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NOVEMBER-DECEMBER 2022

BCInsight

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Cover: Stairs on a large freighter, Rio de Janeiro, Brazil. Maarten Zeehandelaar/ Shutterstock.com

10 Small fruit fertilization

23 Potash project listing

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NUMBER 511 NOVEMBER | DECEMBER 2022

CONTENTS

PHOSPHATES AND POTASH INSIGHT

REGULARS

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PHOTO: IFS

Steve Hallam.

FerTechInform: addressing the knowledge gap

The International Fertiliser Society (IFS) has launched FerTechInform, a comprehensive online technical resource for fertilizer production. The new digital resource combines an information knowledge base with an interactive forum for users. IFS Secretary **Steve Hallam** explains how it works, who it is for, and why it came into being.

The International Fertiliser Society (IFS) recently launched a new, free-to-use online information resource. This unique 'one stop shop' covers many of the technical aspects of fertilizer production.

To make it as relevant as possible to the global fertilizer industry, the resource – known as FerTechInform – was developed by the IFS in consultation with leading fertilizer industry organisations.

A recognised problem

FerTechInform was developed to meet a widely acknowledged need and knowledge gap – one that has long been recognised by the Society's membership and the wider industry.

While there is certainly no lack of technical information available on fertilizer production processes, swiftly collating and verifying this can be highly problematic. Relevant information is often time consuming to locate, out of date, fragmented/incomplete and of questionable accuracy. Accessing this information can also involve a charge.

In our view, engineers and managers who are new to the industry would like to receive an elementary grounding in fertilizer production technology and processes. Equally, experienced staff who change roles are also eager to familiarise themselves with new production processes, product types and technologies.

However, there are two barriers preventing this currently: firstly, there is a general lack of formal fertilizer industry training courses; and, secondly, due to demographic shifts within the industry, there is a rapid fall-off in the number of experienced engineers able to pass on their valuable knowledge to new engineers through on-the-job training.

FerTechInform – the answer?

If that is the problem, then what is the answer? Well, any useful information resource has to fulfil a range of requirements. As a solution, FerTechInform is designed to be:

- A foundation-level resource
- Accessible, reliable and available online all in one place
- Comprehensive, covering all major fertilizer production processes
- Up to date and easy to maintain
- Independent and commercially unbiased
- Available at low or no cost
- Credible and contain relevant and accurate information
- Able to grow and evolve over time
- Provide different levels/layers of detail.

The IFS realised that it was exceptionally well-placed to develop and curate such a resource. We are a not-for-profit, member-led organisation. Our remit is to act as a forum for the dissemination and discussion of technical information about fertilizers and crop nutrition. That is actually our raison d'être.

This is combined with a reputation for publishing authoritative and reliable information. During its 75 years of existence, the Society has built up an archive of more than 870 technical papers. We also maintain a strong network of relationships with leading industry organisations and companies.

This network proved invaluable in developing FerTechInform and incorporating reputable technical sources, including an agreement with the International Fertilizer Development Center (IFDC) to include its renowned *Fertilