potash market
- 26 percent of the 49 million tonne global phosphates market
- 16 percent of the 112 million tonne global nitrogen market.

Global compound NPK production totalled 100.8 million tonnes in 2021, according to the International Fertilizer Association (IFA). World production has been relatively stable since 2015, keeping within the range 96.8-101.3 million tonnes annually.

Regionally, Western Europe is the world's second largest compound NPK producer after China (Figure 1), manufacturing

Fig. 1: **World compound NPK production in 2021, by region (Mt product 2021)**



Source: IFA

around 11.9 million tonnes in 2021. The region is also responsible for 40-45 percent of world compound NPK exports, with international trade ranging from 6.2-6.6 million tonnes between 2018 and 2021, according to IFA.

Although China is a massive producer of compound NPKs – manufacturing more than 69 million tonnes in 2021 – this is overwhelming for domestic consumption with only a couple of percent of the country's output entering international markets (1.5 million tonnes in 2021).

Adapt to survive and thrive

Europe's fertilizer producers are increasingly focussed on premium products such as compound NPKs, water-soluble fertilizers, micronutrient products and nitrates. The shift to NPK production has been a particular popular and successful strategy.

Incorporating compound fertilizers within their product mix has provided European companies with a strong position in the higher-margin NPK market. Indeed, the top ten global NPK exporters includes six of the region's countries – Belgium, Norway, Finland, the Netherlands, Spain and Poland.

Merger and acquisition activity continues to be a characteristic of the European NPK market. Spain's Fertiberia was notably acquired by private equity firm Triton in 2020. More recently, Borealis accepted a binding €810 million offer from Agrofert for its European nitrogen business in June 2022. This was quickly followed by a €35 million binding agreement from Yilfert for Borealis' 98 percent stake in NPK producer Rosier in September 2022.

Russia's invasion of Ukraine hit European nitrogen producers hard last year due its impact on natural gas availability and pricing. Natural gas, the industry's key feedstock, typically accounts for 90 percent of ammonia production costs.

Consequently, record rise in gas prices at the end of August 2022 triggered a spate of ammonia production curtailments across the continent (*Fertilizer International* 510, p8). This eventually affected around two-thirds of European ammonia production (*Fertilizer International* 513, p13).

Although lower European gas prices in November 2022 heralded a return to profitability, last autumn's ammonia production curtailments did have implications for downstream fertilizer production. This affected four million tonnes of Yara's fertilizer production capacity, for example, across its European production sites, this total including 300,000 tonnes of NPK production capacity. Actual production impacts were unlikely to be major, however, due to Yara's ability to import ammonia to replace curtailed production.

Nonetheless, question marks over the competitiveness of Europe's nitrogen producers remain, as domestically produced ammonia has periodically struggled to compete on cost with ammonia imports into the region during 2022 and 2023 (*Fertilizer International* 515, p7).

This is an important issue as the costs and availability of ammonia, a key ingredient in the chemical granulation of NPKs (*Fertilizer International* 513, p46), will ultimately influence the economics of compound NPK production.

CF Fertilisers UK, for example, closed its Ince, Cheshire, site in the UK last year due to mounting cost pressures. The production complex at Ince featured a 380,000 t/a capacity ammonia plant together with downstream production capacity for ammonium nitrate fertilizer (Nitram) and three compound fertilizer (NPK+S) plants with a combined capacity of 415,000 t/a. The site had not produced ammonia since September 2021 due to high natural gas prices (*Fertilizer International* 509, p8).

Yara – a regional and global NPK giant

Yara International is Europe's leading phosphate rock and NPK producer. The company's Siilinjärvi mine in Finland – Europe's only phosphate mine – produces around one million tonnes of phosphate rock concentrate and 300,000 tonnes of phosphoric acid annually.

Yara's combined European operations provide 5.3 million tonnes of compound NPK production capacity (Table 1), more than 80 percent of the company's total global capacity of 6.5 million tonnes for compound NPKs. This is divided between six sites in four European countries: Siilinjärvi and Uusikaupunki in Finland, Glomfjord and Porsgrunn in Norway, Montoir in France and Ravenna in Italy.

Yara is incorporating the latest digital technology into NPK production, as Marcus Furuholmen, the company's senior vice president with responsibility for this, recently explained:

"The production process for NPK fertilizer requires adjustments for each individual grade. It can be challenging for the production teams to keep track of the best set points for each grade to achieve optimum results. Golden Batch is a control room web application that monitors the process and assists operators in selecting ideal set points for critical parameters influencing throughput. The solution helps to reach higher stable production volumes, and we have already seen the first positive results."

Yara is a market-leading producer of compound NPKs, manufacturing 6.0 million tonnes globally in 2022. The company's NPK deliveries totalled 8.5 million tonnes last year, with Yara-produced compound NPKs contributing 5.7 million tonnes to this total alongside 2.5 million tonnes of NPK blends. NPK deliveries within Europe reached 2.1 million tonnes in 2022, with Yara almost exclusively selling its own company-produced compound NPKs (2.0 million tonnes) into this market.

These production volumes and deliveries place Yara well ahead of competing NPK producers such as Coromandel, Gresik, IFFCO, PhosAgro and Acron. The NPK market is a lucrative one for Yara. NPK sales revenues rose by more than 35 percent year-on-year to $7.0 billion in 2022, representing its largest sales segment by product type. The company achieved an average realised NPK price of $874/t in the fourth quarter of 2022, a 37 percent rise year-on-year.

The company's compound NPK products, marketed under the YaraMila brand name, typically sell at a price premium relative to commodity blends.

Premium products able to deliver high margins – including compound NPKs, calcium nitrate (CN), fertigation and micronutrient (YaraVita) products – feature strongly in Yara's fertilizer portfolio. Increasing the capacity to produce and sell these premium products is therefore an integral part of Yara's growth strategy.

This has been partly delivered by expanding European NPK output. An NPK expansion at the Uusikaupunki site in Finland came on-stream in the third quarter of 2016. Further NPK capacity additions in Norway – by 70,000 tonnes at Porsgrunn and 50,000 tonnes at Glomfjord – were also completed during 2018.

The start of the Russia-Ukraine conflict in 2022 had major impacts on European

Table 1: **Yara's European NPK production sites***

	Siilinjärvi, Finland	Uusikaupunki, Finland	Porsgrunn, Norway	Glomfjord, Norway	Montoir, France	Ravenna, Italy
Product	**Production capacity ('000 tonnes)**					
Ammonia			500			
Nitric acid	200	500	1,600	400	300	400
Phos acid	300					
Phos rock	1,000					
NPKs	500	1,200	2,300	600	300	400
Nitrates		200			400	400
CN			1,100	200		

**December 2021.* *Source: Yara*

fertilizer production – including NPK manufacturing. Although Yara's direct investments in Russia and Ukraine are limited, the company did partly rely on Russian phosphate, potash and ammonia as raw materials. It also purchased significant volumes of natural gas from Russia for its European operations.

Yara announced it was ending raw material sourcing from Russian entities in March 2022. It subsequently eliminated the use of Russian-sourced phosphate rock, for example, by increasing sourcing from its own Siilinjärvi mine, as well as from suppliers in South Africa, Morocco, and Jordan.

"Because [we] had performed extensive testing of other sources of phosphate rock, Yara could make the switch in its full-scale NPK plants overnight. This would not have been possible without years of research and strong internal collaboration," said Mohan Menon, the department director for NPKs at Yara Porsgrunn.

Sanctions on Belarus also saw Yara quickly wind-down its sourcing of Belarusian potash with a pledge to eliminate this completely by the start of April 2022.

Major player ICL

ICL Group operates two European NPK production plants located in Amsterdam in the Netherlands and Ludwigshafen in Germany. Combined, both sites provide the company with 850,000 t/a of NPK production capacity within the EU market.

ICL's Amsterdam site has a total nameplate capacity of 550,000 tonnes for NPK production, divided between 450,000 tonnes of granular and 100,000 tonnes of powder products. The Ludwigshafen plant, meanwhile, has a nameplate production capacity of 300,000 tonnes.

ICL is able to produce over 80 different grades of NPK fertilizers from its Amsterdam and Ludwigshafen production sites. The company also has two mines in Europe: potash is mined at Súria in Spain, while the Boulby mine in the UK is the world's first and only polyhalite mine.

ICL also markets *PKpluS®*, a polyhalite-containing range of granular PK fertilizers. These balanced formulations offer phosphorus and potassium supplemented by secondary nutrients, including sulphur, magnesium and calcium.

ICL Amsterdam NPK production plant.

PHOTO: ICL

Grupa Azoty targets domestic and export markets

Grupa Azoty Police, a subsidiary of Grupa Azoty, is Poland's largest manufacturer of phosphoric acid, phosphates and NPK fertilizers. The company is based in Police in the country's southern Lesser Poland province. Its main commercial products include:

- MAP, DAP and NPK fertilizers, incorporating secondary nutrients (sulphur, magnesium) and micronutrients
- A granulated NS fertilizer comprised of ammonium sulphate, urea and magnesite
- Urea
- Liquid ammonia
- White titanium dioxide-based dyes.

A major $15 million (PLN 67 million) phosphoric acid plant upgrade was completed at the Police site in 2019.

Grupa Azoty Police's fertilizer unit is the largest within the company, in terms of production volumes and revenues. Its NPK and DAP products – POLIFOSKA® and POLIDAP® – are market-leading brands in Poland.

Grupa Azoty Police produced 690,768 tonnes of compound fertilizers in 2022, these accounting for 47 percent (PLN 2.5 billion) of total company revenues of PLN 5.3 billion ($1.3 billion). Last year, the domestic and export market accounted for 65 percent and 35 percent, respectively, of total fertilizer and ammonia sales. Key export markets include United Kingdom, Germany, Italy, Sweden, Spain, the Czech Republic, Brazil, Lithuania, Hungary, Greece, Denmark and Romania. Combined sales to those countries accounted for 82 percent of total export sales.

Financial performance in 2022 was largely driven by raw material and final product price trends. Commenting in this, the company said:

"[Annual] results were strongly influenced by the turbulence caused by Russia's aggression against Ukraine, which has a negative effect on the availability and prices of raw materials, eventually also translating into rising prices of final products. In the first six months of 2022, markets continued to be affected by strong upward trends in prices of many feedstocks and raw materials used in production relative to the same period last year, in particular natural gas, phosphate rock, potassium chloride and sulphur, pushing up the prices of fertilizer products.

"The third quarter was a period of high prices and continued increases in the prices of key raw materials used in production. Natural gas prices reached their all-time highs in late August 2022."

Fertiberia adapts

Grupo Fertiberia operates 16 production centres located in four countries – ten in Spain, three in Portugal, two in Algeria and one in France. These are capable of producing around eight million tonnes of fertilizers and intermediate products.

Fertiberia is a major European producer of compound NPKs. The company manufactures 15 types of compound NPKs under its Classic product range. These balanced products incorporate additional secondary nutrients and micronutrients such as sulphur, iron boron and zinc. Fertiberia also offer specific blends formulated for crop types including potato, grape vines, as well as fruit and citrus trees.

Although it has not publicly disclosed production figures in recent years, Fertiberia manufactured more than half a million tonnes of NPK fertilizers in 2020.

The company manufactures compound NPKs at the 250,000 t/a capacity Huelva plant in Spain. Portuguese subsidiary ADP Fertilizantes also has the capacity to produce 400,000 t/a of NPKs and 170,000 t/a of superphosphates at its Setúbal plant. NPK blending plants at Ile-et-Vilaine in France and Utrera in Spain provide a further 120,000 t/a and 25,000 t/a of blended NPK fertilizer capacity, respectively.

Spanish subsidiary Agralia, meanwhile, has the capacity to produce 75,000 t/a of complex liquid fertilizers at its Altorricón site supplemented by an additional 25,000 t/a of capacity at its Villalar De Los Comunero site. The Mengibar site of Spanish subsidiary Fercampo also provides Fertiberia with a further 35,000 t/a of complex liquid fertilizer production capacity.

Fertiberia ceased manufacturing DAP and MAP at Huelva in 2013, citing high production costs, having previously ended phosphoric acid production at the site. The company now sources the phosphoric acid needed for NPK production from international markets.

Fertiberia has been diversifying and expanding its product portfolio. The company launched a new line of NPK fertilizers in 2016 as part of the Fertiberia Advance product line. The company also introduced a new NPK product SulfActive in 2018, part of its Classic product range.

The company is relatively well insulated from the Russia-Ukraine conflict. Spain has a low dependency on Russian natural gas, compared to other parts of Europe, mainly relying on LNG imports and the Medgaz pipeline from Algeria. Fertiberia also sources its ammonia from North Africa, potash from Spain and Jordan, and phosphoric acid from Morocco.

Agrofert buys Borealis NITRO

Austrian-headquartered Borealis Group completed the €810 million sale of Borealis NITRO, its European fertilizer, melamine and technical nitrogen business unit, to Agrofert in July.

The business unit manufactures ammonium nitrate (AN) in France and calcium ammonium nitrate (CAN) in Germany. It also operates around 60 fertilizer warehouses across the continent with a holding capacity of 70,000 tonnes and an accompanying sales and distribution network.

Borealis, which is jointly owned by Austrian petrochemicals company OMV (75%) and Abu Dhabi based Mubadala (25%), had been seeking a buyer for its European nitrogen business since February 2021. The company had previously declined a €455 million offer for the business from Russian-owned fertilizer producer EuroChem Group (*Fertilizer International* 507, p8) following Russia's invasion of Ukraine.

The acquisition of Borealis' assets – which include five fertilizer production plants – makes Agrofert a key European producer and supplier of compound NPK fertilizers. Three of these plants are located in France – having originally been purchased from Total-owned GPN in 2013 – with another each in Germany and Austria. The largest fertilizer production site is in Linz, Austria. This produces ammonia, nitric acid, urea, NPKs and CAN. Its sales volumes totalled 3.9 million tonnes in 2021, generating revenues of €1.5 billion, some €1.3 billion coming from within the European market.

Agrofert owns a diverse range of chemicals, agriculture and food production businesses in central Europe. These had a combined turnover of €7.5 billion in 2021. The Czech company is already one of Europe's leading nitrogen fertilizer producers, with manufacturing sites in Germany, the Czech Republic, and Slovakia.

"Fertilizer production is one of the key segments of the Agrofert Group – and we trust in its future in Europe," said Petr Cingr, vice chairman of Agrofert's board of directors. "Our priority, now, will be to integrate Borealis' nitrogen business into Agrofert to enable us to approximately double our production capacity and, at the same time, to enter new markets, namely France, the Benelux countries, Bulgaria and Serbia."

Yilfert nears complete buyout of Rosier

In a further divestment, Borealis Group completed the €35 million sale of its share stake in Rosier (98.09%) to Yilfert Holdings in January.

Rosier is a major manufacturer of speciality NPKs and liquid and water-soluble fertilizers. The company operates two NPK plants at Moustier in Belgium and Sas Van Gent in the Netherlands. These manufacture the Rosafert range of granular compound fertilizers for basal or top dressing. These NPKs offer high levels of available nitrogen – in nitrate and ammonium form – in combination with phosphorus, potassium, sulphur and micronutrients.

Yilfert, part of Yildirim Group, is now seeking complete ownership of Rosier via a quick purchase of the remaining stake (1.91%) through a mandatory takeover bid at a price of €30 per share.

Borealis increased its controlling interest in Rosier – from 77.4 percent to 98.09 percent – as part of a rescue package at the end of July 2022. Borealis originally acquired a 56.86 percent interest in Rosier from French oil and gas giant Total in 2013.

Rosier does not disclose NPK production figures in its annual reports. However, the company generated sales revenues of €248 million in 2022, up by six percent year-on-year from €234 million in 2021. The company also recorded a profit of €1.4 million in 2022 versus a €37 million operating loss million in 2021.

Commenting on its 2022 operating performance, Rosier said:

"The war in Ukraine led to a steep increase in the price of natural gas and its derivatives (ammonia, ammonium nitrate, ammonium sulphate). Supply of raw materials from Russia and Belarus was subject to an embargo and alternative supply sources needed to be developed.

"The European fertiliser market was heavily under supplied due to the ban on imports from Russian producers. All this has led to increased raw material costs which were offset by a sharp increase in fertiliser product prices."

Rosier's new owner, Yildirim Group, is a private Dutch-Turkish industrial conglomerate headquartered in Istanbul. The company is wholly owned by brothers Ali Riza Yildirim and Robert Yuksel Yildirim. It operates in 54 countries and employs more than 20,000 people.

Yildirim's main business interests are in port management, metals and mining, fertilizers and chemicals, and the energy and power sectors. The company also owns a 24 percent share of CMA CGM Group, the world's third biggest shipping and logistics company.

PHOTO: NITRICITY

Nitric acid produced by Nitricity's lightning-in-a-bottle plasma reactor technology.

Nitrogen technology showcase

Ballestra, Nitricity, Solex Thermal Science and Stamicarbon showcase their state-of-the-art equipment and technologies.

STAMICARBON

Stamicarbon's Ultra-Low Energy plant – first operational experience

Nikolay Ketov, public relations officer

Stamicarbon is the nitrogen technology licensor of Maire Group. The company's latest process technology, the Launch Melt™ Ultra-Low Energy design, is proving a success with customers in East Asia and elsewhere.

The first two plants to apply this technology were the Jinjiang Xinlianxin and Hubei Sanning plants in China with a urea production capacity of 2,334 t/d each. They successfully went into operation in 2021. Two further installations, the Gemlik plant in Turkey and the Henan Xinlianxin plant in China, are under construction currently, while two other plants in China are at the design phase.

Additionally, Stamicarbon recently signed a contract for a new Ultra-Low Energy urea plant in Jiangxi province, China. This will be the seventh plant based on this innovative design and, with a capacity of 3,850 t/d, is also the largest to date (*Fertilizer International* 514, p10).

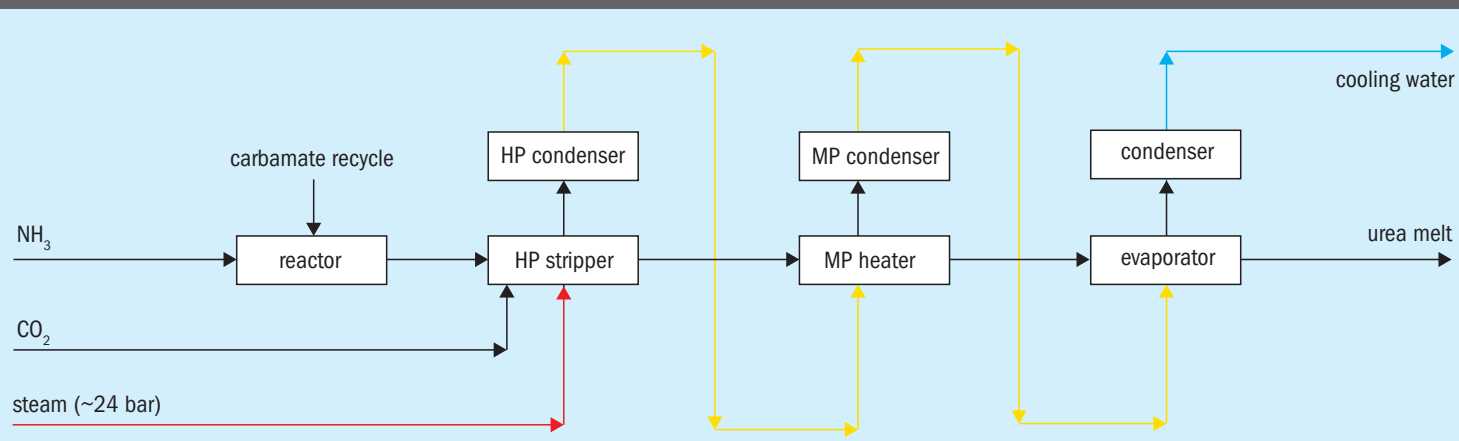
Ultra-Low Energy design is the next generation of Stamicarbon's pool condenser and pool reactor technology. It incorporates proven proprietary advances and benefits from a much lower steam consumption.

Heat integration breakthrough

Traditional urea processes are based on the 'N=2' heat integration concept, so-called because the heat supplied to the urea plant, in the form of high-pressure steam (typically 23 bar and 330 °C), is used twice. Stamicarbon's Ultra-Low Energy design is a breakthrough process that goes one step further by adopting N=3 heat integration — enabling the heat supplied to be used three times instead of two (Figure 1). As a result, the urea plant's overall steam consumption can be reduced by up to 40 percent and its cooling water consumption by about 16 percent, compared to traditional CO_2 stripping processes.

In N=3 heat integration, steam is firstly used as a heating agent to obtain high stripping efficiencies in the high-pressure stripper. Subsequently, the heat is recovered by condensing the strip gas within the synthesis section in the high-pressure carbamate condenser, pool condenser or pool reactor. This is then used to generate low-pressure steam for use in downstream sections of the plant.

Fig. 1: **Stamicarbon's Ultra-Low Energy design is highly efficient. N=3 heat integration allows high pressure steam to be used three times**



Source: Stamicarbon

Process description

Ultra-Low Energy technology retains all the features of Stamicarbon's previous pool condenser and pool reactor designs, such as reliability, operability, and the use of proprietary Safurex® stainless steels. At the same time, it substantially cuts operational expenditure (opex) by significantly reducing steam consumption.

The centrepiece of this technology, the Ultra-Low Energy pool reactor, does have major design differences. This reactor has two U-tube bundles, for example, handling two different fluid mediums. One bundle, the 'steam bundle', generates low-pressure steam, while the second 'carbamate bundle' is used for heat integration within the medium-pressure recirculation section.

Heat integration in the pool reactor is achieved as follows:

- The heat released by condensation of strip gas on the **shell side** of the carbamate bundle – at a pressure of about 144 bar and a temperature of 175°C – is used to decompose carbamate into ammonia and carbon dioxide on the tube side.
- The **tube side** of the carbamate bundle, in contrast, functions as a medium pressure heater.
- Essentially, this design configuration **integrates the shell side and tube side functions** of the U-tube bundle by taking full advantage of the available temperature difference between both process sides.
- It does this **without a heat transfer medium**.
- Importantly, the high heat transfer coefficient achieved allows **the size of the carbamate bundle** to be kept relatively small.

The amount of low-pressure steam generated by this pool reactor design is enough to satisfy urea process requirements.

Stamicarbon's Ultra-Low Energy design includes two high-pressure pieces of equipment: a high-pressure stripper and a high-pressure pool reactor (Figure 2). It optimises urea plant capital expenditure (capex) by avoiding the need for a high-pressure scrubber.

The absence of a high-pressure scrubber also lowers the height of the structure. Instead, the total height of the high-pressure equipment is limited to around 20 metres, this being determined by the elevation of the pool reactor, the urea plant's heaviest piece of equipment. The high-pressure stripper, in contrast, is located close to ground level. Another vessel, the intermediate flash tank occupies the highest elevation at the plant.

First start-up experience

The Jinjiang Xinlianxin Ultra-Low Energy plant in China was the very first plant to operate with this innovative technology. This 2,334 t/d capacity plant successfully started up in February 2021 and produces prilled urea.

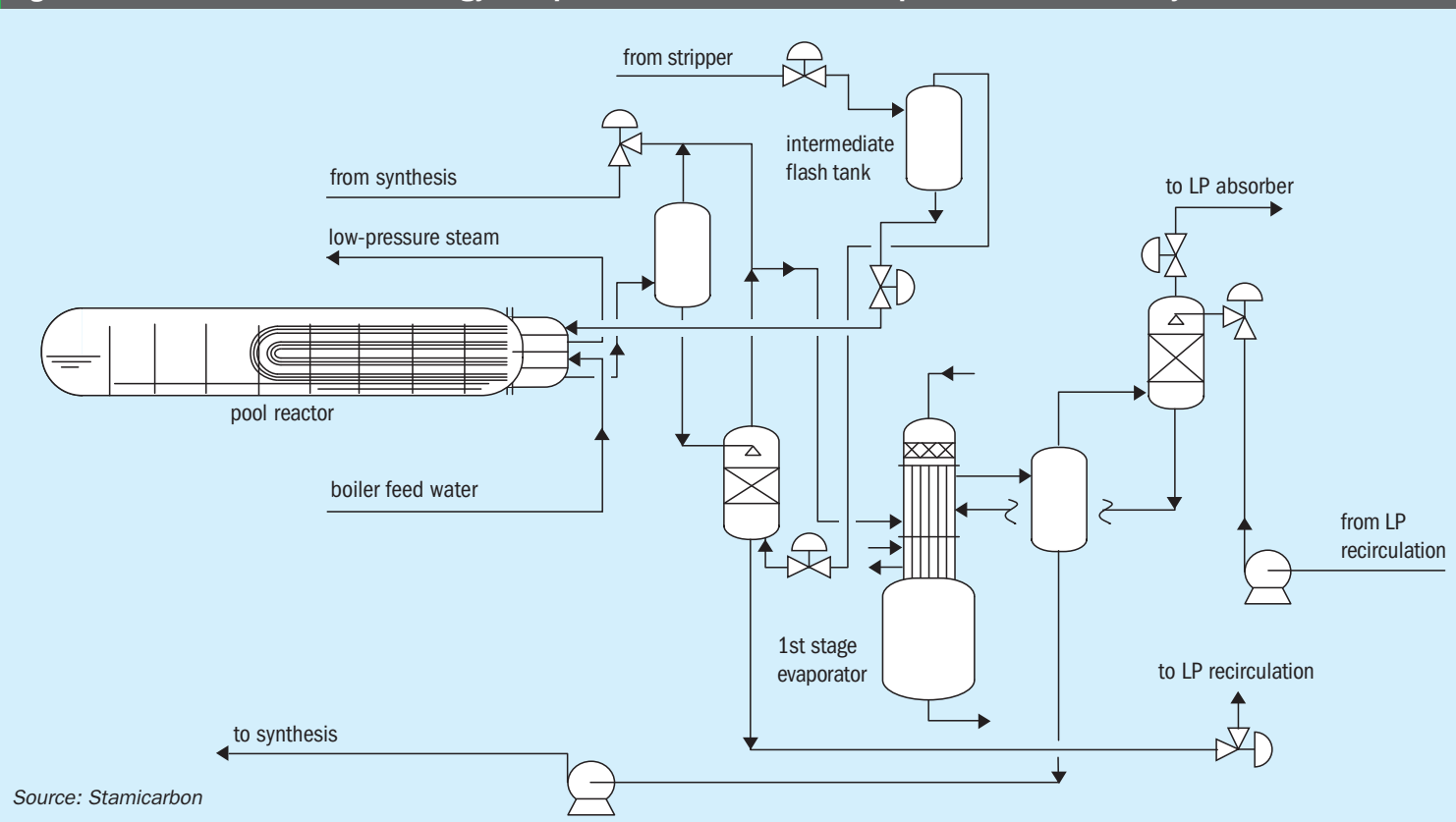
The plant's staff were thoroughly trained by Stamicarbon on the company's Operator Training Simulator prior to start-up. This provided a good understanding of the expected behaviour of the overall plant and its reactor.

The plant's start-up went very smoothly without any issues at the very first attempt. The plant was operated below full capacity initially until the feedstocks were assured. Production was then increased to above 100 percent of rated capacity during the first week of operation.

The energy consumption of the Ultra-Low Energy plant has set a new benchmark for urea production performance worldwide. Also, the presence of the medium-pressure recirculation section dampens disturbances that occur in traditional CO_2 stripping plants due to the direct discharge of liquid from the stripper operation into the low-pressure section.

Actual plant performance parameters from the operation of the Jinjiang Xinlianxin plant are shown in Table 1. These results

Fig. 2: **Schematic of an Ultra-Low Energy urea plant. This incudes a medium-pressure recirculation system**



Source: Stamicarbon

Table 1: **Actual plant performance parameters from the operation of the Jinjiang Xinlianxin Ultra-Low energy plant in China (top row) versus those of standard pool reactor plant (middle row). Percentage improvements in steam and water consumption are shown (bottom row)**

Process concept	Steam consumption (23 bara, 330°C)	Cooling water consumption (ΔTCW as 10°C)
LAUNCH MELT™ Ultra-Low Energy plant China	567 kg steam t urea	61 t CW/t urea
LAUNCH MELT™ Pool Reactor designs	870 kg steam/t urea	73 t CW/t urea
Improvement	35%	16%

Source: Stamicarbon

demonstrate the major advances in urea process technology achieved by the Ultra-Low Energy concept at an average plant operating capacity of 102 percent.

The plan's actual high-pressure (23 bar, 330°C) steam consumption (567 kg/t urea) is even lower than the value predicted during the design stage. Optimisation of process conditions – i.e., the ammonia feed temperature to the synthesis section – is expected to reduce steam consumption by a further 20-25 kg/t urea.

Overall, the plant's innovative design reduces steam consumption by about 35 percent and reduces cooling water consumption by about 16 percent, compared to the traditional pool condenser and pool reactor designs. This is achieved without extra investment cost as the capex of an Ultra-Low Energy plant is comparable to previous traditional designs.

The successful commissioning and stable operation of the Jinjiang Xinlianxin plant also validated the mechanical design and construction materials used in the Ultra-Low Energy pool reactor. The design fully employs Safurex® Infinity∞ steel and therefore benefits from the superior resistance to corrosion this provides.

Plant maintenance is also straightforward. The opening of internal covers, which are fully accessible through the manway, enables unrestricted and non-destructive testing inspections of the tube bundles and the internals of the distribution box without the dismantling of heavy parts.

Ease of operation is another important benefit of Ultra-Low Energy plants compared to those based on traditional urea technology. This key advantage convinced the same Chinese customer to commission a second Ultra-Low Energy plant from Stamicarbon, which is currently under construction, and a third Ultra-Low Energy plant, which is currently under design.

Ultra-Low Energy technology is also suitable for revamping, irrespective of the original technology or capacity. Valuably, its use in plant revamps can increase urea production capacity, by replacing the existing outdated reactor, while simultaneously reducing plant energy consumption. ■

BALLESTRA

Moving methylene-urea production to the fertilizer industry

Massimo Gori and Svet Valkov

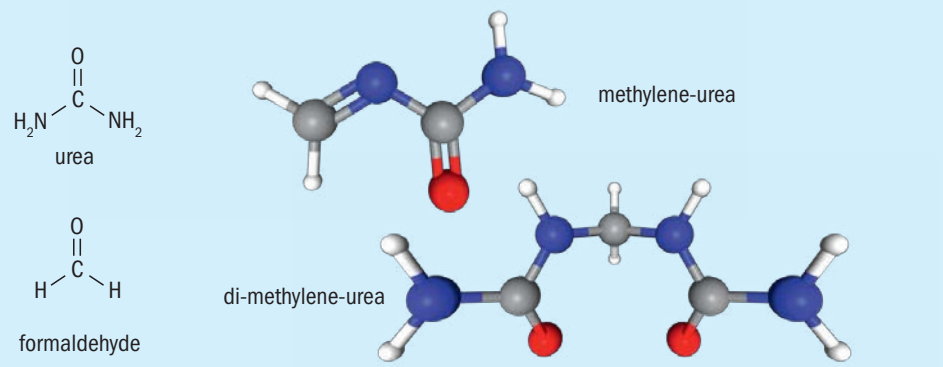
What if the means of delivering a step change in nutrient use efficiency was a product, methylene-urea, already available to the fertilizer industry?

Currently, the production of this compound is limited by the small size of the resin industry that supplies it. Ballestra is therefore working to scale-up methylene-urea manufacturing technology to allow the large-scale production of this slow-release fertilizer within the fertilizer industry.

Methylene-urea chain compounds

Methylene-urea (Me-urea) is obtained by condensing together one molecule of urea with one formaldehyde molecule. If condensation continues, more molecules join together to form di-methylene-urea (Figure 1). Proceeding further with polymerisation increases the chain length and a compound known as ureaform is then formed. The ultimate end product of this polymerisation process is a urea-formaldehyde (UF) resin made up of long reticulated molecular chains.

Fig. 1: **The chemical structures of methylene-urea and di-methylene-urea**



Source: Ballestra

These types of compounds are already well-known within the nitrogen industry. Urea-formaldehyde concentrate (UFC), for example, is an essential additive used to impart mechanical resistance and hardness to urea granules. There is also good awareness of formaldehyde as it occurs as a product of the partial oxidation of methanol, a major basic chemical and close relatives of ammonia.

Valuable slow-release properties

Urea is very soluble in water while UF resins are completely insoluble. The various methylene-urea chain compounds – Me-urea, di-methylene urea and ureaform – sit somewhere in between these two extremes and are partly soluble. Generally, these compounds become more insoluble as their polymer chain length increases.

Urea, Me-urea, di-methylene urea, ureaform and UF resins are all excellent nitrogen carriers and can therefore be used as fertilizers. The slow-release properties of methylene-urea chains can be precisely engineered to dissolve and make nitrogen available within days, weeks, or months, according to the requirements of a particular crop. These compounds will resist water leaching depending on their polymer chain length, starting from urea (very soluble) and arriving at UF resins (insoluble).

Me-urea and longer chain ureaform fertilizers are available in both liquid and granular form and are considered safe for both humans and the environment. These slow-release nitrogen fertilizers, when applied as a foliar liquid, have been shown to be 4-5 times more efficient than conventional nitrogen fertilization, i.e. 4-5 kg of urea are needed to deliver the same yield effects as 1 kg of Me-urea. Granular Me-urea offers similar efficiency advantages and is widely applied in turf (e.g., golf courses) and ornamental markets as well as in agriculture. Both liquid and granular products do not result in crop burn as they have a low salinity and no nitrate content.

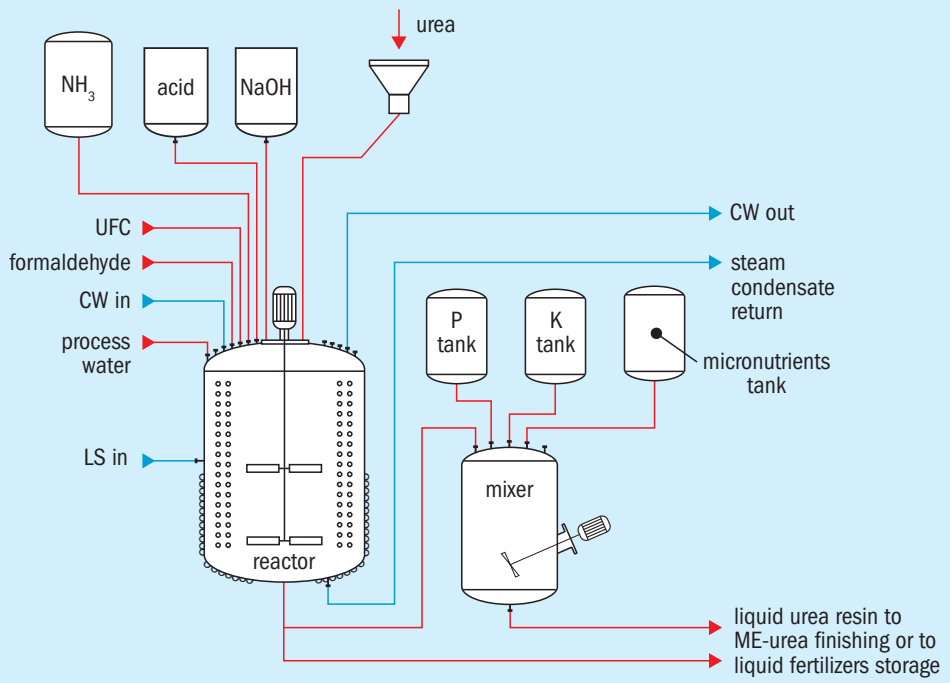
Low volumes, high prices

The valuable fertilization properties of Me-urea compounds are said to have been discovered when grass surrounding a ureaform tank grew greener and taller because of a leak. In reality, Me-urea is a well-studied and well-known product that has been sold and used for decades. It is a proven slow-release fertilizer that is attractive in the wider world market and can therefore command premium prices.

Currently, Me-urea is manufactured by the UF resin industry, a much smaller industrial sector compared to the fertilizer industry, with installed capacity limited to a few hundred thousand tonnes per year.

Interestingly, though, this compound is made from chemicals already found in fertilizer production processes. That opens up the possibility that the fertilizer industry itself could begin to produce Me-urea, rather than sourcing this externally. This would allow fertilizer producers themselves to deliver the necessary step change in nutrient use efficiency – without sharing added value and margins with third parties. Indeed, in this article, we explain how Me-urea manufacturing can be moved from the UF resin sector to the fertilizer industry where it belongs.

Fig. 2: **The methylene-urea reaction section**



Source: Ballestra

Methylene-urea production

Ballestra's Me-urea production system (Figure 2) closely follows the approach already taken by the UF resin industry. The process design guarantees a fully automated, safe and durable production system, with no volatile organic compound emissions. Operators, by adding the recipe to the control system, are ready to go.

The core know-how behind Me-urea production is the process recipe. The use of a batch reactor allows this to be changed easily to deliver different product grades. UFC or formaldehyde are loaded with solid urea or urea solution into the reactor. Polymerisation via acid or basic catalysis is performed in closely controlled cycles with the conditions varied to obtain a specific polymer length (or mix of polymer lengths).

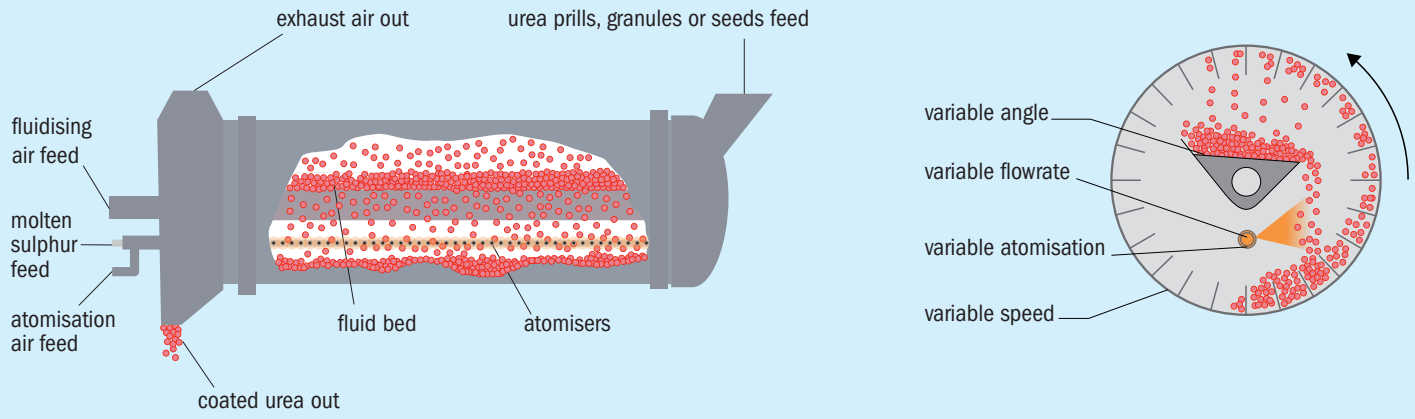
The product obtained can be stored as a liquid nitrogen fertilizer or mixed with other nutrients and micronutrients to obtain a precisely formulated liquid NPK fertilizer. Both of these product types can also be sent for further finishing in a drum granulator.

Although Me-urea production technology is well established, the finishing stage is where most existing plants fall short. This is also the reason why the production capacity of a single Me-urea line is generally limited.

Me-urea is actually a family of different products, not a single product based on a well-defined commercial specification. Because of this, each individual process recipe will require a specific set of finishing parameters for the Me-urea product obtained. However, most available granulation technologies do not have the flexibility to cope with the full range of Me-urea product grades.

This is where Ballestra's fluid drum granulator excels. Essentially, this is comprised of a rotating drum with a fixed table inside made of a perforated metal sheet (Figure 3). The rotation of the drum lifts

Fig. 3: **Schematic of Ballestra's fluid drum granulator**



Source: Ballestra

the granules onto the table, where they are kept in fluid bed conditions by air flowing through holes in the metal sheet. The perforated table is slightly inclined to one side. This allows dry granules from the fluid bed to fall back to the lower part of the rotating drum. While doing so, they pass through an incoming spray of fresh Me-urea, which creates a further layer of material.

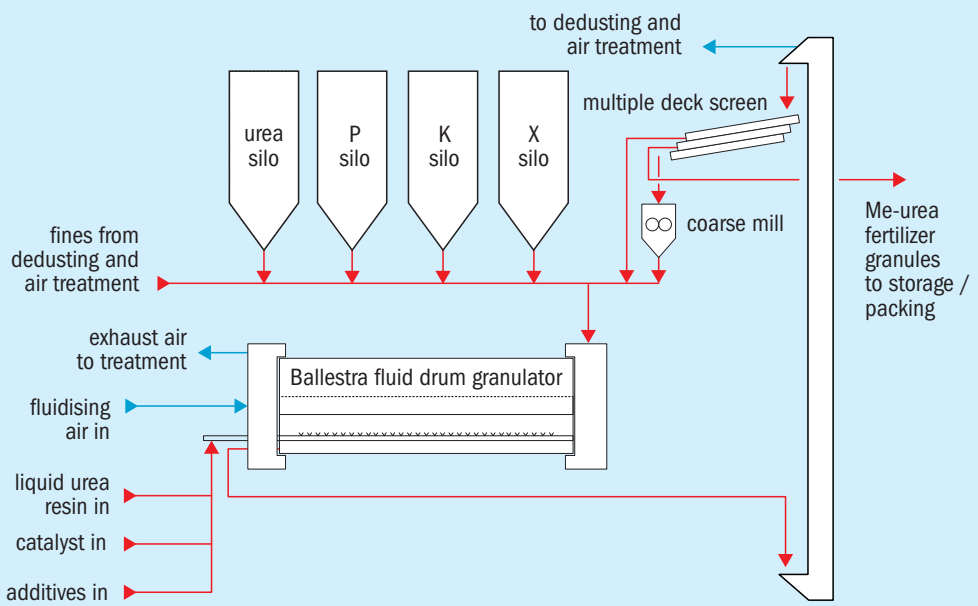
Everything in the design is about flexibility. The following parameters can all be carefully regulated:

- The drum's rotation speed
- The inclination of the fluid bed table
- The temperature and flow of the fluidising air
- The temperature of the freshly sprayed liquid.

Once the proper parameters for each recipe are defined, the result is granules with a solid, onion-like, layered structure and a hardness and mechanical resistance far greater than those of standard urea granules. A notable feature of Ballestra's fluid drum granulator is that the fresh solution is sprayed into an area away from the fluidising air flow. This limits droplet entrainment, compared to a standard urea granulation process, and therefore reduces the duty on the downstream air cleaning section.

Setting aside these differences, the overall finishing scheme for Me-urea (Figure 4) resembles a simplified urea fluid bed granulation process.

Fig. 4: **The methylene-urea finishing section**



Source: Ballestra

More products from the same plant

The finishing process described here is not limited to just Me-urea and ureaform production. Its flexibility also enables the production of other, more complex types of slow-release fertilizers.

Prior to finishing, Me-urea and ureaform, because they are basically UF resins with shorter polymer chains, behave like a glue. Other nutrients can therefore be added as feed particles to the Ballestra fluid drum granulator and become evenly embedded within the solid and hard matrix of Me-urea granules. The resulting NPK and multi-nutrient granules have the same slow-release properties as standard Me-urea granules. This holds true even when the granule is broken as the added nutrients are still firmly fixed within the Me-urea matrix.

The fluid drum granulator can also be used as a quick and economical way of modifying the physical behaviour of urea granules and prills – by, for example, improving their slow-release properties, surface resistance and bulk flowability. This is achieved by coated or fattening urea prills and granules fed to the Ballestra fluid drum granulator with a layer of Me-urea.

The resulting granules have a core of pure urea surrounded by an Me-urea coating. The release of the urea core to the soil can be carefully timed by regulating the thickness of the outer Me-urea coating.

Applying Me-Urea coated urea granules to soils alongside seeds, for example, could provide a fertilization boost exactly when growing crops need it. Furthermore, supplying mixed granules with coatings of different thicknesses can provide a series of fertilization boosts at specific times. The end result

is precision engineered fertilizer granules designed to deliver nutrients at specific times to closely match crop requirements.

Partners on a common journey

Ballestra invites partners to help us shift methylene-urea production away from the UF resin and laminates industry and embed production within the fertilizer industry instead where it belongs. We believe this will make a significant contribution to fertilizer industry sustainability and improve nutrient use efficiency.

As a company, Ballestra offers robust and scalable process and finishing technologies, as well as agronomic, marketing and regulatory support, plus the expertise to deliver new fertilizer product recipes. By combining these strengths with industry partners who have the necessary feedstock availability, marketing push and innovative spirit, methylene-urea technology could be scaled up to meet actual market demand.

New products, intellectual property (IP) and applications could also be jointly developed. Achieving reductions in natural gas consumption during fertilizer production would be another worthwhile objective. ■

NITRICITY

Bridging renewable electricity and food production

Cleiton de Sequeira, director of business development

PHOTO: PIQUE ACTION

Nitricity's solar-fertilizer project in Fresno County, California

Challenges and opportunities

Nitrogen fertilizers are the foundation of modern agriculture and play a central role in global food security. Indeed, it is estimated that around 50 percent of the global population depends on the food produced by these synthetic crop nutrient products.

Today, nitrogen fertilizers are manufactured on a large scale at highly centralised production sites using coal or natural gas as the main feedstock, in combination with water and air. These plants use the traditional Haber-Bosch process to fix molecular nitrogen (N_2) from the atmosphere into ammonia (NH_3).

The ammonia generated in this way can be used directly as fertilizer, when injected into the soil (as is typical in the US Midwest), or instead used as a raw material to produce other nitrogen fertilizers, such as urea and urea ammonium nitrate (UAN).

The Haber-Bosch process revolutionised how nitrogen fertilizers are made and has undoubtedly helped to feed an expanding global population. Haber-Bosch's use of fossil fuels as the main feedstock in nitrogen fertilizer production has, however, becoming a growing concern. For every kilogram of fixed nitrogen obtained, the process generates around 2-4 kilograms of carbon dioxide (CO_2) emissions – the exact amount depending on the type of hydrocarbon feedstock consumed and the individual production process.

Additionally, when nitrogen fertilizers are applied to cropland, they decompose to provide plant-available forms of nitrogen [nitrate (NO_3-) and ammonium (NH_4+)] and nitrous oxide (N_2O), a greenhouse gas (GHG) 300 times more potent than CO_2. Overall, the global production, distribution, and application of nitrogen fertilizers results in 2.88 gigatons of CO_2-equivalent emissions annually, an amount that represents more than six percent of world GHG emissions.

NH_3 produced by the traditional Haber-Bosch process is referred to as 'grey' ammonia. Currently, there are two main ammonia production routes available to reduce CO_2 emissions. The first, the 'blue' ammonia route, still uses natural gas as a feedstock and cuts CO_2 emission via carbon capture and storage (CCS) or other mechanisms. The other route produces 'green' ammonia from hydrogen (H_2) generated by water electrolysis using renewable electricity, instead of sourcing this from natural gas. While both are valid solutions, they each have significant drawbacks. Green ammonia production requires high capital expenditure, for example, and blue ammonia still consumes natural gas and only partially eliminates CO_2 emissions.

The new geopolitical landscape that has emerged since the start of the Russia-Ukraine conflict presents the industry with another challenge. The conflict has triggered an energy crisis in Europe and a global nitrogen fertilizer price rally due to the limited supply of Russian natural gas.

As a result of the conflict, natural gas prices in Europe increased from around $25/MMBtu in January 2022 to a peak of $70/MMBtu in March 2022. Although natural gas prices have receded since then, the global outlook for the interconnected fertilizer, food and energy markets over the next couple of years remains volatile and uncertain due to increased tensions between Russia and Western nations.

In Europe, the impact of the conflict has been unprecedented, with ammonia production curtailments and plant shutdowns across the continent resulting in periods of high nitrogen fertilizer prices across the globe. A major concern is how this will impact food security in the coming years, with many growers across the world reducing their fertilizer application rates in response to high prices.

In a market encountering increasing complexities, from fertilizer production to logistics bottlenecks to climate change, concerted efforts by different players will be necessary to ensure nitrogen fertilizer production remains sustainable and resilient moving forward. In particular, while current systems and technologies have worked well,

innovation is now necessary if the fertilizer industry is to adapt to changing circumstances. Global food security depends on it.

Nitricity – part of the solution

Nitricity offers a wholly different approach to fertilizer production. The company's technology produces water-soluble fertilizers such as calcium nitrate from relatively small production hubs using only air, water, and renewable electricity. Taking the long-term view, this will bring nitrogen fertilizer production closer to the end user while boosting domestic production and reducing reliance on natural gas.

The company was founded in 2018 with the mission to electrify and distribute the production of nitrogen fertilizer. By avoiding the use of fossil fuels (natural gas and coal), Nitricity's technology has the potential to produce cost-effective, climate-smart nitrogen fertilizer for farmers and other stakeholders, while minimising the environmental impacts of fertilizer production, distribution, and application. The company's co-founders are former Stanford PhD and postdoc students with extensive backgrounds in catalysis, chemical engineering, and nitrogen-fixation technologies.

Lightning in a bottle

Nitricity's process mimics the nitrogen fixation that occurs in nature during lightning strikes. It emulates this natural process by using renewable electricity to generate plasma – essentially 'lightning in a bottle' – to break down molecular nitrogen (N_2) in the air. Once N_2 is cracked, it reacts with oxygen in the air to form NO and NO_2 inside a plasma reactor. A series of absorption columns efficiently capture and dissolve these species in water to produce nitric acid (HNO_3).

The 'green' nitric acid obtained can be used to make high-value nitrate-based fertilizers by reacting it with materials such as calcium carbonate, potash, and phosphate rock. Nitricity's production setup, which includes solar PV equipment, advanced plasma reactors and absorption columns, was successfully demonstrated at a solar-fertilizer project in Fresno County, California (see main photo).

In its scale-up journey, Nitricity is currently working to develop bigger and more efficient plasma reactors at its new headquarters in Fremont, California. This new system will be used to deliver

Shipping Nitricity's IFDC demo system from the San Francisco's bay area, California, to Muscle Shoals, Alabama

PHOTO: NITRICITY

Nitricity's fertilizer production hubs. These are expected to arrive on the market and be commercially available within two years.

The major benefits of Nitricity's technology that underpin its go-to-market strategy are:

- **Non-fossil fuel process**. Nitricity's technology will make 'green' fertilizers with low GHG emissions. It also makes the value chain more resilient since it does not rely on the volatile natural gas market.
- **Distributed fertilizer production**. Nitricity's vision for the future is to build distributed production systems able to serve a wide range of acres.
- **Local production**. Nitricity's technology allows the local production of nitrogen fertilizer – something that has not been possible until now in a market dominated by large production plants that depend on natural gas.
- **Increased competition**. The fertilizer industry is heavily concentrated with a few large players controlling the majority of nitrogen fertilizer production.
- **More efficient fertilizer**. Nitricity will make nitrate-based fertilizers which, from an agronomic perspective, tend to be more efficient than ammonium-based fertilizer (e.g., urea) and also generate less nitrous oxide (N_2O) when applied in the field.

The importance of partnerships

Nitricity has been fortunate to have several partners that share its vision to electrify and distribute nitrogen fertilizer production.

Nitricity closed its Series A fundraising round in August 2022. This raised $20 million and was led by Khosla Ventures and Fine Structure Ventures with the participation of Energy Impact Partners, Lowercarbon Capital, and MCJ Collective.

Nitricity was also selected by Elemental Excelerator to be part of their 11th cohort of investments – this comprising 17 companies focused on climate technology and decarbonisation. The investment from and guidance of Elemental Excelerator will bolster Nitricity's plans for growth, particularly the ambition to operate its renewable fertilizer technology at scale in agricultural applications.

In research initiatives, Nitricity is partnering with the prestigious and globally renowned International Fertilizer Development Center (IFDC) in Muscle Shoals, Alabama (see photo). This collaboration is revealing Nitricity's current GHG emissions profile and identifying opportunities for further reductions. More recently, Nitricity has partnered with Frontier and IFDC to accelerate the integration of carbon removal alongside fertilizer production from air, water, and renewable energy.

SOLEX THERMAL SCIENCE

New face to waste heat recovery

Jamie Zachary, marketing and communications manager

PHOTO: SOLEX/ECONOTHERM

Econotherm's heat pipe heat exchangers can supply combustion air pre-heaters with recovered heat that is otherwise lost.

A recent acquisition by Solex Thermal Science is expected to help the thermal energy and bulk materials specialist company grow its waste heat recovery business within the fertilizer industry.

Canadian-headquartered Solex announced the purchase of Econotherm, a leader in waste heat recovery technology, in June this year. Econotherm manufactures heat pipe heat exchangers that capture difficult-to-recover heat from industrial sources including hot and/or dirty exhausts. The UK-based company was established in 2007 and currently operates in the automotive, metals, construction, food, mining, oil and gas, power generation and pharmaceutical industries.

Better together

The Econotherm acquisition was a natural progression for Solex, according to CEO Lowy Gunnewiek, as both companies share a passion for working with customers to best address their operational needs.

"Our global client base in industries such as fertilizer has been asking for an even deeper suite of best-in-class, sustainable solutions that align with their operating needs and respective environmental, social and governance strategies," says Gunnewiek. "By combining Econotherm's deep expertise in waste heat recovery with our established heat exchanger solutions, we now have much deeper capabilities to help customers produce a better product at less expense to them and the environment."

Solex is a global market leader and developer of high-efficiency, indirect heat exchange technology for the heating, cooling and drying of free-flowing granular materials such as solid granules, pellets, beans, seeds and particles.

Over the past 30 years, the company has installed some 900 moving bed heat exchangers (MBHEs) in more than 50 countries worldwide. Originally serving the Canadian fertilizer industry, Solex has since expanded into other industries such as oilseeds, sugar and industrial materials such as minerals/sands, chemicals and polymers.

Delivering the energy transition

Solex's acquisition of Econotherm comes at a time when the company's heat exchangers are being widely installed within the energy transition sector – with a particular focus on industrial waste heat recovery.

Igor Makarenko, Solex's Global Director, Fertilizer, believes there is great potential to build on the existing success of the company's plate-based technology by 'upcycling' more energy from hot working fluids during cooling processes.

"In most cases, the hot fluid that comes out of our moving bed heat exchangers, when cooling fertilizer, is sent to a cooling tower where all the energy within it is rejected to the ambient air," observes Makarenko. "However, this energy can be used in other locations of the plant as useful thermal energy."

The recovered heat can be used, for example, to pre-heat air for combustion systems upstream in the production process – generating the heat needed by equipment such as fluid beds or rotary drum dryers. Alternatively, the recovered heat can be used to pre-heat air to 'trim dry' the fertilizer in MBHEs.

"We are also looking at combining our MBHEs with industrial heat pumps to upcycle the energy from waste to a heat source," says Makarenko. "Heat pumps, being electrically driven, do not create any additional CO_2 emissions either."

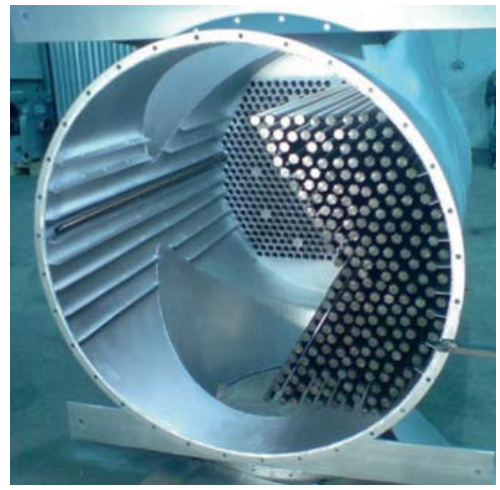


PHOTO: SOLEX/ECONOTHERM

Econotherm's heat pipe heat exchanger equipment incorporates patented superconductor technology –and is highly efficient at recovering waste heat from process exhaust gases.

Complementary technologies

Econotherm's heat pipe heat exchangers (see photo) will complement Solex's existing technology during drying and other process stages, according to Mark Boocock, the company's Managing Director, as well as providing new opportunities for heat recovery and re-use in other areas of the fertilizer production process.

Econotherm's patented superconductor heat pipe heat exchangers can extract heat from 'one-pass air' and then use this to pre-heat ambient air that goes back into the dryer. In Boocock's view, Econotherm's technology has clear and obvious potential for recovering energy from the particle-laden air generated as exhaust during fertilizer drying processes.

"With heat pipe heat exchangers, fertilizer producers can reduce the natural gas consumption needed for drying fertilizer, while also reducing the temperature of the air that's being sent to the scrubbers" says Boocock. "To reduce scrubbing cacpacity, our heat exchangers will also remove some of the particulate load in the air stream."

Upstream fertilizer applications

Ammonia and nitrate production – manufacturing steps further upstream in nitrogen fertilizer plants – are other process areas where heat pipe heat exchangers can be productively used to capture otherwise wasted heat, predicts Boocock.

Ammonia production, for example, employs large gas-fired heaters that supply heat to steam reformers. Solex and Econotherm will therefore be jointly exploring opportunities to recover heat from the exhaust gas coming out of these gas-fired heaters. This has the potential to reduce the amount of primary energy needed in steam production by reintroducing recovered heat back into the heater.

The installation of Econotherm's technology in fired heaters in the oil and gas industry is, says Boocock, already saving its customers "millions of dollars each month" in reduced fuel costs and is cutting greenhouse gas emissions. The use of heat pipe heat exchangers in this sector is long established and has been highly successful.

"It's making a profound difference," says Boocock. "Our solutions, many of which are first-of-its-kind installations, have achieved successful energy savings in applications otherwise considered unsuitable for conventional heat exchanger equipment."

The turbines and condensers in nitric acid production, meanwhile, act as large heat sinks, notes Boocock. In his view, the significant exhaust streams coming out of these front-end turbines provide ideal opportunities for waste heat recovery.

Eliminating catastrophic failures

Additionally, the shell-and-tube heat exchangers normally used to remove heat from tail gas/nitrous gas downstream of boilers can be difficult to manage, suggests Boocock. Typical problems include thermal stress cracking caused by differential expansion between surfaces and casings, and the condensation induced by cold spots leading to corrosion. The traditional thin metal surfaces of shell-and-tube heat exchangers are also vulnerable to erosion and corrosion.

Econotherm's technology, in comparison, is much less prone to these operational issues. In heat pipe heat exchangers, pipes can expand and contract freely without applying stress to casings, for example, while their isothermal operation eliminates cold spots and condensation. Because heat transfer is not affected by wall thickness, thicker walls are also used with this technology – typically 2.5-3.5 millimetres – providing higher erosion allowances.

Heat pipe heat exchangers also eliminate the catastrophic failures associated with other types of heat exchanger. This is because of built-in multiple redundancy, an intrinsic feature of the technology. Each heat pipe within Econotherm's equipment functions independently and autonomously.

"As a result, in general, the consequence of failure is minimised and manageable," says Boocock, whose company is at the forefront of heat pipe research and development.

"There is a lot of waste heat coming out of a fertilizer plant that's not being recovered. What we are offering is a type of heat exchanger that moves the risk and return on investment indicators in a positive direction – allowing fertilizer producers to look closer at their existing processes," sums up Boocock.

Unlocking the full value of crop residues

Crop residues are the plant materials that are left in the field after the harvested portion is removed. Many growers are increasingly valuing these materials due to their nutrient content and soil health benefits. **Dr Karl Wyant**, Nutrien's Director of Agronomy, highlights the value of crop residues and discusses how to manage these more effectively without interfering with on-farm activities. Ag retailers, in particular, are well-placed to advise growers on how to unlock value from their residues.

Growers are increasingly adopting practices (e.g., no tillage, reduced tillage, cover cropping, etc.) that allow residues to accumulate on the field. Although beneficial to crops and soils, this can negatively impact other key operations due to extra costs, slow spring warm up at planting, and by interfering with farm equipment.

How, then, can growers derive the most value from their crop residues while avoiding these potential downsides?

What are residues?

Crop residues are the plant parts that remain on the field (e.g., leaves, stalks, stems, etc.) after the harvest is completed (see main photo). While residues are often considered a waste product of the 'main event', the industry increasingly recognises that improved residue management makes agronomic and financial sense.

Research has shown that, by keeping residues on the field and allowing them to decompose over time, a grower can improve soil organic matter (e.g., soil carbon), reduce wind and water erosion, better control evaporation and runoff, and increase the infiltration of rain, snow, and irrigation water.

Growers have also reported higher yields under improved residue management systems. This is most likely due to substantial recycling of the N, P and K present in decaying plant tissues, these being released to be used again by the following crop when acted on by soil microbes.

Consequently, what were once viewed as an afterthought in crop production – residues – have gained considerable attention in farming operations across the globe. Fertilizer producers and agricultural input providers alike are now presented with opportunities to engage with growers in residue management, as outlined here.

PHOTO: KARL WYANT/NUTRIEN

Corn residues left over after harvest near Rockwell City, Iowa, USA.

Residues as a source of nutrients

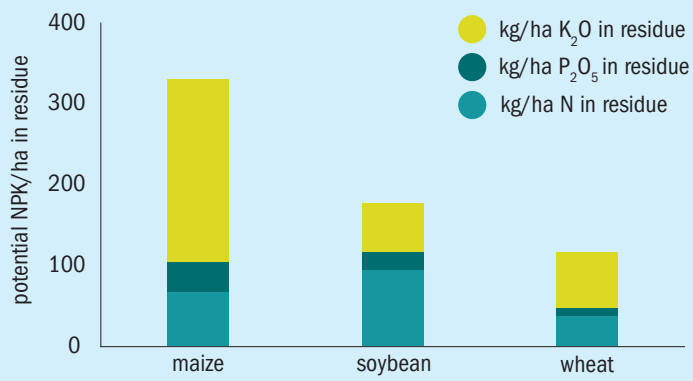
Crops need fertilizers, together with other available nutrient sources, to build the entire plant (roots, shoots, stems, leaves, grain, etc.) over the growing season. The whole nutrient management plan therefore contributes to supporting plant growth with the end goal of a profitable yield.

One can get a sense of how much NPK a crop needs by looking at the total nutrient uptake of the plant over the season (IPNI, 2012). These values are much larger than the fraction that is removed from the field in the harvest.

Subtracting the NPK (kg/ha) in the harvested portion from the total uptake NPK (kg/ha), for a given crop and yield, will reveal how much NPK potentially remains in the crop residue at the end of the season (Figure 1a). Furthermore, by multiplying these values by the fertilizer cost of each nutrient ($/kg NPK), you can assign a financial value to the nutrients contained in the residue that could be liberated for future crop use (Figure 1b).

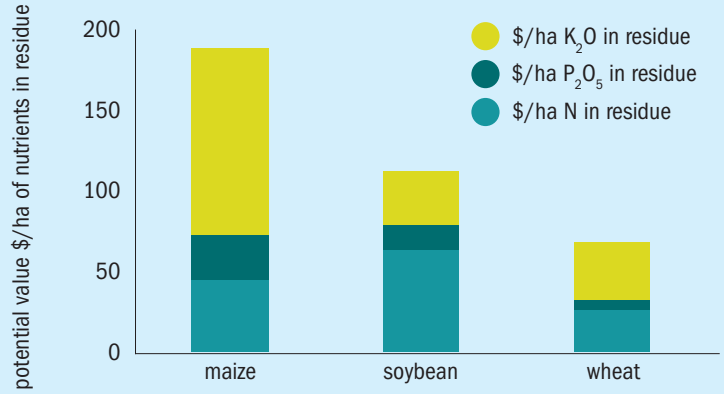
One challenge that remains, when evaluating nutrient release from residues, is how to allow for the recalcitrant nature (e.g., hard to decompose) of the remaining plant parts at the end of the season (e.g., stems, stalks, husks, etc.). In practice, there are several management options available (see Figure 2) to ensure the timely release of crop nutrients from residues to help maximise their value.

Fig. 1a: **Maximum potential nutrient quantity in residues after harvest for maize (yield = 11.1 t/ha), soybeans (yield = 3.5 t/ha), and wheat (yield = 3.0 t/ha). Yields are derived from 2021 USDA NASS averages. Maximum residue nutrient potential was calculated by subtracting the NPK removed in the harvested grain (kg/ha) from the total NPK uptake (kg/ha) (IPNI 2012).**



Source: Nutrien *Note: Root residues not included for simplicity.*

Fig. 1b: **Maximum potential nutrient financial value of residues after harvest for maize (yield = 11.1 t/ha), soybeans (yield = 3.5 t/ha), and wheat (yield = 3.0 t/ha). Yields are derived from 2021 USDA NASS averages. Maximum potential value of nutrients ($ per kg of N, P_2O_5, and K_2O) are derived from mid-July 2023 urea, 11-52-0, and 0-0-60 prices.**



Source: Nutrien *Note: Root residues not included for simplicity.*

Managing residues

A grower has several options for managing crop residues. Table 1 presents the most common management techniques and their benefits and disadvantages. Growers can face potential yield penalties if they do not manage residues properly or ignore them all together.

The accumulation of residues on croplands does have disadvantages. Residues can, for example: prevent the soil from warming at planting in colder climates; harbour pests and diseases; interfere with on-farm operations (e.g., block the planter, clog harvesting equipment, etc.). Furthermore, unless residues are actively managed, the grower may also have a lost opportunity for a timely nutrient source for the next crop (Figure 2).

Several options have been developed to help deal with the disadvantages of accumulated crop residues. Burning residues is an attractive option in some regions due to its low cost and speed. But concerns about air pollution, increased regulation, and the loss of crop nutrients has caused some growers to rethink this approach.

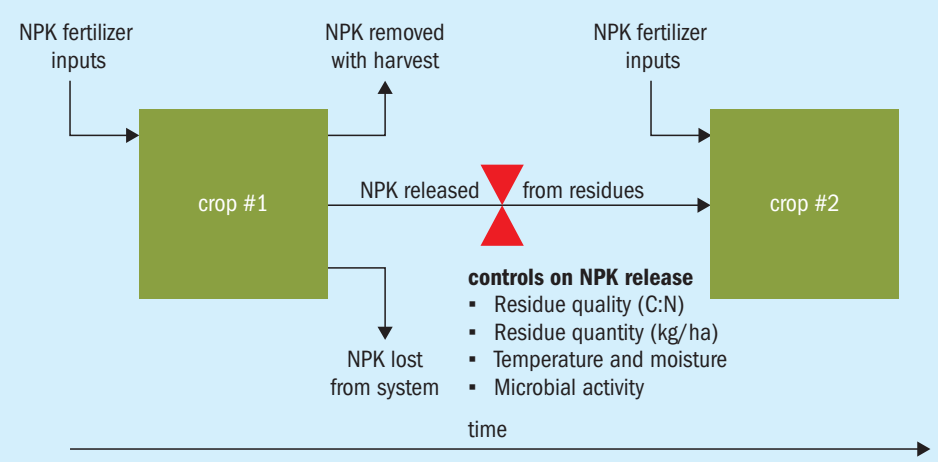
Tillage, in some form or another, helps to bury residues, which can hasten decomposition and limit their potential interference with planting and harvesting activities. On the other hand, tillage can disrupt soil structure and has costs associated with labour and equipment.

Finally, some growers choose to bale or graze their residues. This can provide a year-end income stream and help reduce future residue interference with farm activities. However, grazing and baling can accelerate nutrient export off the field, leading to higher fertilizer inputs for the next crop. In summary, traditional residue management practices offer several benefits but often have drawbacks (Table 1).

Overall, the drawbacks are making current residue management tools look less attractive, given recent trends to improve soil health and quality though no-tillage or reduced tillage, cover cropping, etc, or outright bans on burning.

So how might a grower and their ag retailer solve the challenge of accumulated residues when traditional tools are no longer employed? Enter new product technologies on the marketplace for improved residue management.

Fig. 2: **Ideally, nutrient release from crop residues needs to be timed to occur so it can help meet nutrient demand in the subsequent crop. Controls on release speed are marked by a red hourglass. Improved crop residue management, by making the timing of NPK release from residues more dependable, offers the potential to provide key nutrients for the next crop.**



Source: Nutrien

Table 1: **Common field residue management practices are listed along with pros and cons of each.**

Practice	Description	Pros	Cons
No action	Leave residues on field without management	No cost; leaves soil protected from the elements	Residue can accumulate and prevent soil from warming at planting; residue can harbour pests; residue may interfere with on farm operations (e.g., planting, harvesting); lost opportunity for timely nutrient source for next crop; NPK release timing might not be fast enough
Burning	Remove residue via fire	Inexpensive and effective; common practice; can clear and warm field surface	Removal of fodder source; source of air pollution; increased regulation and bans; lost opportunity for nutrient source for next crop
Tillage	Bury and mix residue with soil	Common practice; can clear and warm field surface; allows for increased residue contact with soil and microbes	Increased costs; disturbance to soil structure
Baling or grazing	Allow livestock to consume residue	Additional income source; can clear and warm field surface	Large scale removal of nutrients from the field; increased costs for baling

Emerging trends in residue management

In recent years, several approaches have emerged promising to enhance residue management while eliminating the drawbacks from common practices mentioned in the previous section. Products can be sorted roughly by their active ingredients (see Table 2 for examples).

Although these emerging products represent a potential new cost to growers, their adoption could hasten the release of the nutrients in the residue and help farmers unlock the fertilizer value therein (see Figures 1a & 1b). Ag retailers and product suppliers, therefore, have an opportunity to educate their customers on how to correctly use and position new technologies for optimum efficacy and performance.

In the field, **adding nitrogen** (e.g., UAN 32-0-0 or a high N analysis residue management product) in with post-harvest weed burn down sprays or water runs has been reported to help with residue management. Proponents claim the nitrogen in the fertilizer helps overcome N limitation in carbon-rich residues, so allowing microbes to flourish. While some debate exists on the efficacy of this practice, it remains a popular option nonetheless (see end bibliography).

Other new emerging trends in residue management centre around soil microbes – the organisms in the soil that are doing the heavy lifting on decomposition. Soil microbes include bacteria and

Table 2: **Selected emerging field residue management practices and their pros and cons**

Practice	Description	Pros	Cons
Nitrogen addition	Add nitrogen to residue to stimulate microbes	Common practice; can be combined with end of season weed management practices or water runs	Increased costs (fertilizer and fuel); some doubts over its efficacy
Microbes	Add living microbial inoculants to residues	Many products to choose from; some products target residue management specifically	Increased costs (product and fuel); concerns with product viability; challenges to establishing effective population at end of season
Enzymes	Add enzymes to help break down plant parts	Many products to choose from; some products target residue management specifically	Increased costs (fertilizer and fuel); product ingredient (e.g., enzyme type) must match targeted crop residue fraction (e.g., cellulose, sugars, starches, lignin, etc.) for best performance
Microbial foods and other carbon sources	Add food sources to help boost microbial populations	Many products to choose from; can be blended in with post-harvest field activities	Increased costs (fertilizer and fuel); microbes must be active to consume product and digest residues; food source must be edible by microbes

Source: Nutrien

fungi that live within the soil, on the soil surface, and even occupy the residue itself.

Microbes are also known for their role as pathogens and for causing disease in agricultural systems. However, in this case, we are relying on the microbes to perform decomposition – the key essential function for improved residue management.

Essentially, decomposition is the cumulative activity of the bacteria and fungi as they 'work' on crop residues. These microbes consume the decaying plant parts for energy (carbon) and nutrients and then release nutrients back to the soil, so contributing to and building the overall fertility of the field.

Due to their vital role, several residue management strategies have been proposed to optimise microbial populations to ensure they continue to be active in the soil after harvest:

A **first strategy** involves adding living bacteria and fungi to the crop residue. By 'inoculating' the residue in this way, the goal is to raise the decomposition rate of the residue by increasing the microbial populations. One challenge with these products is keeping the living organisms alive during storage, application, and post application. A non-viable product, at any stage, can lead to reduced efficacy and wasted input dollars.

A **second strategy** involve skipping the living microbial 'middleman' altogether by simply adding enzymes – the chemical machinery microbes themselves use to drive residue breakdown. Enzymes are non-living and can be applied with post-harvest herbicides or other materials. A potential drawback is that, because many enzymes are highly specific to the decomposition of certain plant parts (e.g., cellulose, lignin, etc.), the grower must match the product ingredient to the crop residue and its properties.

A **final strategy** involves the use of microbial foods. These are a broad class of ingredients whose goal is to feed the bacteria and fungi that are already in the soil and residues. The aim here is to hasten residue breakdown by feeding these decomposers with a carbon source that increases their populations after harvest. This strategy assumes microbes are limited by the availability of an edible carbon source and not limited by nitrogen (see above section).

The fact that microbial foods are non-living should make mixing and compatibility less of a concern relative to microbial inoculants (the first strategy). A drawback of this approach, however, is that soils with very low microbial counts might struggle to provide enough activity to improve residue breakdown.

In any case, with so many new residue management products on the market, growers are turning to their ag retailers for more information and help with selecting the right ingredient to meet their goals.

Closing remarks

Crop residue management continues to attract attention as growers look to reliably recycle nutrients into next year's growing season. Furthermore, many growers are recognising the nutrient and soil health contributions of residues and incorporating these into management plans.

Growers are also having to contend with increased residue biomass overall, as traditional residue management systems are phased out (e.g., burning), or conservation practices are put in place (e.g., reduced or no tillage and cover crops). If poorly managed, residues can negatively impact other key operations due to costs, slow spring warm up, and interference with equipment.

The current situation does, however, provide opportunities for the ag retail supply chain to step in. Ag retailers are well positioned to help growers better understand the value of their crop residues. They can also provide the know-how and right products to help their customers unlock the full post-harvest potential of their crop. ■

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ISG Pit to Ship Solutions™

CAPEX or OPEX Logistic, Storage and Ship Loading System

ISG, helping you on your way to your Environmental, Social and Corporate Governance journey (SCG).

Introduction: Intermodal Solutions Group (ISG) supply a logistical, storage and ship loading system to the fertiliser bulk industry.

ISG is Benchmarking their successful minerals system which has been implemented around the world using bulk containers and their patented lid lifting system on the tippler, to the fertilizer industry.

The system: The bulk containers are loaded at the production facility either by loading chutes or conveyor belts into the container roof hatches.

Once loaded the containers are sealed and the lid is not removed again until the bulk product is ready to be emptied.

The containers are transported by road or rail to the loading port. **Container ports** are employed for international export. **River ports** are utilised for river distribution.

Storage: The containers are used as storage sheds eliminating the usage of conventional dust and labour-intensive sheds. **No double handling**.

At the river ports some customers have bagging facilities so the bulk product is unloaded using the container tippler into the bagging shed through a chute arrangement which then delivers the product into bags for river distribution.

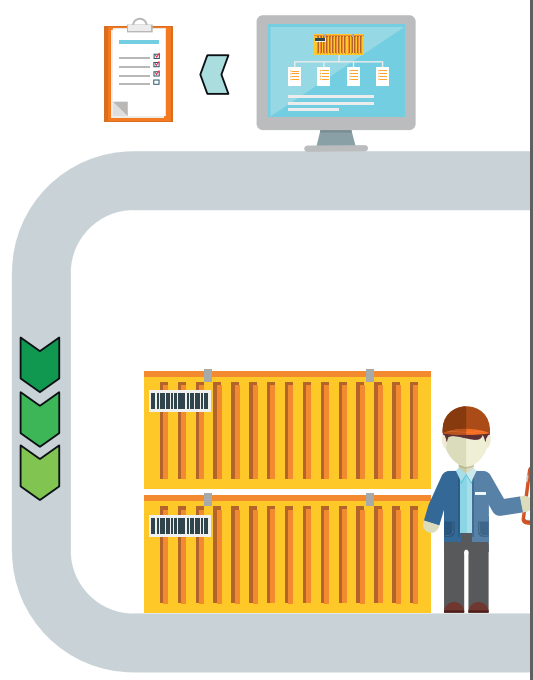
At the ocean ports some customers use the current port facilities with the addition of the container tippler. When the ship arrives, the containers are moved around to the quay side and lifted into the ships hold.

The lid is automatically lifted off the container and then the tippler rotates the container 360degrees emptying the fertilizer into the ships hold.

The lid is then replaced and the containers are taken back to the processing plant to start the loop again.

1 The urea is loaded into the patented ISG containers at the processing plant and the containers are sealed. Each container holds around 30 tons of urea.

4 From the database a report can be generated using the RFID information so you can manage the amount of product being shipped.



5 At the port the containers are block stacked awaiting the bulk ship to arrive.

Green and Clean ISG, helping you on your way to your Environmental, Social and Corporate Governance journey (SCG).

Fertilizer Grade Container

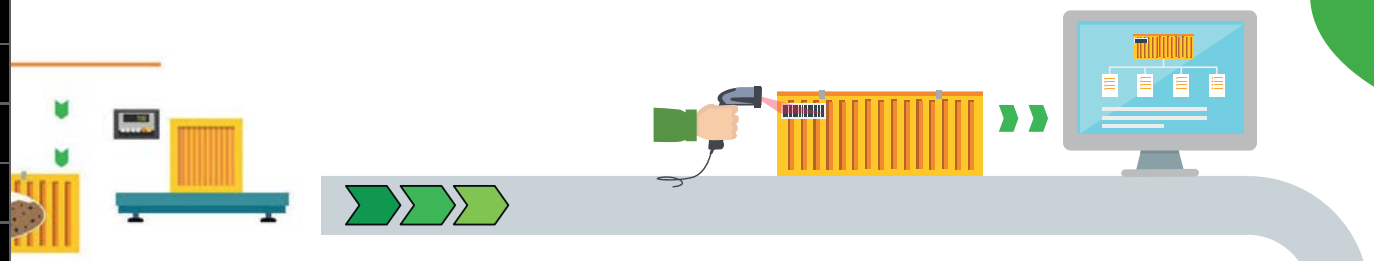
Tippler Loading

Urea Logistic, Storage and Ship Loading Flow Chart

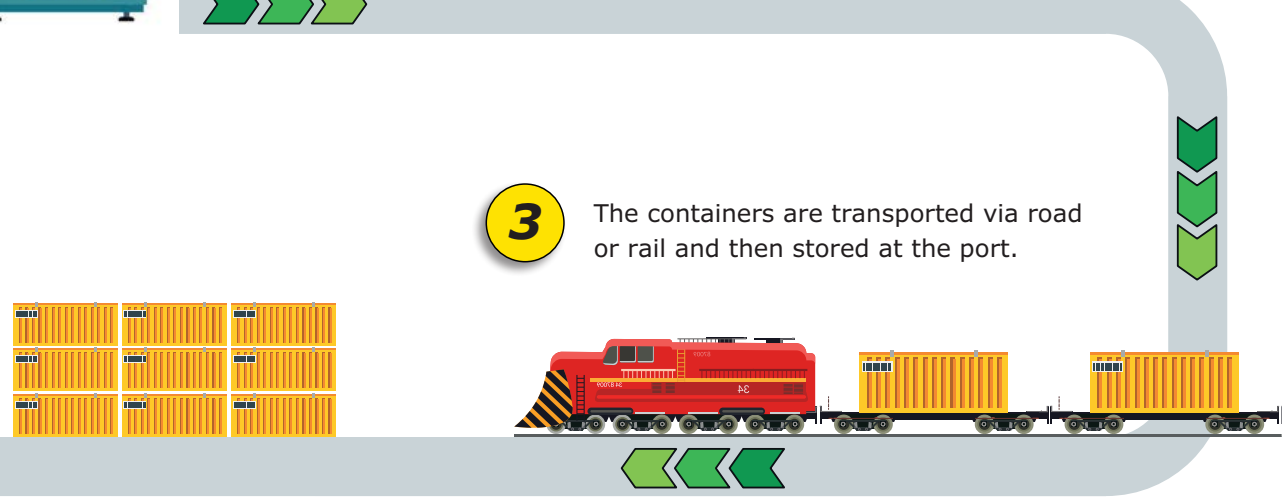
Case Study Number 01: Urea transport in Bolivia Brunei Urea loading

2 The containers are fitted with RFID tags so they can be tracked on their way to the ocean or river port.

See live videos on our website of ships being loaded at: www.pittoship.com



3 The containers are transported via road or rail and then stored at the port.



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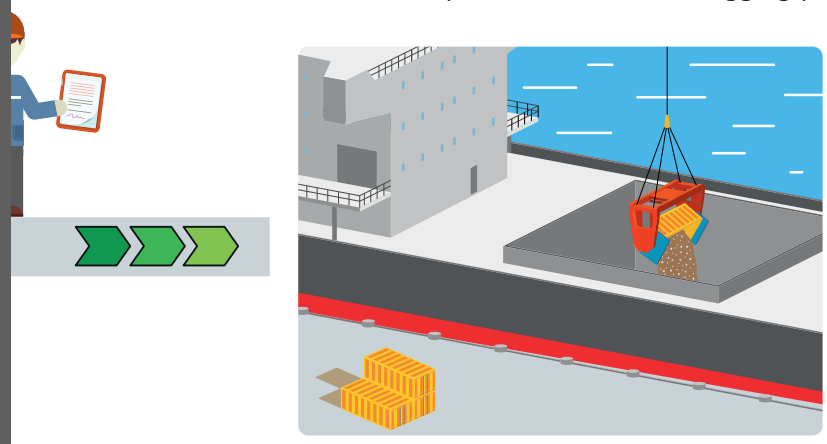
6 When the ship arrives the product is tipped into the bulk ships hold using a tippler. Some customers have a bagging facility at river ports. They use this system to move the bulk product to the river bagging plant.

7 The bulk ship departs with your product on board. The containers are returned to the processing plant, for the cycle to start over again.



"The environment matters"

Sealed from the processing plant to the ships hold

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IFA 2023 Annual Conference

Some 1,400 delegates from 533 companies and 83 countries gathered in Prague, Czech Republic, for the 90th International Fertilizer Association (IFA) Annual Conference, 22 May – 24 June 2023. We report on the main highlights of this three-day flagship event.

Violinist, conference welcome reception.

PHOTO: IFA

IFA's long standing annual conference is the largest and most prestigious event on the global industry's calendar. For decades now, it has provided a once-a-year opportunity for fertilizer professionals to congregate, network and catch-up on the latest industry developments.

The theme of this year's conference was 'Fertilizers 2023: Where Food and Energy Markets Meet'. This reflected the fertilizer industry's increasingly high profile and its impact on other global industries.

Opening remarks

The conference was opened by **Svein Tore Holsether**, IFA's outgoing chair and the president and CEO of Yara International. He highlighted the interconnection between food and energy:

"Why do we eat food in the first place? It is to get energy. It takes energy to produce food, whether that's for fertilizers or to grow food itself.

"What we've been through in the past few years – from Covid, war or climate change – has had an impact [on food and energy markets] and it's important we explain the implications of that. We have to, as an association, be a credible source of information and contribute to policy making and decisions."

Farmers are on the front line when it comes to climate change. All parts of the food system are also interdependent. Holsether therefore called for an integrated approach involving every player in the food value chain – all the way through to the consumer.

"There are very few professions, if any, that are as affected by climate change as farmers are," he said. "The whole food system is part of the problem, it's also a significant part of the solution. That's why – despite our differences – we need to pull together to secure the decarbonisation of the food system, and we all have a role in doing that and, ultimately, this is really our license to operate as an industry."

Everything goes back to energy, suggested Holsether:

"We have to be in the driving seat. Our industry has an advantage when it comes to decarbonisation as we have the technologies to decarbonise, whether it's carbon capture and storage, green energy producing green hydrogen, or through precision farming. Renewable energy will be key and needs to be driven with even higher speed across the world – particularly in Europe where we are lagging behind on the implementation of green energy for fertilizer production."

Leadership on sustainability

Katy Jarrett, head of the UK sustainability practice at Spencer Stuart, gave the keynote address. She provided an overview on how well the fertilizer industry and related sectors are performing when it comes to leadership on sustainability.

"What I can tell you about [sustainability] leadership is that it's incredibly hard and it's never been harder since the energy transition that's come upon us," said Jarrett. "What we realised is that… nobody was equipped to lead when it came to sustainability as they were either a generalist, or they were a specialist five rungs down the company and couldn't meet the CEO, or they put money to work but didn't really understand climate change."

The pursuit of perfection was a major obstacle, she suggested.

"Underlying all of this, was this idea that there was a limited time to save the planet, but there was an obsession about what the perfect corporate action is. So, nobody takes any action because everyone's worried about being perfect," Jarrett said.

There were signs of progress, however, as Spencer Stuart had observed a very real shift in the background of sustainability leaders during the last five years, as Jarrett explained:

Alzbeta Klein , IFA's director general and CEO, in conversation with Tony Will, the president and CEO of CF Industries and IFA's incoming chair.

PHOTO: IFA

"We tried to think about what the perfect leader would be when it came to sustainability and climate change. We interviewed 100 companies [in 2022] who were facing the energy transition problem – about 50 of them were within the fertilizer supply chain – interviewing people who were executing on the sustainability mandate, and we had some quite interesting results.

"The people with the background you have now executing on sustainability in the energy transition are [mainly] social and environmental scientists or people who are formally in strategy. It's unfortunate that supply chain, which is such a huge disruptor when it comes to the energy transition, are so underrepresented – but we're hoping to get that up as well."

Encouragingly, two metrics in Spencer Stuart's 2022 survey confirmed that sustainability leaders have a frequent access to CEOs and that most of these meetings were judged to be productive.

"The positive one is the [internal relationship] between CEOs and sustainability [leaders] which is fantastic," said Jarrett. "91 percent of people said that the CEO is now actively supporting their strategy, and they have roughly the same amount of facetime as success in communicating with the CEO."

Encouragingly, this suggests sustainability strategies are now being taken seriously at the very highest levels in companies faced with the energy transition.

Food security and sustainable supply chains

This theme was discussed during a lively debate between **Matt Simpson**, CEO of Brazil Potash, **Julian Palliam**, CEO of Foskor and **Jaine Chisholm Caunt** OBE, director general of the Grain and Feed Trade Association (Gafta).

A balance was needed between globalisation, on one hand, and domestic security of supply on the other, argued Matt Simpson.

Brazil, for example imports 95 percent of its potash requirements. This had left the country extremely exposed when potash prices hit $1,200/t in April last year. Did this make sense when Brazil was sitting one of the world's largest undeveloped potash deposits, asked Simpson.

"Where these elements [raw materials] are essential and leave you very vulnerable, if it is possible to produce these domestically, then you should, even if it does come at a higher cost," he said. "Because [then] you won't have the susceptibility to the supply chain shocks we're seeing."

Jaine Chisholm Caunt made a robust defence of international trade. Gafta's view was that sustainability means producing grains such as soybeans in places where they can be grown most efficiently, at large scale with fewer agricultural inputs and less water, and then shipped to where they are needed the most.

"There isn't a single country in the whole world that is totally self-sufficient, we all rely on each other," she said. "One in six people rely significantly on international trade to actually feed themselves."

Some form of globalisation remains necessary, agreed Jullian Palliam, as this will enable Africa to use its abundant resources, such as uncultivated agricultural land, to contribute to world food security.

However, Palliam suggested that, in southern Africa, supply chain reforms were needed to increase trade. Exports of key raw materials could be boosted, for example, by improving port access and availability. Allowing ships to berth quickly would make a tangible difference, in his view, by reducing the demurrage charges that ultimately get passed on to farmers and other suppliers.

Unlocking finance was also vital.

"From an energy point of view, in Africa we have a lot of sun and a lot of water, we can see renewable energies playing a bigger part," Palliam said. "The biggest hurdle is actually money. Africa needs patient capital, capital that is willing to wait not just one season, but multiple seasons – and also not pricing risk that is ludicrous, with interest rates across Africa 2-3 times worse than anywhere else in the world."

Clean energy to feed and fuel the world

In this session, **Alzbeta Klein**, IFA's director general and CEO, sat down for a 'fireside chat' with **Tony Will**, the president and CEO of CF Industries and IFA's incoming chair.

The two discussed both food security and energy security as the fertilizer industry moves into clean energy markets. The new opportunities being created for the industry by the energy transition, and the contrasting policy approaches to net zero, were also highlighted.

Will praised the US Inflation Reduction Act (IRA). He contrasted the IRA's incentives-based system – its "carrot approach" – with energy transition policies in the EU, Canada and the UK which, in pushing for net zero, had "gone after it with a stick" with measures such as carbon taxes.

"The US Inflation Reduction Act, in combination with the Infrastructure Bill, has put an $85/t tax credit available on carbon capture and sequestration," said Will. "For our industry, that provides the right level of incentive to work with other partners – in our case Exxon Mobil – to find ways to actually inject [CO_2] into the ground and sequester it permanently."

Will also extolled the wider benefits of fertilizer industry decarbonisation – especially the creation of capacity to supply low-carbon ammonia – both to agriculture and emerging markets such as power generation.

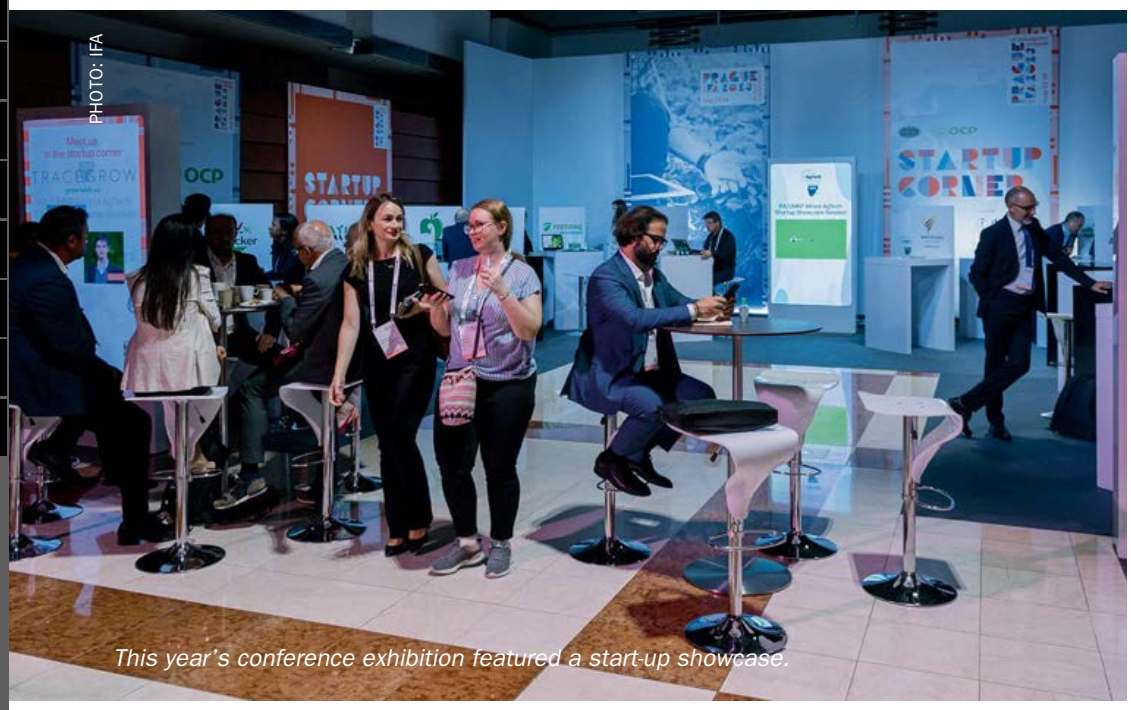
"We have a blueprint for how we are going to get to net zero by 2050," said Will. "The fact that we can provide a low-carbon intensity product that will help others decarbonise difficult-to-abate industries is a situation where one plus one equals much more than two."

Summing up, Will said: "Sustainability has to start with profitability. Because if you're no profitable you're certainly not going to be sustainable in the longer term."

Embracing the energy transition

The event's second panel discussion put together **Marco Arcelli**, the CEO of ACWA Power, **Dimitrios Koufos**, the head of sustainable business and infrastructure, climate strategy and delivery at the European Bank for Reconstruction and Development (EBRD), and **Stuart Neil**, director of strategy and communications at the International Chamber of Shipping (ICS).

The three panellists explored the energy transition theme in greater depth, especially the opportunities for decarbonisation of the fertilizer and shipping industries.



This year's conference exhibition featured a start-up showcase.

Preparedness was the key to the energy transition for Marco Arcelli. He paraphrased Hemingway to make his point:

"Bankruptcies happen gradually and then suddenly – it's the same for decarbonisation," Arcelli said. "Decarbonisation will happen at some point, it will be very quick, and you need to prepare for that. Saudia Arabia is at the centre of the world for this."

EBRD is scaling up its climate finance and is planning to allocate around $10-11 billion annually in future, according to Dimitrios Koufos. But this is just a fraction of the finance that will be necessary to deliver the energy transition.

"The scale of the challenge is enormous," said Koufos."Between now and 2030, we'll need to find capital equivalent to the GDP of China, about $14 trillion."

The EBRD is currently working with the Egyptian government on decarbonising its domestic fertilizer sector. "The bank will be expanding its operations in sub Saharan Africa from 2024, which has a lot of important aspects of food security and energy," Koufos said.

Stuart Neil gave a sober assessment of the scale of the change needed to decarbonise shipping. The ICS, which represents 80 percent of the global merchant fleet, recently surveyed its membership. "They don't see ammonia as [a shipping fuel] being significant for another six years and probably nearer 20 years – it's just the scale," Neil said.

He added: "When you look at how much energy is going to be needed to decarbonise to meet the IEA's net zero target … shipping's going to need 3,000 terrawatt hours. That's the whole of renewables at the moment – but there is a massive opportunity."

Ships will not be able to run on ammonia without the necessary global infrastructure – Clean Energy Marine Hubs (CEM-Hubs) – in place. "Clean Energy Marine Hubs are looking at the offtake, the ports, the shipping, all the elements in the supply chain from production to end use – and de-risking that with governments to … make it happen," he said.

As Neil mentioned during the conference, the CEM-Hubs initiative was formally adopted at the Clean Energy Ministerial (CEM) summit in Goa, India, in July. "We're building the coalition of private sector and governments ready for when this gets launched by energy ministers in July," said Neil. "We are very open to working with everyone to make this a reality."

Leadership

In the final keynote panel, **Jeanne Johns**, then CEO of Incitec Pivot Limited, **Bob Wilt**, Ma'aden's CEO, and **Alexander Schmitt**, the CMO at Anglo American, shared their views on the business leadership qualities needed to deliver food security and the energy transition.

"We can't fail, it's not an option for us," urged Bob Wilt, referring to the fertilizer industry. "We are too vital, whether it's the energy transition or food security, we are at the epicentre – this group has got to succeed."

Population growth was not taking place in wealthier regions such as Europe, observed Jeanne Johns: "It's going to be places where affordability really matters. We need to make sure we find solutions that keep the food affordable as well as green."

The need to act now was imperative for Alexander Schmitt. "2050 sounds far away – but I think of my son who is 12 years old now," Schmitt said. "He will be 40 then, younger than many of us in this room, and that's the perspective we need to think about, the generations to come."

Medium-term market outlook

The 2023-2027 medium-term outlook was presented by **Laura Cross**, IFA's director of market intelligence, and IFA's demand program manager, **Armelle Gruère**.

On the demand side, Armelle highlighted the continuing importance of fertilizer affordability. This would remain the number one factor influencing fertilizer use over the medium-term, according to a recent IFA survey, followed by water availability and climate change.

After a two-year contraction, fertilizer demand looks set to rebound this year. IFA expects global consumption to recover by 4.0 percent in the fertilizer year (FY) 2023, following a 2.8 percent decline in FY 2021 and a 4.9 decline in FY 2022.

Laura Cross summarised IFA's 2023-2027 outlook using the following 'hack':

- **Nitrogen**. Demand growth of 1.9 percent p.a. Driven by recovery in Eastern Europe & Central Asia, Latin America and South Asia, offset by a slowdown in mature markets. Supply growth driven by Russia, China and a wave of low-carbon (green and blue ammonia) projects.
- **Phosphate**. Demand growth of 2.6 percent p.a. Led by South Asia and

Latin America and driven globally by improved affordability in 2023. Supply growth driven by a small number of large projects.

- **Potash**. Demand growth of 2.5 percent p.a. Driven by Latin American yields and, globally, by improved affordability capped by availability. Supply driven by a large projects offset by the impacts of sanctions.

Cross praised the industry's performance on fertilizer supply.

"The industry did a pretty phenomenal job of keeping supply moving, keeping trade flowing globally in the last year, especially in light of those sanctions uncertainties," she said. "Raw material costs [i.e. natural gas] remain elevated and that's something we need to watch over the short- and long-term."

While sanctioned countries had fortunately found a route to market, observed Cross, fertilizer supply from Belarus and Russia had not normalised and recovered to its pre-2022 levels.

"That's been a good thing for farmer affordability and food security globally. But they haven't returned to their normal rates," she said. "So, this isn't a universal recovery and that will continue to disrupt things in the next five years."

The industry's investment cycle and priorities are changing, advised Cross, with a wave of blue and green ammonia projects emerging. "We need to keep track of the different incentives in place at the local level if we want to understand exactly how much new low-carbon capacity is likely to commission," she observed.

On the demand side, Cross said that although affordability has improved it remains the key determinant of fertilizer use. She also warned of El Niño's arrival in 2023.

"Weather risks are coming and will become another driving force as we get into the second half of 2023," she said. "South Asia and Latin America are our largest drivers of short- and medium-term demand, and when it comes to weather risks most of those are in the southern hemisphere – it's therefore mostly the global south that will be impacted by El Niño."

Cross also highlighted Africa as a demand region on the rise. "Even though major growth is still centred in those big agricultural-producing regions, we do see Africa emerging as the fastest growing market at the end of our medium-term outlook," she said.

The fertilizer industry was less in the spotlight than it was 6-12 months ago, suggested Cross, as the supply and price fears of a year ago had waned.

"Things have improved from a farmer affordability perspective," summed up Cross. "But we are now starting to see lots of other factors coming into play – the role of climate regulation, low-carbon investment, as well as food security and how fertilizers impact that." ■

Patrick Heffer (right), IFA's Deputy Director General, listens to the AgTech first prize winner Hunter Swisher (left), CEO of Phospholutions.

PHOTO: IFA

New to this year's annual conference was The Africa AgTech Startup Showcase. This was launched by IFA and Morocco's Mohammed VI Polytechnic University (UM6P) with the support of OCP Group. The following eight finalists were given the opportunity to pitch to delegates:

- **Phospholutions** develops technologies that increase fertilizer efficiency, affordability, and minimise the environmental impact of global phosphorus use
- **Natura Crop Care** offers innovative, patented climate-resilient solutions for sustainable soil health that are capable of reducing carbon footprints and doubling the income of farmers
- **Agri IOT** is developing Croptune, a real-time mobile application that recognises and helps correct nutritional deficiencies in crops
- **Foodlocker** is a platform that connects African smallholder farmers with large buyers through market access and precision agriculture, as well as linking up farmers with inputs, credit and expertise
- **Albo Climate** offers a remote and accurate solution for quantifying, mapping, and monitoring the carbon sequestered in ecosystems globally
- **Farmer Lifeline Technologies** has developed a solar-powered device that scans crops and alerts farmers to pests or diseases while providing recommendations on fertilizers or pesticides
- **Agricolleges International** is an online learning institution that provides affordable, accessible and industry-relevant education and training in agriculture and related industries
- **Safi Organics** is using decentralised fertilizer production to help rural under-served rural communities become self-sufficient in both crop production and the consumption of agricultural inputs.

Following questions and scoring by a jury of industry experts, Phospholutions won the first prize of €20,000, while runner-up Farmer Lifeline Technologies was awarded €10,000 in prize money. ■

Coating agents and equipment

The quality of finished fertilizers can be maintained during transport, handling and storage by protecting the surfaces of granules and prills with coating agents. Valuably, fertilizer coatings can also be used to control the release of nutrients in the field.

HOLLAND NOVOCHEM

Future-proof fertilizer additives

John Brennenraedts, area manager

Founded in 1992 by a team of experienced fertilizer additive engineers, Holland Novochem markets a long-established range of high-quality anti-caking, moisture repellents and de-dusting agents. Over the last three decades, this independent company has grown to become Europe's leading in-depth provider of coating agents to the fertilizer industry.

Holland Novochem's head office and laboratory are located just outside of Amsterdam in the Netherlands, while its state-of-the-art production site is strategically located on the Merwede river near the port of Rotterdam.

Holland Novochem serves fertilizer industry customers in more than 90 countries through four branch offices located across Eastern and Western Europe. The company offers an extensive range of branded fertilizer additives through its well known NovoFlow and Novodust portfolios (see box). These low-toxicity, environmentally- friendly products successfully address many of the problems associated with the production, storage and transportation of fertilizers, whether in solid or liquid form.

The Holland Novochem way

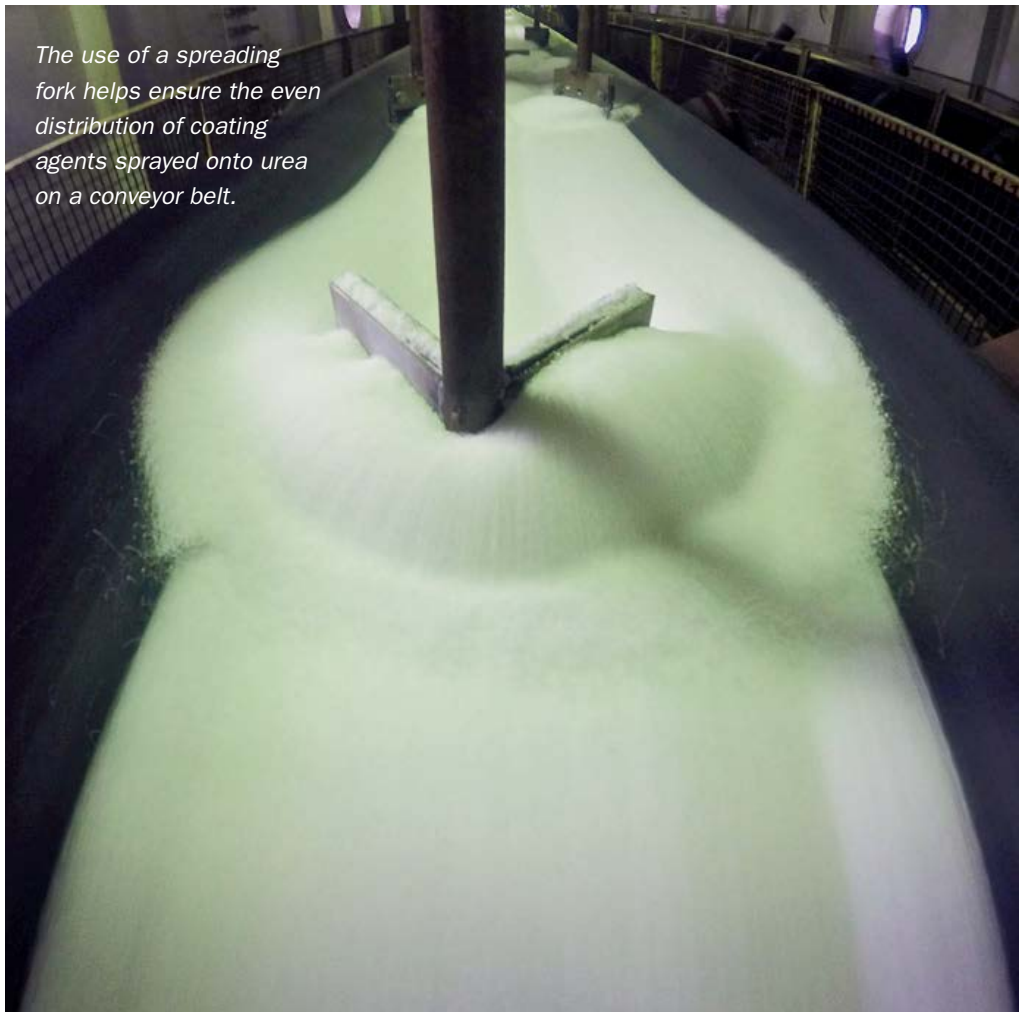
Over the years, Holland Novochem has built up a strong reference list that includes all the major global fertilizer producers. The company attributes its success to the following factors:

- **Dedicated staff**: building long-term partnerships with our customers is the priority of our highly-experienced chemical, technical, logistic and commercial staff – a team that collectively has more than 150 years of customer-focussed business experience.
- **Sustainable technology**: we select well-studied and highly pure raw materials for use in all our products, with strict adherence to the maximum limit of two percent polycyclic aromatics. Holland Novochem was the first company to develop and supply bio-based and biodegradable coatings to the fertilizer industry worldwide. The successful development of bio-based coatings enables us to supply customers with products that are free of microplastics and conform to environmental regulations such as REACH. Use of bio-based coatings also avoids the price fluctuations that can affect inorganic products.

PRODUCT RANGE

Fertilizer additives are Holland Novochem's bread and butter. The company's product range includes:

- **NovoFlow** anti-caking and moisture repellent coatings: these provide protection against caking and moisture uptake. They are suitable for all major types of fertilizers. Formulations are custom-made – according to the specific needs of fertilizer producers – to reduce caking and/or moisture.
- **NovoDust** anti-dust coatings: these substantially reduce dust generation during the handling and storage of fertilizers. Dust prevention is becoming an increasingly important due to the introduction of ever more stringent environmental and safety regulations – and the general requirement for cleaner workplaces.
- **NovoCor** corrosion inhibitor for liquid fertilizers: the addition of an inhibitor is essential for highly corrosive liquid fertilizers, such as UAN and AN solutions. NovoCor works by creating a stable organic barrier film on metal surfaces. This provides long-term corrosion protection for the whole of the distribution chain, from production to the end-user.
- **NovoFoam** anti-foaming agent: this strong anti-foaming product controls foam formation during the reaction of phosphate rock with acids.
- **NovoTec** granulation additive: this granulation enhancer can optimise the production process and/or improve the quality of fertilizer granules for a variety of fertilizer grades, especially AN, CAN and NPKs.



The use of a spreading fork helps ensure the even distribution of coating agents sprayed onto urea on a conveyor belt.

PHOTO: HOLLAND NOVOCHEM

- **Independence**: the way we operate means the company is not restricted to using specific in-house raw materials, such as amines or paraffins.
- **Cost awareness**: we are able to meet the wishes of our customers by finding the optimal balance between price and performance.
- **State-of-the-art laboratory**: our modern lab has all the necessary facilities to run specific tests on fertilizer additives, enabling us to design custom-made formulations and to develop new applications.
- **Consistent high quality and reliability**: production from one single location close to Rotterdam is highly advantageous as it allows our very experienced production and logistics teams to guarantee in-time-delivery and security of supply to customers.

Customer service holds the key

The Holland Novochem's philosophy is to focus on delivering the best service with the best products. We understand that each fertilizer plant and every product it generates require dedicated customer service. Our drive and motivation is therefore to work with our customers to find the most suitable and best performing additives for their specific products. In recent years, this has involved prioritising sustainability and reducing the carbon footprint of our products.

In these disruptive times, the best way of helping customers stay ahead, in our view, is by providing them with innovative tailor-made solutions that match both their current needs as well as future environmental requirements. We achieve this by working in close cooperation with our customers, sharing our extensive expertise and R&D know-how, to provide them with future-proof answers.

It's only natural

Traditionally, fertilizer additives, such as anti-caking agents and moisture repellents, have been based on petrochemical compounds, especially paraffins and mineral oils. The performance of these additives can be further enhanced by the addition of other active ingredients derived from petrochemicals such as alkyl amines.

During the last few years, there has been strong and growing awareness that petrochemicals need to be replaced with more sustainable products derived from natural sources. This transition is being encouraged by international and regional policies. The United Nations has set 17 Sustainable Development Goals (SDGs) for 2030, for example, while the Green Deal policy package launched by the European Commission commits the EU to becoming climate neutral by 2050. Both developments are likely to prompt a further shift away from traditional coating agents within a relatively short time span.

Holland Novochem first began to carry out extensive research on bio-based fertilizer additives twenty years ago. Since then, the results of these highly productive studies have formed the basis of dozens of successful patents. Over time, the company has seen increasingly widespread adoption of its sustainable coating products by customers worldwide, with the numbers increasing annually. These new fertilizer additives are commonly derived from vegetable oils such as sunflower, rapeseed and soybean oil.

While this is a very positive development for the fertilizer industry, the complete transition from traditional coating oils to bio-based alternatives could have a downside if it affects the overall availability of vegetable oils. Fertilizer industry demand should not, in our view, restrict the availability of vegetable oils as food commodities. This situation can be avoided if the vegetable oil industry provides new production capacity to meet the extra demand from the fertilizer sector and other industries.

Farmers will still need standard fertilizers to grow enough crops to feed the entire world population. Despite the best efforts of producing companies and industry trade associations, the production of climate-neutral fertilizers, protected by fully sustainable additives, cannot be guaranteed at present. Fluctuations in the availability and price of feedstocks and raw materials, such as natural gas and ammonia, can also have a hugely adverse effect on fertilizer industry operations.

Nevertheless, Holland Novochem believes it has a natural responsibility to provide our customers with products that – as well as keeping them competitive – contribute to the wellbeing of our beautiful planet for years to come. Indeed, our R&D team is continuing to optimise our bio-based product line. Recent breakthroughs have already established highly sustainable and environmentally friendly anti-caking agents. ■

FEECO INTERNATIONAL

Coating drums: nutrient use efficiency's secret weapon

Michael Eidge, FEECO process sales engineer

In the fertilizer market, coatings are an essential tool in controlling both product perception and performance, thereby helping manufacturers to meet changing customer preferences and demands.

Coatings have long been used to control the dust and caking behaviour of fertilizer granules during transport and handling. Most recently, however, there has been increasing interest in the ability of coatings to control the release rate of nutrients from granules in soils, a characteristic that can maximise the nutrient use efficiency (NUE) of fertilizers.

What many fertilizer producers fail to recognise, though, is that two critical factors will determine whether coatings achieve their desired effect:

- Firstly, the formulation of the coating itself and its corresponding physical and chemical properties
- Secondly, how the coating is applied onto the fertilizer product.

PHOTO: FEECO

FEECO Coating Drum.

To put it simply, even the best coating agent is only as good as its application method. That makes finding the right coating process and equipment absolutely critical. As this article will highlight, more and more fertilizer producers are turning to coating drums to deliver the best results.

Coating to improve nutrient use efficiency

Coatings provide a powerful tool for managing the rate of nutrient release from fertilizer granules, a valuable characteristic that has become increasingly important as growers seek to boost crop productivity by maximising their yields while simultaneously minimising nutrient losses.

Coated granular fertilizers, usually known as controlled-release fertilizers (CRFs), are advanced products that supply crops with a 'slow drip' of nutrients that more closely matches how plants take up nutrients. This contrasts with the immediate nutrient release that can accompany the application of traditional commodity fertilizers, a characteristic that can be both inefficient and bad for the environment. Plants can only take up so much when nutrients are oversupplied, leaving the remainder to be lost as runoff.

An extensive range of coatings, both organic and inorganic, is available on the market, each having inherent advantages and disadvantages. Waxes, oils and polymers are among the most common types of coating applied in the fertilizer industry.

In general, while individual coating agents behave differently, they all have the same essential function: controlling the release of nutrients by creating a coating that acts as a barrier between the nutrient and its surrounding environment. The gradual breakdown of this barrier controls (prevents or slows) the rate at which moisture can infiltrate the granule and start releasing nutrients.

While the underlying principle is simple, coatings have become a science in their own right. Thanks to sophisticated coatings technology, CRFs have now been developed that are incredibly effective at producing more food from the same (or smaller) plots of land. That is because the improved NUE of these products ensures that more nutrients end up in the crop and less are lost to the environment.

PHOTO: FEECO

Urea granules: uncoated (top) and coated (bottom).

Coating drums: the key to uniform coating

As previously mentioned, in addition to improving NUE, coating protects fertilizer granules during transport and handling. This is a vital way of combating two common problems faced by fertilizer producers, traders and distributors – namely dust formation and caking. If left unprotected, breakage and moisture damage to fertilizer granules can infringe on profits, and also leave suppliers facing liabilities and many other frustrations.

Additionally, applying a coating to granular fertilizers, by improving product appearance as well as performance, allows manufacturers to 'add value' and market these granules as premium products to an increasingly discerning market.

The effectiveness of any coating agent, as previously mentioned, is dependent upon its application. For a coating to be effective, it must be applied at, firstly, the right thickness and, secondly, as uniformly as possible. Product performance can suffer greatly if both these conditions are not met, because of sub-standard behaviour in shipping, handling, storage, and eventual field application.

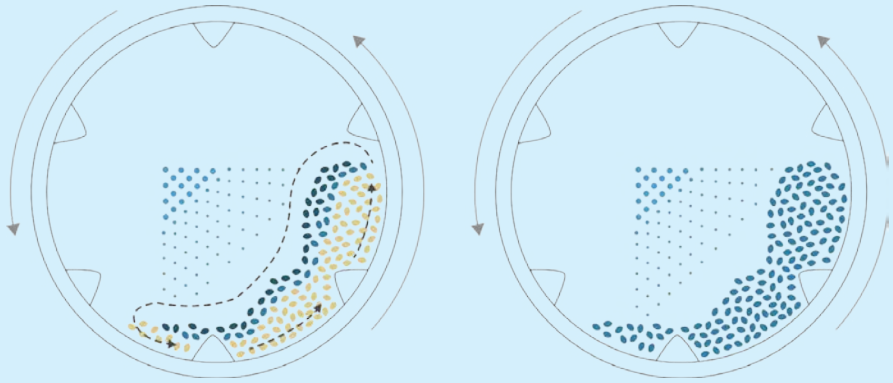
It is for these reasons that the coating drum has become the equipment of choice for coating fertilizer granules. When properly designed, a coating drum can achieve both a high level of coating uniformity and deliver the high throughput required by the industry. These valued process characteristics are a result of the unique coating mechanisms that occur inside coating drums during their operation.

Coating drum operation

The general operating principles of coating drums are similar to other types of rotary drum found in fertilizer plants.

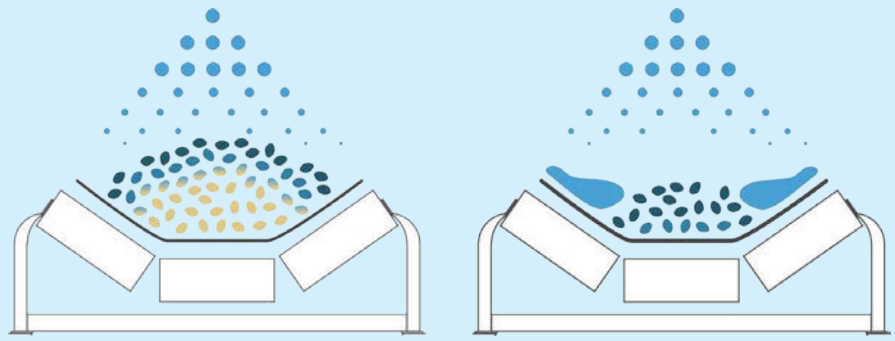
Material is fed into the inlet of a rotating drum on a continuous basis. A spray system distributes the coating across the material bed. As the drum rotates, the bed tumbles, distributing the coating via granule-to-granule contact. Tumbling flights help to achieve an even coating distribution throughout the bed by encouraging rotation and agitation (bed turning, see Figure 1). Gravity helps to move material through the coating drum, which is slightly angled with the inlet end raised. Material is processed for a predetermined retention time within the drum

Fig 1: **Fertilizer coating drum at the start of (left) and after completion (right) of the process. The tumbling action (dashed arrow, left) is enhanced using tumbling flights that encourage bed turning. This ensures the sprayed coating agent is evenly distributed throughout the bed.**



Source: FEECO

Fig 2: **Coating fertilizer granules on a moving conveyor belt. The sprayed coating only infiltrates the surface, because only the top of the pile is exposed on the moving conveyor, leaving the granules underneath uncoated (left). Trying to ensure all granules on the belt are coated by cutting throughput can cause overspray and the costly waste of significant amounts of coating agent (right).**



Source: FEECO

Table 1: **Factors influencing the coating process include both process variables (left column) and variables introduced by the physical and chemical characteristics of fertilizer materials (right column).**

Key process variables	Key material variables
• Material feed rate	• Particle size distribution
• Spray locations	• Material temperature
• Coating spray rate and concentration	• Particle shape
• Coating temperature	• Chemical composition
• Tumbling flight design	• Moisture content
• Drum rotational speed	• Bulk density
• Drum angle	• Surface quality
• Percent fill	
• Nozzle type	
• Retention time	

Source: FEECO

before being discharged continuously.

This approach is in stark contrast to how granules are coated on a conveyor belt, another popular but less effective fertilizer coating method. Some producers try to ensure all the granules on the conveyor belt are properly coated by reducing the quantity of material being conveyed. However, this can result in both overspray (spraying onto the belt) as well as the oversaturation of materials with the coating agent (Figure 2). This wastes significant amounts of coating and often causes operational problems.

For this reason, fertilizer producers that switch from conveyor belt coating to a coating drum process can often reduce the amount of coating agent applied while still achieving the desired result. Plant downtime and maintenance can also be reduced, because the build-up of overspray on conveyor belts is completely avoided.

Coatings provide a powerful tool for managing the rate of nutrient release from fertilizer granules, a valuable characteristic that has become increasingly important as growers seek to boost crop productivity

Developing an effective coating drum process

Numerous factors influence the coating process. These include both process variables and variables introduced by the physical and chemical characteristics of fertilizer materials (Table 1). With so many factors influencing the coating process, testing is an integral part of designing a successful coating machine.

Fertilizer producers, by taking advantage of testing services, such as those provided at FEECO's Innovation Center, can understand how well a selected coating will perform with their materials in practice. Such tests can also establish the coating drum's design requirements and determine the process parameters needed to achieve the desired result. Test runs can be used to help evaluate different coatings and coating formulations, and establish key process criteria such as percent fill, spray rates, etc. Valuably, these data can then be incorporated in the design of the commercial-scale coating drum unit.

Concluding remarks

As well as preventing water absorption and dust generation, coating can be a powerful tool for controlling the rate of nutrient release from fertilizer products. This is particularly true when the process is carried out in a coating drum. The unique tumbling action imparted by the rotating drum, combined with its bed turning action, evenly coats the surface of every granule. The resulting controlled release fertilizers (CRFs) are reliable and effective, thanks to their superior coating uniformity, offering growers much better nutrient use efficiency (NUE) compared to standard products.

Container transport *and* bulk shipping – the best of both worlds!

Intermodal Solutions Group (ISG) is introducing a container-based storage, transport and ship loading system for bulk fertilizers. The company's innovative Pit to Ship Solutions™ system could transform fertilizer logistics and help the sector meet its environmental, social and corporate governance (ESG) goals.

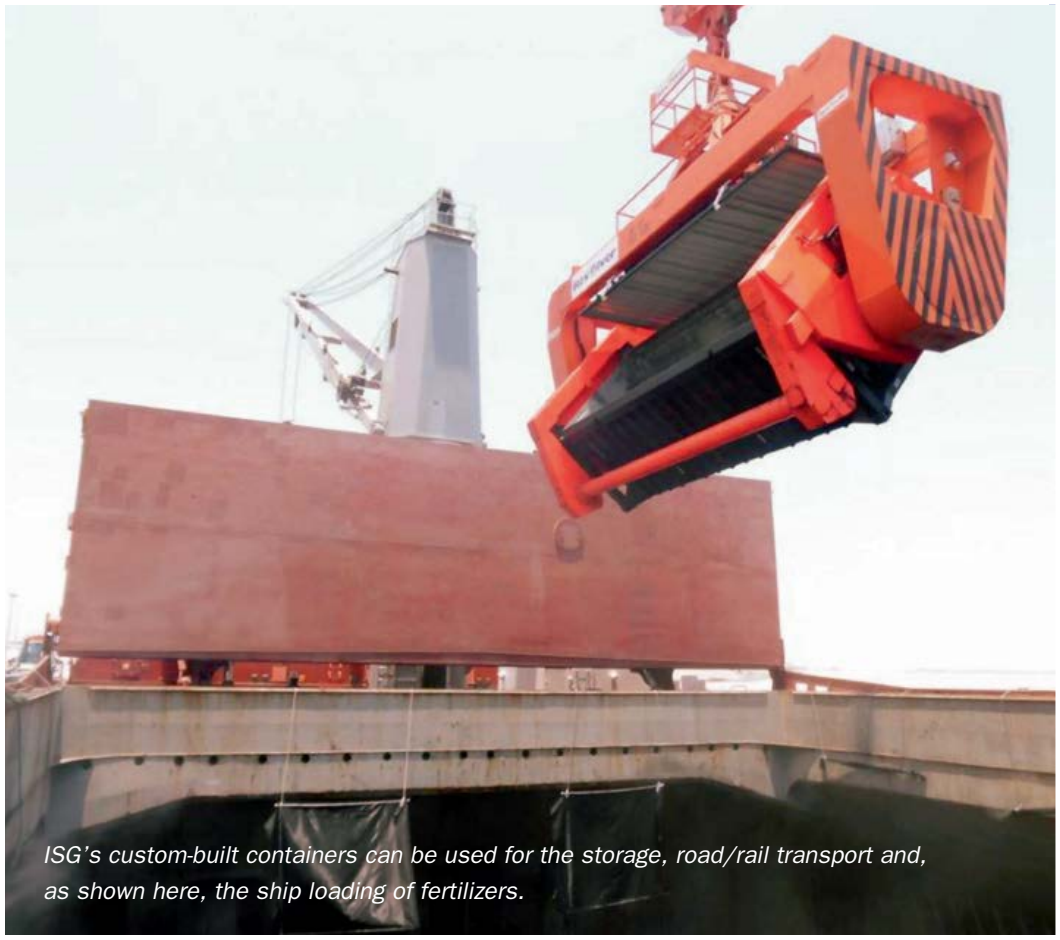
For more than a decade, the environmentally-friendly storage, transport and ship loading system from Intermodal Solutions Group (ISG) has set a new benchmark in mining industry logistics via container ports. For the first time, the company's innovative Pit to Ship Solutions™ system can now be used for fertilizer logistics too.

Containerisation is not a new idea. It has, in fact, been around for over thirty years. But the use of customised containers, firstly for fertilizer storage, then for road/rail transport, and finally fertilizer ship loading, is a completely new concept – well, for the fertilizer industry at least!

The copper mining sector, in contrast, has been doing this for over fifteen years now. Recently, though, the same approach has been adopted by several urea suppliers and taken to new levels.

Container transport by rail or road

Fertilizer is loaded into ISG's custom-built containers using conventional loading chutes or front-end loaders. These containers, each of which can hold about 30 tonnes of fertilizer, are specifically designed without doors. Instead, their lids come off, or their roof hatches are opened, depending on the preferred product loading procedure.



ISG's custom-built containers can be used for the storage, road/rail transport and, as shown here, the ship loading of fertilizers.

Loading fertilizer into a container with a front-end loader for onward rail transport.

The sealed, custom-built containers can store fertilizers safely and securely. Conveniently, they are also stackable.

PHOTOS: ISG

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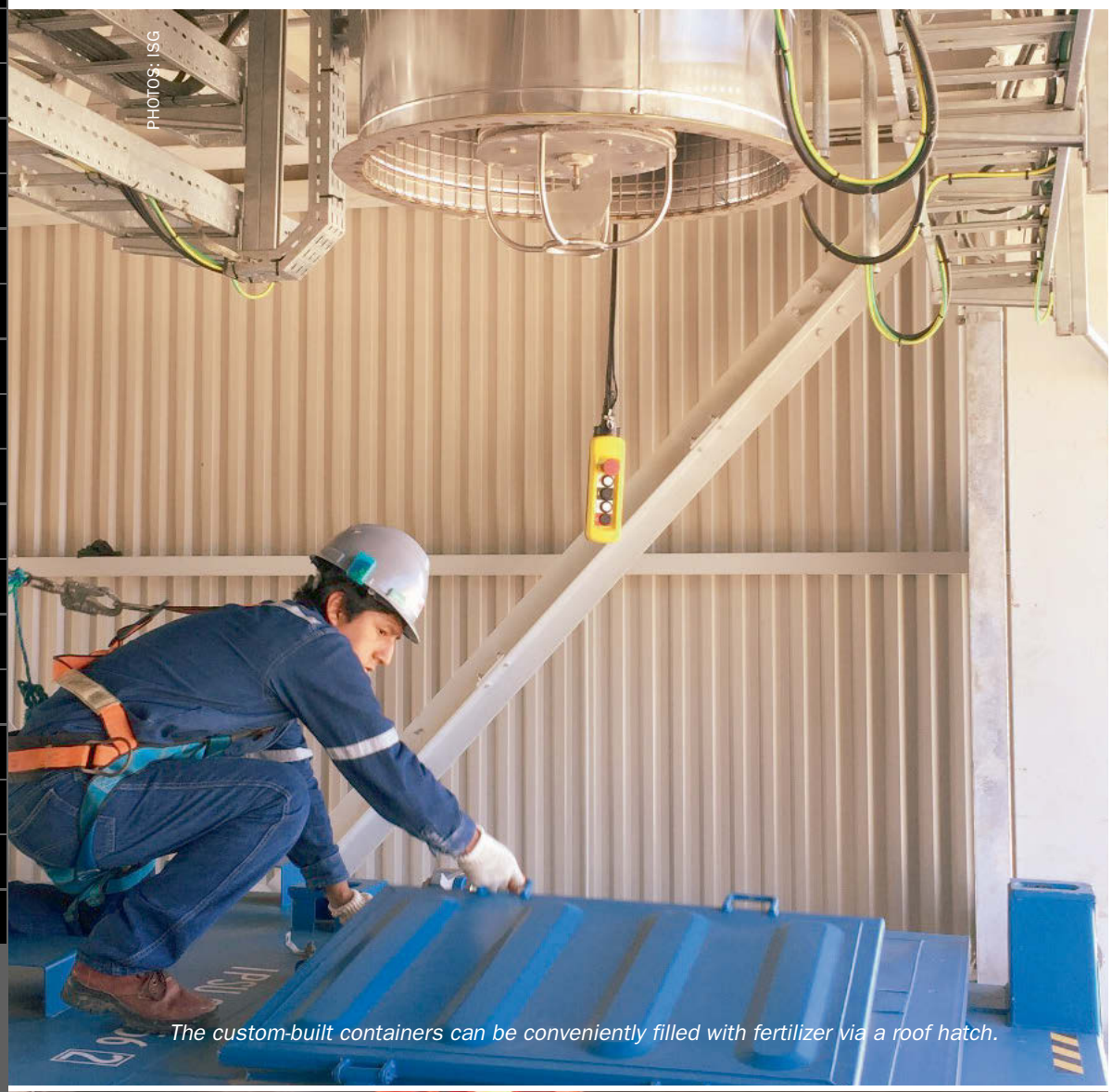


The custom-built containers can be conveniently filled with fertilizer via a roof hatch.

Fertilizer can be easily loaded into the hold of a bulk ship at a container port using a tippler device to rotate and empty the storage container.

The containers are immediately sealed after loading at the production or blending plant. This keeps the granular fertilizer product moisture-free and prevents the entry of any undesirable contaminants that can occur around storage areas. Conveniently, the containers are also stackable.

Once loaded, the containers are easily transported by rail or road to the loading port. This is typically a container port for international export or a river port for inland distribution.

Bulk loading at the port

Crucially, ISG's Pit to Ship Solutions™ system avoids the use of storage sheds and double handling at the port. Instead, the fertilizer remains safely and securely stored within its robust sealed container until the ship arrives.

Once the ship has docked, bulk loading can proceed via a special tippler and lid lifting device. Only at this stage is the lid of the container finally taken off – for the very first time since loading – while the tippler places the container into the ship's hold. The tippler then tips the fertilizer into the hold, quickly, smoothly and efficiently, by rotating the container full circle through 360 degrees.

The lid is then replaced, the containers go back to the plant to be refilled with fertilizer, and the whole storage, transport and ship loading process starts over once again.

Unique advantages

The best thing about this innovative fertilizer logistics system is that the ship loading takes place in a container port not a bulk port. Indeed, the only thing the container port needs to purchase is the tippler. Everything else the system needs is already provided by container port authorities. Importantly, the existing port infrastructure can handle the custom-built containers as their footprint is identical to a standard 20-foot-long container.

ISG's system has already been used successfully to transport urea 900 kilometres from Bulo Bulo in the Bolivian jungle to Quijarro, a river port on the Tamengo Canal close to the country's border with Brazil.

Overall, Pit to Ship Solutions™ from ISG offers the fertilizer industry clean logistics to help the sector on its ESG journey!

Fertilizer blending boosts ag productivity

Ag Growth International (AGI) is a leading manufacturer of fertilizer blending systems. **Robert Fitzpatrick**, AGI's product segment manager, highlights the latest innovations in fertilizer blending equipment and explains how these contribute to operational efficiency and agricultural productivity.

AGI blending system installed at Nutrien's Kansas town operation in Illinois.

PHOTO: AGI

Today, the agriculture industry is facing rising food demand at a time when the acreage of cropland remains inelastic. To meet this challenge, the need to maximise crop yields per acre has never been more important. This is true in mature and established agricultural economies. It is also becoming more and more critical to the success of newer crop growing and food producing regions.

To add to an already difficult task, the availability of agricultural workers has declined since the global Covid-19 pandemic. This is a potentially permanent change that is requiring a pivot towards a greater reliance on limited resources – and boosting productivity using agronomic know-how and available technologies.

The entire fertilizer blending process, by maximising crop yields and optimising resource efficiency, has a crucial role to play. Crop producers are now able to tailor nutrient compositions to their specific soil requirements by adopting an integrated approach that combines technology-based agronomic analysis, efficient and intelligent material transport systems with automated precision fertilizer blending equipment.

In recent years, the industry has been able to modernise the entire fertilizer blending process through amazing advances in equipment and technology. Ag Growth International (AGI) has remained at the forefront of the fertilizer blending industry by developing cutting-edge equipment and technologies. This article explores the latest innovations in fertilizer blending equipment and processes, highlighting their importance to the entire farming ecosystem, and explains how they contribute to operational efficiency and productivity.

From global production to regional distribution

The individual components of nitrogen, phosphorous and potassium (NPK) fertilizers are typically moved from their point of manufacture in very large bulk shipments. Millions of tonnes of phosphate and potash ore, for example, are extracted globally and processed to produce finished P and K fertilizers, while other components such as N fertilizers are synthesised chemically on a similarly larger scale globally.

Given the wide distribution of these very large-scale N, P and K production operations across the globe, blend components are typically shipped via boats and barges to regional distribution points. From there, these commodities are shipped onwards in smaller quantities to blending facilities.

PHOTOS: AGI

AGI terminal receiving conveyor.


AGI's flagship Declining Weight blending system.

In North America, fertilizer components are typically shipped in loose bulk form, while in other parts of the world they tend to be shipped in bag form and stored near blending operations.

Quick and safe handling and conveying

The effective supply and proper use of fertilizers starts with the efficient and safe conveying and handling of materials. Indeed, conveying and handling is a critical part of the fertilizer blending process. It is essential to ensure that fertilizer components are moved quickly and safely from one location to another, while avoiding damage or contamination.

While many types of material conveying systems are available, loose bulk mechanical conveying systems are typically favoured by the agricultural world due to their simplicity and low cost. Mechanical systems use a variety of methods to move fertilizer materials, including belts, rollers, chain paddles and screws or augers. The type of system selected depends on the size and type of the operation, as well as the distance the materials need to be moved. Belt conveyors, for example, are often the best choice for moving large quantities of fertilizer over long distances.

Belt conveyors are the most basic and common type of conveyor used in the agricultural industry, as the speed and direction of the belt can be adjusted easily to suit the job. AGI manufactures several different types of belt conveyors – such as slider, tri-roller and troughing roller belt conveyors – to satisfy a wide range of conveying applications.

Chain paddle conveyors (or drag chain conveyors), in contrast, use paddles attached to chain links to move fertilizer from one location to another. Chain paddle conveyors are commonly used in more rugged applications – the transfer of fertilizers from trucks to storage being one example.

Screw conveyors use a rotating screw/auger to transfer materials. Screw conveyors are often used in applications where accuracy and precision are important, e.g., when transferring a fixed amount of fertilizer to a specific location.

AGI uses a variety of approaches to transport fertilizer commodities. Our experts have developed innovative ways to reduce material losses using their extensive materials handling and storage knowledge. The design of conveyor and handling systems need to meet the demands of the toughest environments, ensuring that fertilizer components are moved safely and efficiently. AGI's conveyors are therefore built to withstand the harsh environments typically encountered at fertilizer blending sites, including elevated temperatures, corrosive chemicals, and caustic dust.

Precision blending systems

Precision blending systems, as their name suggests, blend together different fertilizer components at very precise ratios. The resulting customised blends – having been prepared to extremely accurate recipes – deliver an ideal mix of nutrients to crops and uniformly disperse these in target soils.

By analysing the agronomy of a specific plot, customized nutrient blends can be formulated according to specific soil and crop requirements. As a result, farmers can ensure their crops receive the exact nutrients they need for healthy growth and high yields.

Precision blending minimises the risk of misapplying nutrients – too much, too little or to a recipe that is just plain wrong for the location – providing growers instead with exactly what their crops need. This reduces waste and improves crop yields. The ability to produce fertilizer blends consistently and accurately also improves customer satisfaction by helping deliver crop yields and quality that are equally consistent.

AGI can cover all the fertilizer needs of crop growers – from high precision, high volume continuous blending systems to high precision, low volume batch blending systems. Several groundbreaking blending systems introduced by the company in recent years offer industry-leading precision, efficiency, and scalability. AGI's flagship Declining Weight system (see photo) boasts a blend accuracy of 95 percent (continuously). The company's high capacity, high precision blending tower offers another high performance blending option.

AGI's liquid impregnation and mixing systems are another strength. These precisely blend additives with the right commodities at the ideal point in the blend process. When the fertilizer blend requires powder micronutrients, AGI has this covered too, as precise amounts of almost any micronutrient can be added to blending systems using a powder screw feeder.

Automation and control systems

Automation and control systems have become game changers in the fertilizer blending industry. By streamlining operations and reducing labour costs, these intelligent systems provide significant benefits to customers. Importantly, they help deliver a smoothly flowing blending process all the way through to truck load-out, bagger system or storage location. Examples include:

- Precision material metering devices coupled with weigh scale inputs
- Multi-flight mixing impregnation augers
- Controlled, progressive feed-rates.

FERTILIZER BLENDING INSTALLATIONS: EXEMPLIFYING SUCCESS

Recent AGI blending equipment installations feature the latest advances in precision blending and demonstrate their importance to customers. Numerous agricultural projects worldwide have improved their blending accuracy, increased production capacity, and reduced operating costs by successfully installing cutting-edge equipment. These installations have been able to satisfy the evolving needs of farmers. They also showcase the tangible benefits provided by advanced equipment such as higher agricultural productivity.

AGI's fertilizer blending systems have garnered widespread recognition globally. The company has successfully installed its equipment in numerous high-profile projects worldwide over the past fifteen years. By adopting the latest technologies, customers have benefitted from higher blending accuracy, better resource utilisation, and greater overall profitability. These success stories offer valuable insights and provide a performance benchmark for other customers wishing to upgrade their fertilizer blending operations.

The provision of an advanced blending systems to a large-scale cooperative in the US Midwest is one notable installation. By enlisting AGI's blending expertise, this cooperative has been able to significantly enhance its productivity while reducing operating costs. The blending control technology provided allows the cooperative to move materials extremely efficiently while reliably delivering a high blending accuracy. The result has been improved crop yields and better customer satisfaction. ■

AGI belt conveyor at a new blending plant.

PHOTO: AGI

Overall, automation reduces the risk of errors and maintains product quality by making sure that blending processes are consistent and repeatable.

AGI's blending systems are equipped with state-of-the-art automation and control software. This guarantees precise blending ratios, minimises product waste, and delivers and distributes nutrients with pinpoint accuracy.

Sustainability and the environment

The importance of sustainability and environmental protection in modern agriculture cannot be overstated. Equipping fertilizer blending systems with features that focus on sustainability helps customers respond to the trend for environmentally-responsible farming practices. These advanced features are designed to optimise resource use, reduce energy consumption, and minimise waste throughout the blending process. As well as being necessary for regulatory compliance, these features meet growing consumer demands for environmentally friendly products.

Efficient blending systems enable farmers to significantly reduce the carbon footprint associated with fertilizer applications by delivering blends that specifically match the needs of their crops and soils. By allowing farmers to enhance crop yields, while minimising their impact on natural resources, this benefits the environment and aligns with modern farming practices.

AGI has responded to the growing demand for sustainable agricultural practices by introducing environmentally conscious features to its fertilizer blending equipment. The company's game changing blending systems:

- Optimise resource efficiency by reducing energy consumption and minimising waste
- Offer efficient blending while minimising the carbon footprint associated with fertilizer production
- Enable farmers to enhance crop yields while minimising their environmental impacts.

Partnering on productivity

The fertilizer blending equipment industry continues to evolve, introducing innovations that boost agricultural productivity. Examples include precision blending systems, automation and control systems, and features that focus on sustainability. These new advances in equipment help customers maximise crop yields, minimise waste, and meet the demands of sustainable agriculture.

By embracing the latest innovations in blending, farmers can enhance their operational efficiency, boost profitability, and contribute to the long-term sustainability of the agricultural industry. Looking ahead, future developments in fertilizer blending systems hold immense potential for transforming global agriculture, guaranteeing food security, and addressing environmental challenges.

In response to these demands, Ag Growth International is continuing to drive innovation in the fertilizer blending industry – through its advanced blending equipment, intelligent automated systems, and commitment to environmental sustainability. This is enabling purchasers of fertilizer blending systems to achieve unprecedented levels of precision and productivity. The company remains at the forefront of an evolving industry, delivering cutting-edge technologies that revolutionise the way farmers approach fertilizer blending.

With AGI as a partner, farmers can confidently embrace a more productive agricultural future. ■

September-October 2023

phosphates & potash INSIGHT

Integrated and efficient phosphate production

New anhydrous hydrofluoric acid (AHF) plant at Nutrien's Aurora site, North Carolina. This captures fluorosilicic acid (FSA) generated on-site as a co-product of phosphoric acid production.

PHOTO: NUTRIEN/ARKEMA

Leading companies such as Ballestra, Buss ChemTech, Elessent Clean Technologies (MECS) and Prayon Technologies are working together to solve the numerous production challenges facing the operators of integrated phosphate fertilizer production plants.

Cost reduction and revenue generation have become increasingly important imperatives in the manufacture of phosphate fertilizers. Greater resource efficiency has also risen up the industry's agenda with the emergence of the circular economy and policies on waste prevention. This has seen plant operators turn to production methods that are able to consume low-grade phosphate rock and/or generate pure and saleable gypsum as a by-product.

Energy consumption is also coming under closer scrutiny. Phosphate production can be highly energy-intensive due to the cumulative energy demands from process steps such as mining, crushing, grinding, beneficiation, phosphoric acid production and product granulation.

There is also renewed interest in the commercial recovery of fluorosilicic acid (FSA), rare earth elements (REEs) and uranium during phosphate production. As well as improving process efficiency and reducing costs, the sale of such co-products can generate extra revenues for phosphate producers.

One company alone cannot hope to have the necessary expertise and experience to address all of these multiple challenges and opportunities. Instead, an integrated approach is required during the design, construction, operation and maintenance of phosphate production assets. This is now happening with leading companies such as Ballestra, Buss ChemTech, Elessent Clean Technologies (MECS®) and Prayon Technologies working together to collectively solve the numerous production challenges facing the operators of integrated phosphate fertilizer production plants[1].

This has become necessary because:

- Phosphate rock, as a finite resource and the industry's main feedstock, must be extracted and processed as efficiently as possible.
- The complete production process – from upstream phosphate rock mining to phosphate fertilizer finishing downstream – requires holistic problem solving to satisfactorily address multiple economic, technological and environmental challenges.
- The operability, profitability and longevity of production assets are determined by the overall design of the phosphate manufacturing complex and, critically, by the technology selection for the phosphoric acid and sulphuric acid plants.
- The ability to generate revenues from process by-products such as phosphogypsum and fluorine can deliver both environmental and economic benefits.

Milan-headquartered Ballestra has extensive experience in the design and supply of chemical plants. For the fertilizer industry, the engineering company offers production plants for sulphuric acid, merchant-grade and purified phosphoric acid (MGA and PPA), single superphosphate (SSP), triple superphosphate (TSP), potassium sulphate and granulated NPK compound fertilizers.

Ballestra is able to implement an integrated approach to phosphate production, offering both MECS® technology for sulphuric acid plants and Prayon technology for phosphoric acid plants through its long-term partnerships with both companies. It also offers an economically attractive fluorine recovery process for phosphate plants through its ownership of Swiss-headquartered Buss ChemTech.

Table 1: **Phosphoric acid production routes**

	Dihydrate route*	**Hemihydrate route***
Single crystallisation	Dihydrate (DH)	Hemihydrate (HH)
Double crystallisation + one filtration	Di Attack – Hemi Filtration (DA-HF)	Hemi Recrystallisation (HRC/Nissan H)
Double crystallisation + two filtrations	Dihydrate – Hemihydrate (DHH/CPP)	Hemihydrate – Dihydrate (HDH)

** Route is called as per the first crystallisation.* *Source: Prayon*

The rock quality challenge

In certain regions, availability, resource depletion and the long-term decline in P_2O_5 grades are becoming issues for producers sourcing phosphate rock. Quality is a critical consideration as the presence of high levels of minor elements (Al, Fe, Mg) in phosphate rock can cause production problems, particularly at phosphoric acid plants. These elements are associated with high viscosities during filtration, gel formation during acid concentration and equipment scaling, for example[1].

To address these challenges, Prayon Technologies offers two innovative chemical processes capable of beneficiating low-grade phosphate rock (*Fertilizer International* 500, p35):

- The **EcoPhos** process – an acquired technology based on the use of dilute hydrochloric acid
- The **GetMoreP** process – a similar technology developed in-house by Prayon based on the use of dilute sulphuric acid.

Both processes generate dicalcium phosphate (DCP). This flexible end-product can be used as a high purity feedstock (39-41% P_2O_5 and 32-34% CaO) for phosphoric acid plants, enabling the manufacture of a range of downstream phosphate products.

Sulphuric acid plant heat recovery

The standard wet process route for phosphoric acid production involves the digestion of phosphate rock with sulphuric acid. This is typically supplied by on-site sulphuric acid plants. The reliability, output and energy efficiency of these plants are therefore major considerations for integrated phosphate producers.

In the sulphuric acid process, the energy released through combustion and other exothermic reactions is easily recovered as high-pressure (HP) steam. In contrast, the recovery of low-level energy – such as the heat produced during SO_3 hydration – is usually uneconomic and is instead lost at the cooling tower.

However, with the MECS® Heat Recovery System (HRS™) from Elessent Clean Technologies, sulphuric acid plants can significantly increase their thermal efficiency by upgrading and recovering this low-level energy as medium-pressure (MP) steam. The amount of steam generated usually ranges from 0.4-0.6 tonnes of steam per tonne of acid produced. Typically, this steam can then be used to produce three megawatts of electricity per 1,000 t/d of acid capacity (*Fertilizer International* 508, p28).

The longevity and reliability of equipment are also important cost factors in sulphuric acid production. Beneficially, MECS® HRS™ can meet these requirements too, being designed with durability and low maintenance in mind (*Fertilizer International* 508, p28).

HRS™ technology has been deployed at sulphuric acid plants for around 40 years with over 100 units installed worldwide. It can also provide UN-accredited carbon-free energy for plant owners and neighbouring communities.

Elessent Clean Technologies is a major technology provider to the phosphates sector. More than 70 percent of the sulphuric acid produced using MECS® technologies, for example, goes into phosphate fertilizer production.

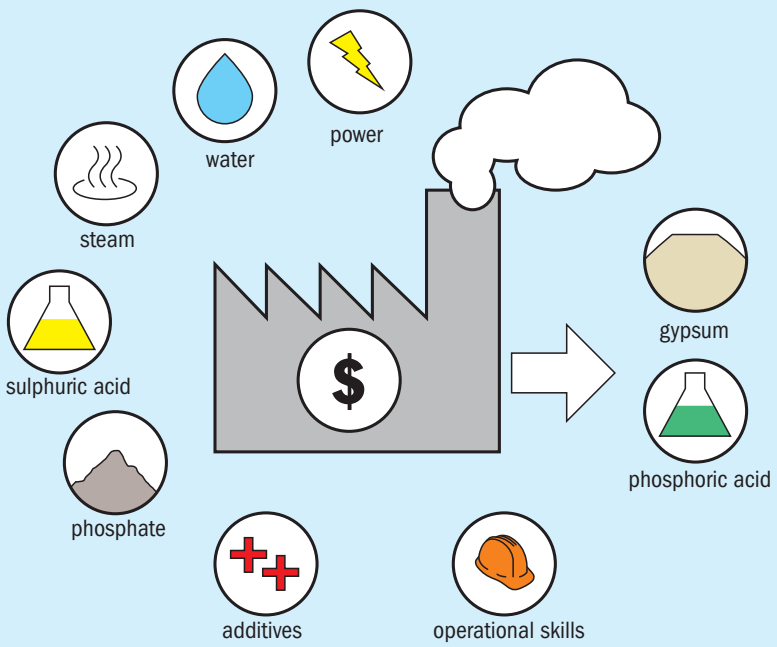
Phosphoric acid process selection

The wet process is the most economical and widely-adopted method for commercial phosphoric acid production globally. Phosphate rock is attacked with sulphuric acid to produce phosphoric acid and a solid calcium sulphate by-product. These are subsequently separated by filtration (*Fertilizer International* 481 p49).

The six available wet process routes for phosphoric acid production have distinctly different characteristics. They vary according to whether dihydrate (DH) or hemihydrate (HH) calcium sulphate crystals form initially, and by the number of crystallisation and filtration steps involved (Table 1).

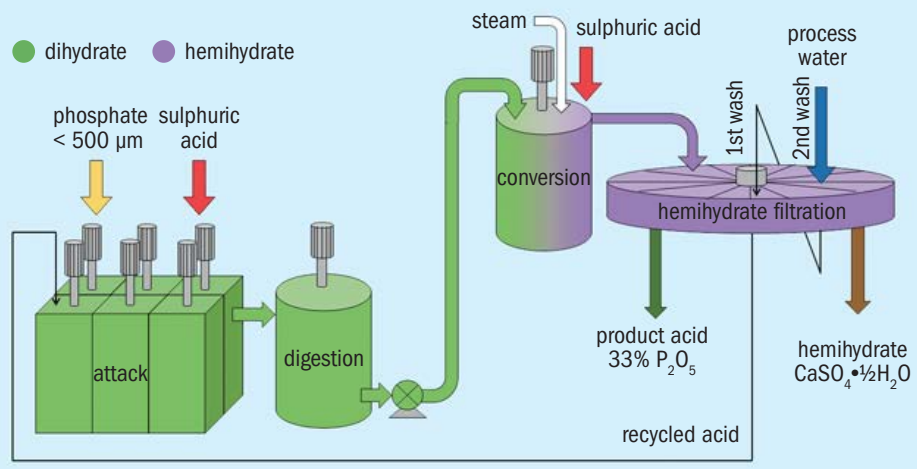
Prayon has developed commercial phosphoric acid production options for five of these six process routes, the one exception being the HRC (Nissan H) process (*Fertilizer International* 481 p49).

Fig. 1: **Phosphoric acid selection criteria**



Source: Prayon

Fig. 2: **Prayon's innovative new DA-HF process**



Source: Prayon

The company's technology is used in more than 130 phosphoric acid plants in over 30 countries globally[1].

In Prayon's view, process selection, and the relative merits of each process route, can be assessed using the following criteria (Figure 1):

- Phosphate rock consumption and tolerance of impurities
- Quality and amount of sulphuric acid needed
- Steam, water and power consumption
- Additive usage
- The quality/strength of the phosphoric acid product
- The quality of phosphogypsum by-product
- Plant operability and ease of maintenance (opex)
- Sensitivity of the process to instability
- Investment cost (capex).

While investment cost is an important factor, it is vital to select the phosphoric acid process that best suits project circumstances and ensures the successful operation of the whole phosphate fertilizer complex, rather than opt for the phosphoric acid unit with the cheapest capital cost. That's because a lower cost phosphoric acid plant, if undersized or inflexible, can perform poorly and make the whole production process uneconomic (*Fertilizer International* 481, p49).

While double crystallisation processes generally have a higher investment cost than single crystallisation processes, Prayon's new DA-HF process (Figure 2) can offer valuable performance advantages at a reasonable investment cost[1].

Grupa Azoty is currently operating the world's first DA-HF plant at its Police production site in Poland. This was installed as part of a revamp of the company's existing DH plant. The new DA-HF plant was engineered by Ballestra, who also helped commission the plant in 2019 in collaboration with a team from Prayon (*Fertilizer International* 496 p52).

The phosphogypsum challenge

As it expands globally, phosphate fertilizer manufacturing is generating ever larger volumes of phosphogypsum waste. Billions of tonnes of this material are currently being managed at great cost within giant waste stacks.

Nevertheless, phosphogypsum is finding increasing use as a co-product in agricultural, building and construction applications, particularly outside of the United States. This is a sign that the previously unwanted solid waste generated by the phosphate industry is becoming a valued resource (*Fertilizer International* 478, p58).

It is estimated that some 50-60 million tonnes of phosphogypsum are now being utilised worldwide (*Fertilizer International* 501, p45). Notable examples of commercial phosphogypsum (PG) use include:

- **Belgium** (Prayon): high-quality PG for the cement and plaster market.
- **Brazil**: most PG now goes to agriculture (5 million t/a) following its reclassification.
- **Canada** (Nutrien): PG for agriculture and for afforestation using man-made 'anthrosols' – PG mixed with soil in a 9:1 ratio.
- **China** (Wengfu Group): more than half of PG output is used in agriculture and construction, or recycled as ammonium sulphate/calcium carbonate.
- **Kazakhstan** (UN): large-scale remediation of saline/sodic soils.
- **India**: PG reclassified as a co-product, not waste, in 2008. Widely sold for construction, agriculture, soil additive, cement and as bagged fertilizer (Paradeep). Examples include afforestation for green energy (Coromandel) and road construction (Paradeep).
- **Russia** (PhosAgro): use of PG in agriculture, construction and road building
- **Tunisia** (GCT): PG for brickmaking, road construction, housing and for remediation and the return of land to productive use.

Nutrien, for example, has successfully established high yielding poplar and willow plantations (see photo) on top of waste stacks in Alberta, Canada, using artificial soils created from weathered phosphogypsum (*Fertilizer International* 501, p45)

"The tree plantations established at Nutrien are predicted to sequester 30 tonnes CO_2 equivalents per hectare per year," Nutrien's Connie Nichol told *Fertilizer International*. "Thus, in 20 years, the gypsum stack area reclaimed to date will sequester 12,000 tonnes of CO_2. This same area is also predicted to produce 10 oven dry tonnes/ha/year of above ground woody biomass."

Phosphoric acid process selection has a major influence on phosphogypsum quality and therefore use. Double crystallisation processes (HDH, DA-HF and CPP), for example, due to their higher resource efficiency, can generate higher quality phosphogypsum suitable for industrial applications as this contains much lower P_2O_5 levels. This factor is critical for gypsum used in plaster and the cement market. Valuably, two of these processes (DA-HF and CPP) also generate hemihydrate, a self-drying gypsum product that offers significant energy and cost savings for the industrial end user[1].

Prayon's approach to phosphoric acid manufacturing provides a good example of how to manage and use phosphogypsum. The company has been successfully selling gypsum as a co-product for more than forty years. Currently, almost all of the phosphogypsum produced at its CPP phosphoric acid plant in Engis, Belgium, is

sold for plaster and cement manufacture or for agricultural use (*Fertilizer International* 501, p45).

Prayon's commercial customer Knauf established a plaster production plant close to Engis on the opposite bank of the River Meuse. Phosphogypsum from Prayon's production plant is transported by conveyor belt across the river to a discharge point where it is temporarily stored. Over a period of several weeks, the phosphogypsum cures naturally in-situ, reverting from wet hemihydrate (HH) cake (18% free water, 6% crystalline water) to rehydrated dry dihydrate (DH, 5% free water, 19% crystalline water). The resulting gypsum product requires no further treatment prior to its shipment down river by barge to Knauf's stucco plaster factory (*Fertilizer International* 501, p45).

Fluorine – nuisance pollutant to revenue earner

The production of phosphoric acid (H_3PO_4) and phosphate fertilizers creates silicon tetrafluoride (SiF_4) as a toxic off-gas. This originates from the natural levels of fluorine present in sedimentary (0.10-0.14 kg F per kg P_2O_5) and igneous (0.06-0.08 kg F per kg P_2O_5) phosphate rock. Currently, this problem is mainly tackled by absorbing SiF_4 in water to form fluorosilicic acid (FSA, H_2SiF_6). The FSA obtained is then neutralised and either stored in ponds or disposed of into the sea (*Fertilizer International* 504, p44).

World phosphoric acid production, and by association FSA, is on the rise. Assuming phosphoric acid contains three percent fluorine on average, around 1.4 million tonnes of by-product FSA was produced globally in 2019, according to some estimates.

Although usage remains comparatively low, around 200,000 tonnes (fluorspar equivalent) of FSA is consumed annually in aluminium fluoride (AlF_3) manufacture, meeting some 11 percent of the global industry's fluoride needs. Water fluoridation and fluoride salt manufacture consume a further 200,000 t/a of FSA by-product. Some FSA is also used during phosphoric acid production as a sulphuric acid substitute, reducing the latter's usage by about five percent (*Fertilizer International* 504, p44).

Prayon offers a fluorine recovery system that can be installed during the concentration of phosphoric acid to 48-60% P_2O_5. This prevents fluorine being released to the atmosphere via the stack, or being sent back to the phosphoric acid plant where it results in scaling. This recovery system can simultaneously save on maintenance costs and increase revenues if the recovered FSA is sold for the manufacture of hydrofluoric acid or aluminium fluoride (*Fertilizer International* 504, p44).

The anhydrous hydrogen fluoride (AHF) process from Buss ChemTech (BCT) also offers the international phosphate industry a commercially attractive route for recovering FSA and creating added-value products. BCT's technology, by manufacturing anhydrous hydrogen fluoride (AHF) from FSA, provides access to higher value markets such as organic and inorganic fluorochemicals or high bulk density (HBD) aluminium fluoride. The manufacture of AHF also creates indirect value, for the environment and the economy, by substituting for the large amounts of calcium fluoride (CaF_2) which would otherwise need to have been mined (*Fertilizer International* 504, p50).

BCT first commercialised FSA-to-HF conversion technology in the early 2000s. The company went on to successfully commission its first industrial AHF plant for Chinese phosphate producer Wengfu Group in 2008. This proved such a success that Wengfu now operates six BCT-constructed AHF plants (*Fertilizer International* 504, p50).

BCT recently completed the first AHF project outside of China for Nutrien at its Aurora plant in North Carolina. Arkema also took part in this project as the AHF consuming partner. BCT, which is owned by Ballestra, expects global capacity for FSA-to-HF technology projects to reach more than 200,000 t/a of AHF this year (*Fertilizer International* 504, p50).

Acknowledgement

This article is partly based on a presentation by Ballestra, Buss ChemTech, Prayon Technologies and Elessent Clean Technologies (MECS®) given at CRU's Phosphates Conference & Exhibition in Tampa in March 2022[1]. This set out the case for an integrated approach to the design and construction of phosphate fertilizer production plants.

References

1. Valkov, S., et al., 2022. Exploiting more with integrated approach. *CRU Phosphates 2022 Conference & Exhibition*, 7-9 March, Tampa, Florida.


PHOTO: NUTRIEN

Poplars planted on a phosphogypsum stack in 2016 have grown extremely well.

Low-chloride options and market drivers

Applications of chloride-containing fertilizers need to be carefully managed for crops such as berries, broad beans, citrus fruits, nuts, potatoes and stone fruits. Selecting chloride-free nutrient sources instead can offer distinct advantages.

Potassium chloride – a valued commodity

Potassium chloride (KCl, muriate of potash, MOP) has a number of well-known natural advantages as a fertilizer. It is widely available, relatively low-cost and readily soluble in water. Equally importantly, it has the highest potassium content (60-62% K_2O) of any of the mineral forms of potash.

Potassium chloride delivers K to plant roots both quickly and effectively, and also mixes well with other nitrogen and phosphate fertilizers. Indeed, the evidence suggests that the use efficiency of N and P fertilizers improves when applications are combined with K.

Potassium plays a key role in photosynthesis and the formation of sugars. It also has a direct role in protein synthesis and is therefore an essential element for cell growth and development. Potassium is also an important nutrient when it comes to mitigating the effects of salinity, cold, frost, waterlogging, drought and other stresses on crop production. It also offers protection against insects, pests and various diseases[1].

In contrast, the chloride component of KCl benefits some crops but can have an adverse effect on others.

Crops exhibit a range of responses to chloride. Typically, MOP and other chloride-containing fertilizers can be applied at rates of up to 140 kg of Cl per hectare with no negative effects on crop growth or yield[2]. However, careful or restricted applications sometimes become necessary for a limited number of chloride-sensitive crops – especially when exacerbated by factors such soil salinity and salt stress.

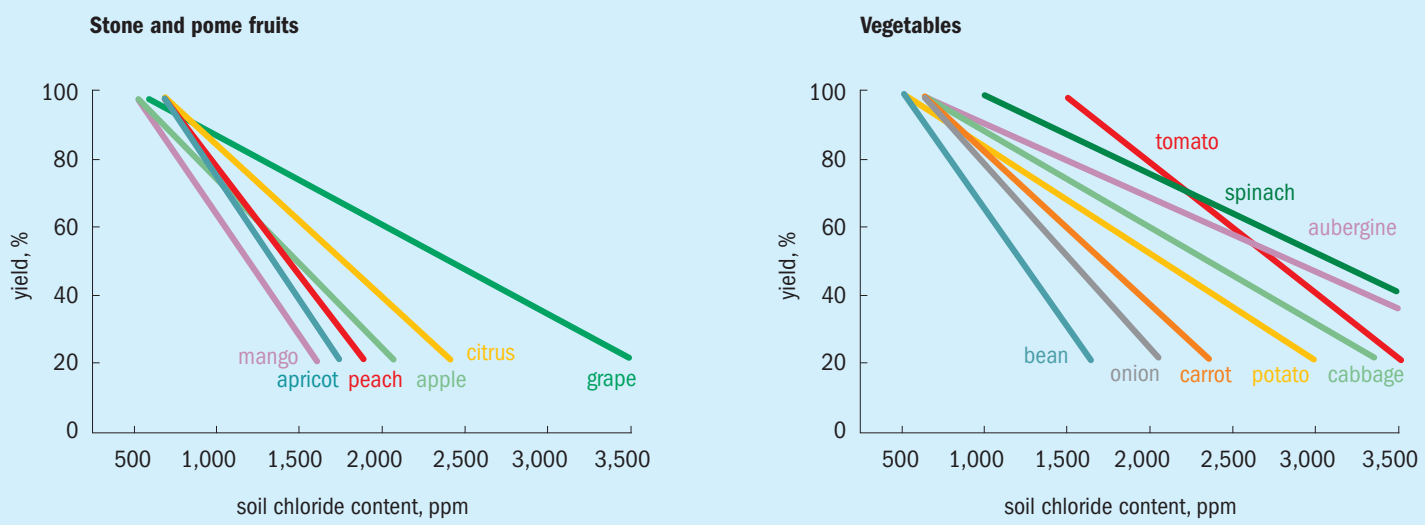
Soil salinity – a growing problem

Salinity is a major problem for world crop production, according to the FAO, affecting about 20 percent of cultivated land and 33 percent of irrigated land globally. In total, more than 833 million hectares of soils worldwide are salt-affected currently.

The area of salt-spoiled irrigated land has increased from 45 million hectares to more than 62 million hectares in two decades – with damaging agricultural, environmental and economic consequences. The annual cost in lost crop production from saline land degradation caused by irrigation has been estimated at $27.3 billion globally, equivalent to an economic loss of $441/ha.

Chloride levels and salinity in soils can become elevated due to one or more of the following:

Fig 1: **The effect of chloride on selected fruit and vegetables**



Source: K+S

Table 1: **Crop sensitivity to foliar injury from chloride in sprinkler irrigation water**

Crop	Sensitivity to foliar injury (Cl concentration, mmol/litre)
Almond, apricot, citrus, plum	<5
Grape, pepper, potato, tomato	5-10
Alfalfa, barley, corn, cucumber, sesame, sorghum	10-20
Cauliflower, cotton, sugar beet, sunflower	>20

Source: Xu et al. (2000)

- Use of saline irrigation water
- Influx of seawater into groundwater in coastal areas
- Poor soil drainage due to either a lack of rainfall or lack of leaching
- Overuse of chloride-containing fertilizers (KCl, NH_4Cl, NPK 15-15-15 etc.).

In recent years, interest has grown in the management of fertilizer use under saline conditions due to increasing agricultural use of saline water and recycled sewage water. Irrigation water containing less than 150 mg/litre of Cl can be used on most crops. Salinity does become problematic, however, if it starts to disrupt plant nutrient uptake and translocation by:

- Raising the total ionic strength of the soil solution
- Increasing competition between nutrients and Na^+ and Cl^- ions.

This can lead to sodium-induced calcium and/or potassium deficiencies and chloride-induced inhibition of nitrate uptake. Phosphorus uptake by plants is similarly suppressed under saline conditions[2].

Chloride – the good and the bad

Chloride is required by plants for photosynthesis, fluid pressure control (osmoregulation) and for specialist parts of the leaf (stomatal guard cells) (*Fertilizer International* 471, p39).

Although chloride application is rarely needed at rates over 10 kg/ha, relatively large amounts of Cl are essential for some crops such as kiwifruit and sugar beet. Oil palms and coconut plants also need Cl to help the outer layer of their leaves to function (charge balance in guard cells)[2].

Yield response to chloride varies widely (Figure 1) with some crops exhibiting a high degree of tolerance. Sugar beet is one crop that requires large amounts of chloride to flourish, and shows higher yields with increasing chloride applications up to soil concentrations of 1,600 mg/kg[1].

Wheat and other cereals can be sensitive to chloride deficiency. This makes potassium chloride applications beneficial in areas such as the US Great Plains and the Canadian Prairies where soil chloride is often below critical levels. In contrast, the excessive application of chloride-containing potash can hurt US soybean yields, according to recent research by the University of Minnesota.

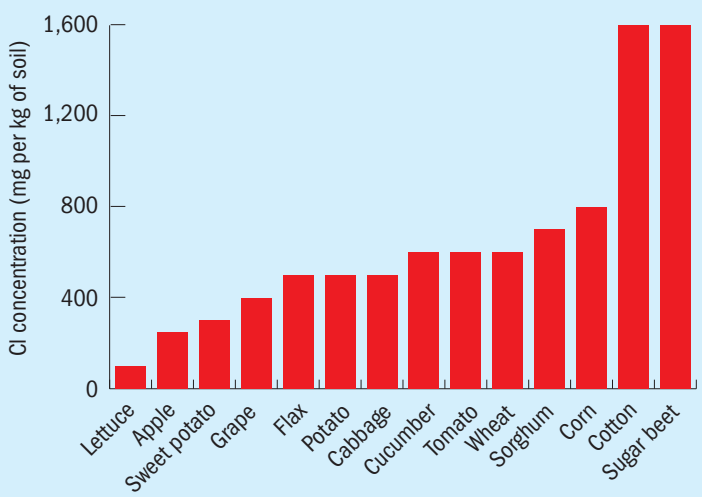
Critical soil Cl toxicity concentrations for different crops are shown in Figure 2. While chloride deficiency can occur in crops with high Cl requirements (e.g., kiwi fruit, palms and sugar beet), chlorine toxicity is much more common as a limiting factor in crop growth worldwide, particularly in arid and semi-arid environments. A critical chloride toxicity threshold of 15-50 mg/g and 4-7 mg/g have been reported for chloride-tolerant and chloride-sensitive crops, respectfully[2].

As a general rule, non-woody plants are less susceptible to Cl toxicity than woody plants, such as citrus trees, and bean crops[2]. Relatively insensitive crops such as rice, wheat, sorghum, cotton, tomatoes, aubergines, bananas and peaches, meanwhile, can tolerate Cl in fertilizers at rates of 1,350-1,800 kg/ha each season[1].

Application rates of chloride-containing fertilizers such as MOP do need careful management for other crop types. Chloride applications for crops with a moderate chloride tolerance, such as soybean, pea, strawberry, peanut, apple and sugarcane, should typically fall within the range of 675-1,350 kg/ha. Other crops, especially pepper, cabbage, lettuce, rape, tobacco, potato and sweet potato, are more chloride sensitive and Cl applications should not exceed 675 kg/ha each season[1].

The presence of chloride in sprinkler irrigation water can also result in foliar injury in some crops (Table 1.).

Fig 2: **Critical soil chloride toxicity concentrations for selected crops**



Source: Xu et al. (2000)

Table 2: **Salt indices for selected fertilizer products**

Product	Salt index
Potassium chloride (MOP)	116.3-109.4
Ammonium nitrate (AN)	104.7
Urea	75.4
Potassium nitrate	73.6
Ammonium sulphate (AS)	69.0
Calcium nitrate (CAN)	52.5
Potassium sulphate (SOP)	46.1
Potassium magnesium sulphate (SOPM)	43.2
Monoammonium phosphate (MAP	34.2
Diammonium phosphate (DAP)	29.9
Ammonium phosphate	26.9
Superphosphate	7.8-10.1

Source: FAO

Selection of a fertilizer with a lower salt index (Table 2) is one option for chloride-sensitive crops, particularly under saline growing conditions. This lowers the risk of salt burn and damage to seedlings and young plants.

Chloride-free potassium fertilizers

Popular chloride-free alternatives to potassium chloride (*Fertilizer International* 488, p48) include:

- Potassium sulphate (K_2SO_4, SOP)
- Potassium nitrate (KNO_3, NOP)
- Potassium magnesium sulphate ($K_2Mg_2(SO_4)_3$, SOPM)
- Polyhalite ($K_2Ca_2Mg(SO_4)_4.2H_2O$)
- Monopotassium phosphate (MKP, KH_2PO_4)

Of these potash alternatives, potassium sulphate (SOP) and potassium nitrate (NOP) are the most widely produced and applied by growers currently. Although sold at a premium, both can offer crop yield and quality advantages over MOP for specific crops under certain growing and soil conditions.

While MOP may be the preferred potash fertilizer for cereals and oilseeds, SOP is favoured for more chloride-sensitive, higher-value cash crops, notably fruits, vegetables, tobacco and tree crops. The other obvious advantage of SOP, as a sulphur source, is that it can be applied to address sulphur deficiency.

Total global SOP production capacity is around 11.2 million tonnes, according to some estimates, although actual production is around 6.6-7.3 million tonnes annually. SOP demand divides regionally between:

- China – 62 percent
- Europe – 17 percent
- The Americas – nine percent
- Middle East and Africa – seven percent
- South Asia, Southeast Asia and Oceania – three percent.

Outside China, Tessenderlo Kerley International (GranuPotasse, SoluPotasse, K-Leaf), K+S Group (KALISOP), and Compass Minerals (Protassium+) are the leading SOP producers. Major Chinese producers include Xinjiang-based Luobupo and Migao Corporation (*Fertilizer International* 488, p48).

SOP remains the cheapest low-chloride source of potassium, according to Tessenderlo Kerley International. The ability to supply plant-available sulphur is becoming increasingly valued too. Sulphur fertilization is particularly important in crops with a high sulphur demand such as brassica, canola and onions.

Potassium nitrate (NOP) offers a chloride-free source of both potassium and nitrogen. It can be soil applied as prills and is also widely used as a water-soluble fertilizer in irrigation systems (fertigation) and foliar sprays. Global production capacity stands at around 5.5 million tonnes currently. Major NOP producers include SQM (Qrop KS, Ultrasol K Plus), Haifa Group, Yara, KEMAPCO and Migao Corporation (*Fertilizer International* 488, p48).

NOP offers crop benefits during critical growth stages, such as during the booting of rice or tuber-bulking in potatoes, for example. Its nitrate content is also associated with improved water use efficiency and greater nutrient uptake (K, Ca, Mg) during fertigation (*Fertilizer International* 503, p56).

How big is the low-chloride crop nutrition market?

The global SOP market is forecast to grow by around four percent over the next decade or so, from 7.1 million tonnes currently to 7.4 million tonnes by 2035, according to Argus. Demand growth will be led by Europe (+4.0%) followed by Africa and the Middle East (+3.1%), the Americas (+1.1) and China (+0.5%).

However, there is a widely-held view that the SOP market is supply-constrained with market growth partly limited by supply and availability. Unmet demand for SOP does exist in the market, according to Tessenderlo Kerley International: "We believe that SOP market growth is probably constrained by supply. The supply/demand balance remains very tight – it is difficult to supply all demand – [and] if there was more product on the market it would almost certainly be consumed. So, potentially, growth could be higher if more production was available."

Historically, the ability of SOP – and other MOP alternatives – to provide a chloride-free form of potassium to crops has undoubtedly been a key market driver, as CRU have commented previously (*Fertilizer International* 475, p49):

"Although the potassium requirement of crops is the most fundamental determinant, it's really the cultivation of chloride intolerant and chloride-sensitive crops which is the core driver of SOP demand. MOP, the cheapest form of potash, contains high levels of chloride which can be harmful to the yield and quality of many crops."

Two concepts in particular – demand elasticity and unmet demand – can help predict the potential market size for low-chloride crop nutrition products.

While chloride-free potassium fertilizers are the only viable option for highly chloride-intolerant crops, they are optional choices for less chloride-sensitive crops – and therefore will only be selected by growers if the yield and quality improvements justify the extra costs involved. Because of this, the agricultural market requirement for chloride-free potassium can be split between 'inelastic' demand from chloride-intolerant crops and 'elastic' demand from other less chloride-sensitive crop types (*Fertilizer International* 475, p49).

Previously, CRU has estimated the demand potential for chloride-free potassium sources in more than 180 countries globally. This was based on a model that combined crop acreages and yields with crop-specific potash removal rates and a chloride-sensitivity value for each crop type (*Fertilizer International* 475, p49).

Results suggest that low-chloride crop demand is mainly linked to around 10 crop types in five key countries (Figure 3):

- China: potatoes, tomatoes and beans
- India: potatoes, mangoes and peas
- United States: almonds, potatoes and citrus
- Russia: potatoes, sunflower seeds and apples
- Brazil: citrus, tobacco and beans.

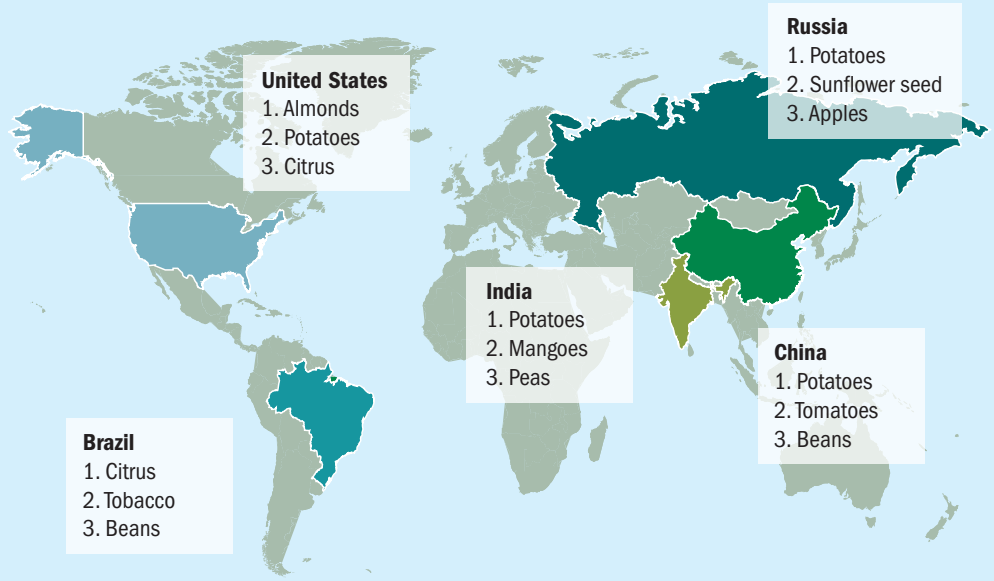
China emerges as the country with the greatest potential for low-chloride crop nutrition, accounting for about a third of the world's total potential for chloride-sensitive potassium demand. Russia, Brazil and Nigeria also show high demand potential for low-chloride sources of potassium, based on the chloride-sensitive crops grown in these countries (*Fertilizer International* 475, p49).

"Cultivation of chloride-sensitive and intolerant crops has grown very rapidly in areas of significant population growth, such as Africa, South Asia and Southeast Asia – we think there's a lot of future potential in these regions. In addition to India, countries which appear to be significantly under-consuming SOP appear to be Russia, Brazil and Nigeria to name just a few." commented CRU.

Similarly, an analysis in 2019 by Sirius Minerals, the former owner of the Woodsmith polyhalite project in the UK, identified significant unmet global demand for chloride-free potassium. They calculated that chloride-sensitive crops were responsible for 32 percent of total potash consumption, yet the actual supply of chloride-free potassium fertilizers to these crop types was much lower at only nine percent.

Their analysis suggested that, globally, 23 percent of potential low chloride potassium demand in the market was therefore unmet. If completely fulfilled, this potential shortfall could translate to around 70 million t/a of polyhalite demand, for example. This calculation was, however, clearly a scoping estimate and not a prediction or demand forecast by the company.

Fig 3: **Demand potential for low-chloride potassium fertilizers is associated with 10 crop types in five countries**



Source: Fertilizer International 475, p49

Attractive to new entrants

Potassium chloride (MOP) accounts for around 95 percent of the global potash market. The SOP market, while much smaller at seven million tonnes annually, is far more lucrative with products traditionally selling at large premiums (>$200/t) over MOP. In mid-July, for example, SOP was trading at $630/t Northwest Europe versus $330/t for MOP Vancouver.

The combination of a supply constrained SOP market and attractive price premiums has attracted new entrants. In Western Australia, two well-advanced SOP projects, Lake Way and Beyondie, were competing to enter production in the second half of 2021 – pursuing long-held ambitions to make Australia an SOP production centre and export hub for the Asia-Pacific region.

As Andy Hemphill, potash analyst at ICIS, commented in May 2021: "The chequered flag is being unfurled as the race to be first to market with potassium-rich sulphate of potash (SOP) fertilizer drawn from the barren wastes of Western Australia nears its conclusion. Producers are keen to take advantage of an expected wave of demand for SOP and high-potassium blended fertilizers over the coming years – with a particular focus on China, and the growing Asian markets."

These ambitions, however, have yet to be realised. One front running project, Lake Way, went into receivership on the brink of production in October 2021, although it was subsequently rescued by Czech-owned Sev.en Global Investments last year. The other project, Beyondie, which did finally start to produce and sell SOP commercially in 2022, also entered administration in August.

In the US, meanwhile, Peak Minerals is developing the Sevier Playa SOP project in Millard County, Utah. This well-advanced project has the potential to become America's largest SOP producer, targeting eventual production of 474,000 t/a under its second phase expansion plans (*Fertilizer International* 511, p44). In March, the company secured a $30 million loan from a strategic investor to fund front-end engineering and design (FEED) and preconstruction activities.

ICL has made a success in growing the market for polyhalite since converting its Boulby mine in the UK to production of this low-chloride multi-nutrient fertilizer, branded Polysulphate, five years ago. Boulby officially became the world's only polyhalite producer in August 2018. Since then, Polysulphate production at the mine has continued to rise to meet demand – reaching 953,000 tonnes in 2022, up by 21 percent year-on-year. Revenues

The under-construction Woodsmith polyhalite mine in the UK.

PHOTO: ANGLO AMERICAN

TESSENDERLO KERLEY CELEBRATES 30 YEARS OF SOLUPOTASSE®

SoluPotasse®, Tessenderlo Kerley's flagship SOP (sulphate of potash) fertilizer brand, is celebrating its 30th birthday in 2023. The market-leading product has been providing growers across the globe with the high quality, water-soluble grade of SOP for more than three decades.

A proud legacy

When SoluPotasse® was introduced into the market in 1993, Tessenderlo Kerley was the first SOP manufacturer worldwide to develop a fully soluble grade of SOP. The product was launched by the company in response to an increasing demand from growers wishing to use SOP in fertigation systems.

SoluPotasse®, which is produced in Belgium, has since become the global leading water-soluble SOP brand. Over three million tonnes have been sold since its launch, with sales in more than 100 countries. This makes 'the pink bag' (see photo) the world's most-popular water-soluble SOP product.

SoluPotasse® is widely regarded as being best-in-class. It provides a highly soluble form of potassium and sulphur (in sulphate form) and is suitable for a wide variety of crops via fertigation.

This high-grade product, developed and subsequently enhanced by a team of scientists and agronomists, has set new standards. Its formulation ensures efficient nutrient uptake by plants and delivers superior results compared to traditional potassium fertilizers.

It continues to be valued by professional growers throughout the world as a versatile water-soluble fertilizer capable of boosting crop yields and quality. This is especially true for chloride-sensitive crops and areas at risk from salinity.

A sustainable SOP fertilizer

"SoluPotasse® has been recognised for many years as a leading product in sustainable agriculture. It contains virtually no chloride, which ensures that soil salinity can be avoided, and its superior soluble quality makes it ideal for fertigation and precision farming. Furthermore, SoluPotasse® has a carbon footprint across the full value chain that is 15-20 percent lower than the average for SOP production. We have dedicated considerable work and investments in our production processes over the last couple of years and our ambition is to decarbonise our production even more in the years to come," explains Geert Gyselinck, Executive Vice President Tessenderlo Kerley International.

"By upcycling sulphur by-products from refineries into safe, non-hazardous fertilizers that become a valuable resource for growers, our SOP fertilizers are actively contributing to creating sustainable agriculture throughout the world. Moreover, the by-product hydrochloric acid from our SOP production process is, in turn, converted into coagulants that are used for the treatment of municipal and industrial wastewater, as well as for the purification of drinking water."

A bright future

As SoluPotasse® celebrates its remarkable 30-year journey, Tessenderlo Kerley is as committed as ever to innovation and sustainable agriculture – and is continuing to collaborate globally with researchers and farmers on further advances in SOP fertilizers. The company is also exploring new technologies, refining its formulations, improving its production energy mix, and decarbonising its processes.

PHOTO: TESSENDERLO KERLEY

SoluPotasse® is instantly recognised by growers globally due to its distinctive pink bag.

(SoluPotasse® is a registered trademark of Tessenderlo Group.)

Geert Gyselinck says Tessenderlo Kerley will become an even more sustainable company in the next 30 years:

"We have an undisputed strategy to remain at the forefront of the specialty SOP market. To this end, we will continue to consistently deliver high-quality products while simultaneously improving our focus on customer service.

"As we celebrate the legacy of SoluPotasse®, we must acknowledge its significant contribution to agricultural productivity and environmental preservation. Here's to the 30 years of excellence realised so far and the many more years to come!" ■

from ICL's polyhalite product range also increased last year due to higher selling prices (*Fertilizer International* 514, p19).

In February, Anglo American also unveiled a strategy update for its large-scale Woodsmith polyhalite mine project in the UK. The mining major has earmarked around $4 billion to complete the under-construction project. Initial production of the company's POLY4 polyhalite fertilizer is now scheduled to begin in 2027. The mine's ultimate annual output has also been increased to 13 million tonnes (*Fertilizer International* 514, p44). ■

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Fertilization management – SOP versus MOP

Many crops are sensitive to chloride due to a genetic susceptibility. Similarly, crops can become stressed when soil salinity reaches high levels, a situation that typically occurs in water scarce regions. So, when is low-chloride crop nutrition needed? **Dr Heike Thiel** of K+S Minerals and Agriculture GmbH provides some answers.

BEASTFROMTHEEAST/ISTOCKPHOTO.COM

A flowering potato plant. Potatoes prefer potassium sulphate (SOP) over potassium chloride (MOP) as this can increase the starch content of their tubers.

Introduction

Although some crops are chloride-tolerant, many others – notably potato and other fruit and vegetables – are only partly tolerant or chloride-sensitive. Farmers will therefore require low-chloride fertilizer sources, or fertilizers with no chloride content, in certain situations if they are to grow and harvest the best quality and highest yielding crops. This is especially true under saline growing conditions when water availability is low.

Potassium chloride (MOP) is produced and sold on a massive scale globally with potash products such as 60er Kali® proving popular with the world's famers, particularly in broad acre agriculture. Low-chloride potassium sources, although less widely used and generally more expensive, are also available. The most common types are:

- Potassium sulphate (SOP) products such as KALISOP®
- Potassium magnesium sulphate products such Patentkali®
- Potassium nitrate (NOP).

Table 1: **The main functions of potassium (K) in plants**

- Directly and indirectly affects photosynthesis
- Plays a role in plant metabolism– enzyme activation
- Helps to use water efficiently and with resistance drought stress
- Involved in carbohydrate synthesis (sugar and starch)
- Supports carbohydrate transport from the leaves to the plant's storage organs (tubers, grains, beets, etc.)
- Helps improve the quality and value of harvested products by raising protein and vitamin content

Source: K+S

The SOP sourced from natural mineral deposits in Germany provides crops with a valuable source of both sulphur and potassium. Sulphur is an important macro nutrient required for healthy plant growth but is often lacking in soils. SOP produced in Germany and elsewhere is also much less likely to exacerbate existing salinity problems in soils, compared to chloride-based products such as MOP.

As the role of potassium in crop nutrition is well-known (Table 1), the focus of this article is instead on chloride and sulphate and their effects on plants.

Chloride's effects on soils and plants

Chloride can accumulate in soils or be introduced via irrigation water, making strict fertilization and water management plans necessary due to its deleterious effects. This negatively-charged anion is notable for being water-soluble and highly mobile in soils.

We should not forget that chloride (Cl^-) is actually an essential micronutrient with vital functional roles in plants.

Table 2: The functions of sulphur (S) in plants

- Improves nitrogen efficiency
- Essential for the synthesis of sulphur-containing amino acids and supports the whole of protein synthesis
- Activates important enzymes in energy and fatty acid metabolism and plays an important role in the creation of oils
- A component of chloroplast protein
- Important for the formation of sulphur-containing plant compounds such as the allium and mustard oils which influence the taste and smell of various crops
- A component of vitamin B1 in cereal grains and legumes etc
- Important for production of the plant's own defensive compounds (phytoalexins, glutathione)
- Reduces nitrate in vegetables

Source: K+S

Table 3: Which crops love chloride and which do not?

Classification	Crop	Product
Chloride-loving: Chloride based fertilisers are preferred.	Sugar beet, fodder beet, celery, Swiss chard, coconut	Korn-Kali® Korn-Kali+B® 60er Kali®
Chloride-tolerant: Chloride based fertilisers can be used but most vegetables prefer sulphate based fertilisers because of their sulphur demand.	Cereals, maize, oilseed rape, asparagus, cabbage, beetroot, rhubarb Grassland, clover, oil palm, rubber, rice, groundnut, cassava, soybean, sugar cane, banana, cotton	60er Kali® Korn-Kali® Magnesia-Kainit®
Partly chloride-tolerant: Chloride based fertilisers can be used if they are applied on time before the start of vegetative growth.	Sunflowers, grape vines, stone fruits, blackcurrants, seed potatoes, potatoes for human consumption, tomatoes, radish, kohlrabi, peas, spinach, carrots, leek, horse-radish, chicory, pineapple, cucumber, kiwifruit, coffee, tea	Patentkali® KALISOP® KALISOP® Premium Korn-Kali®
Chloride-sensitive: Only fertilisers containing potassium in the form of sulphate should be used.	Starch potatoes, potatoes for processing, tobacco, redcurrants, gooseberry, raspberry, strawberry, blackberry, blueberry, mango, citrus, pepper, chilli, avocado, cashew, almond, peach, cocoa, hops, pomes and stone fruits (especially cherries), bush beans, broad beans, cucumber, melon, onion, lettuce, early vegetables, all crops under glass, conifers, flowers and ornaments as well as seedlings and transplants of most plants	Patentkali® KALISOP® KALISOP® Premium

Potassium chloride (MOP) based products:
60er Kali® 60% K_2O; Korn-Kali® 40% K_2O, 5% MgO, 6% S; Korn-Kali+B® 40% K_2O, 5% MgO, 6% S, 0.25% B; Magnesia-Kainit® 9% K_2O, 4% MgO, 3.6% S

Potassium sulphate (SOP) based products:
Patentkali® 30% K_2O, 10% MgO, 17.6% S; KALISOP® 50% K_2O, 17.6% S; KALISOP® Premium 50% K_2O, 17.6% S

Source: K+S

It is essential for splitting water molecules during photosynthesis, for example. It is also important in osmotic regulation and, in combination with potassium, has a valuable part to play in maintaining the water balance within plants.

Being necessary for growth, plants will display classic deficiency symptom when chloride is missing due to metabolic problems. These symptoms hardly ever appear in the field, however, due to the small chloride requirement of most crops. While plants have an average Cl content in the 2-20 mg/g range (dry matter basis), the optimal growth requirement is typically 10 to 100 times lower for most plant species.

In chloride-sensitive crops, excessively high chloride content will lower germination rates, cause seedling injury, and result in lower yielding, poorer quality crops. The accumulation of excessive amounts of chloride in cells is toxic to chloride-sensitive plants and the resulting strong osmotic effects reduce the transport and storage of assimilates.

Sulphur – essential for growth

Sulphur, the second macronutrient in SOP, optimises plant growth and is present in highly efficient sulphate (SO_4) form. It is essential for protein synthesis, improves nitrogen efficiency and helps plants produce their own defensive substances (Table 2).

Sulphur is associated with significant yield increases in oilseeds and legumes. Onions, leeks and garlic also require sulphur due to its presence in their characteristic flavour-forming compounds.

Sulphur is exclusively taken up by plants from the soil in the form of sulphate anions. The adsorption capacity of soils for sulphate is poor due to its negative charge. This means sulphate, similar to the nitrate anion, is at risk of leaching, especially during the winter months.

The risk of severe sulphur deficiency exists on all light soils. Additional risk factors include above-average precipitation, structurally weak soils, as well as all conditions that lead to a restricted root system. However, sulphur supply for the entire vegetative growth period is usually ensured by fertilizing with sulphate to satisfy spring demand, as evaporation in the spring and summer generally exceeds precipitation, thereby avoiding leaching.

When to avoid chloride's negative effects?

SOP is generally favoured over MOP (KCl) as a potassium source for chloride-sensitive crops, including potatoes, certain fruits and vegetables, tobacco, almonds etc (Table 3).

Citrus fruits, for example, become bigger and heavier and contain more sugar and juice when they are fertilized with SOP. Pineapple also benefits from potassium fertilization with SOP – whereas fruit yield, fruit size and fruit quality characteristics, such as the sugar acidity ratio and flesh colour, are negatively affected when chloride fertilizers are applied.

> **In chloride-sensitive crops, excessively high chloride content will lower germination rates, cause seedling injury, and result in lower yielding, poorer quality crops.**

Avoiding fertilizers with high chlorine levels – and favouring SOP instead – can have beneficial effects. When applied to potato crops, for example, SOP helps to start the enzymatic browning process by raising the plant's free amino acid content and levels of phenolic compounds. Additionally, SOP increases the starch content of potato tubers by improving the translocation and storage of assimilates.

Potatoes are leafy crops that require large quantities of potassium. When growing potatoes, farmers should focus on selecting the mildest possible type of potassium fertilizer with a low salt index – while avoiding those with high chloride levels due to their potentially damaging effects. The translocation of assimilates formed within leaves and the development of a fine root system are both impaired, for example, in potato plants which receive larger amounts of chloride. The potato plant's leaf system can also become stressed when the fertilization regime is inadequate.

Chloride affects plants by increasing the osmotic potential of the soil water. Because of this, applying chloride-based products in regions facing water scarcity should be avoided as this can lead to higher soil salinity levels. The use of these products can also reduce the ability of plants to take up water.

Conclusion

Summing up, fertilizer applications need to be tailored to both the individual requirements of the crop and the environmental conditions of the growing region. In practice, nutrient management needs to take account of two key factors: on the one hand, there are chloride-sensitive crops and, on the other, there are regions with little precipitation. In these low rainfall regions, the accumulation of chloride from fertilizers needs to be specifically avoided, as this can add to existing soil salinisation, making the soils either barely usable or completely unusable.

In these circumstances, fertilization with chloride-free fertilizers based on sulphate such as SOP (K_2SO_4) offers an ideal solution. While these products are usually more expensive, they provide extra value as they contain sulphur – another vital plant nutrient – in addition to potassium. Indeed, farmers benefit twice by fertilizing with SOP: not only have they eliminated the potentially negative impacts of chloride on their crops, they also gain sulphur, a nutrient involved in many important growing processes. ■

Low-chloride fertilizers – a proven strategy for chloride sensitivity

PHOTO: ICL

Tending to a strawberry crop.

The use of low-chloride fertilizers is a proven strategy for managing chloride sensitivity in crops and avoiding excess chloride in soils. ICL offers a wide range of crop nutrient products for this purpose. **Patricia Imas**, agronomist at the company, outlines the main options.

Chloride (Cl) has been classed as an essential plant nutrient since the 1950s. It plays a valuable role in osmoregulation of the whole plant, photosynthesis, nutrient transport, and enzyme function. Chloride is also involved in stomata regulation, opening and closing guard cells on leaf surfaces.

Chloride – in common with other micro-nutrients – is only required in very small amounts. Excessive Cl levels can therefore be detrimental to certain plants, affecting crop yields and quality.

Symptoms of chloride toxicity in plants include leaf burn, stunted plant growth, leaf drop and nutrient imbalances. Damage from chloride toxicity is associated with:

- Crops irrigated with saline water and/or grown on saline soils
- High water tables and/or capillary movement of Cl into the root zone
- Poorly drained soils that receive runoff from other areas, especially in coastal zones
- Intrinsic crop-sensitivity to Cl.

Excess chloride is especially harmful to so-called chloride-sensitive crops. These include various fruits and vegetables (e.g., soft fruits, grapes and avocado), hops, tobacco and some ornamentals.

The use of low-chloride fertilizers is a proven strategy for managing chloride sensitivity in crops and avoiding excess chloride in soils. ICL offers a wide range of crop nutrient products for this purpose. These are designed to meet fertilization requirements while minimising the input of chloride. They include:

- Controlled-release fertilizers (CRFs)
- Water soluble fertilizers (WSFs) for fertigation and foliar application
- Polyhalite.

These low-chloride product options are described below.

Controlled-release fertilizers

Controlled-release fertilizers (CRFs) are granular products coated with a semi-permeable membrane. These supply nutrients to plants throughout their entire growth cycle by gradually releasing these into the soil over a given time period. The targeted crop nutrients delivered by a one-time application of CRFs encourage uniform growth, maximise yields, and improve plant resilience. The other benefits of CRFs include greater nutrient use efficiency, reduced input costs, and lower leaching and volatilisation losses (which benefits the environment).

ICL offers fully coated NPK granules as part of its **Agroblen** product range. These low-chloride CRFs deliver nutrients over a fixed period (from 2-3 months up to 16-18 months) and are suitable for soil-grown, chloride-sensitive soft fruits, including strawberry, blueberry, raspberry and blackberry.

By applying only a few grams directly to the row or placed into the planting hole, Agroblen supplies nutrients in a controlled manner and according to plant needs. Because of this, NPK losses are significantly reduced, thereby ensuring more nutrients are available for plant uptake. The controlled release of nutrients over time also eliminates the labour, equipment and material costs associated with the multiple application of conventional granular fertilizers.

ICL also offers **Agromaster** – a CRF product line that combines both coated and uncoated NPKs – for all open-field, soil-grown vegetables that are sensitive to chloride, including crops with short growth periods such as lettuce. These powerful fertilizers partly deliver nutrients in an uncoated form for immediate take-up by plants to stimulate intensive growth. At the same time, they also provide NPKs in coated form. This prevents nutrient losses via run-off, leaching from light soils and/or losses under heavy rainfall conditions.

The use of Agromaster products allows fertilizer rates to be reduced without affecting crop yields. They are also versatile and, by creating a buffer supply of nutrients in the soil, especially valuable in circumstances where fertigation is not possible.

Nonetheless, where possible, the ideal fertilization plan should always be based on fertigation with water-soluble fertilizers, as this precisely supplies nutrients according to both the age of the plantation and the phenological stage of the plant.

Water-soluble fertilizers for fertigation

ICL has a wide range of water-soluble fertilizers (WSFs) designed for both fertigation and foliar application with chloride-sensitive crops.

The **Solinure** product family are formulated for fertigation in greenhouse and tunnel systems. These chloride-free NPK products are made of highly pure raw materials, contain chelated trace elements, and are low in urea.

Solinure Polymarine is ICL's newest addition to the Solinure family. This next generation, chloride-free fertigation product incorporates a seaweed extract and delivers both immediate and long-lasting crop nutrition. It functions by stimulating crop growth, improving stress tolerance, and supplying micronutrients in the necessary amounts.

ICL also offers a broad portfolio of fully water-soluble straight fertilizers under its **Nova** range. These include the chloride-free monopotassium phosphate (MKP) product **Nova PeaK 0-52-34**.

ICL is the world's largest MKP manufacturer. **Nova PeaK** is widely used as a fertigation product by growers and is particularly popular in hydroponics. It can be applied flexibly due to its high phosphorus and potassium content and the absence of nitrogen. Nova PeaK is chloride-free, contains almost no impurities and has a very low salt index (150-300 ppm sodium content). It is entirely safe for foliar application or sprinkler irrigation and avoids the risk of phytotoxicity or leaf-burn.

ICL's **Nova PeKacid 0-60-20** is a patented water-soluble PK fertilizer with an acidifying effect. This chloride- and sodium-free product is safe to use, being provided in powder form, and is ideal for both open-field and soilless crops. **Nova MagPhos** 0-55-18+7MgO is another fully water-soluble, chloride- and sodium-free fertigation product option that combines magnesium with phosphorus and potassium. It is also suitable for foliar spraying, especially at the flowering stage.

PHOTO: ICL

Agroleaf Power is an ideal low-chloride product for the foliar fertilization of grapes.

Water-soluble fertilizers for foliar application

High chloride concentrations in foliar sprays can lead to leaf burn, discolouration, and other forms of damage in many chloride-sensitive plants. Chloride-free fertilizers are therefore preferred for foliar application to reduce these damage risks.

ICL's **Agroleaf Power** range of foliar fertilizers combines high nutrient content with outstanding purity, including almost zero chloride levels. These water-soluble products dissolve quickly and completely and are offered in a wide range of macro and micronutrients formulations to match crop needs. They are designed to target individual growth stages and correct both nutrient imbalances and minor nutrient deficiencies. Additionally, Agroleaf Power products incorporates DPI and M-77 technologies for improved photosynthesis.

Agroleaf Crop is a preventive range of foliar products that are easy to incorporate within a complete fertilization programme. These chloride-free and fully soluble formulations are offered in special mixes of macro and micronutrients for different crops, such as cereals, maize, oilseed crops and potatoes. Agroleaf Crop products also reduce nutrient costs per hectare as they can be applied to leaves using a lower volume of spray. They are also compatible with a large number of plant protection products when tank mixed.

Finally, **Nutrivant** from ICL is a unique foliar fertilizer range available in crop-specific nutrient mixes. Products incorporate patented Fertivant technology that can break through the leaf cuticle. Foliar use of Nutrivant results in more even spread, faster penetration and longer lasting nutrient uptake.

Polysulphate

Polysulphate® is a unique multi-nutrient fertilizer rich in four key plant nutrients: sulphur, potassium, magnesium and calcium. It contains the natural mineral polyhalite and is exclusively mined in the UK by ICL.

Polysulphate is provided to growers in its natural state, being delivered directly from mine to field with no industrial processing. As a natural mineral fertilizer, it is widely approved for use in organic agriculture – holding organic certification in many countries internationally.

The low salt index and the very low chloride content of Polysulphate make it ideal and safe to use on even the most chloride-sensitive crops. ■

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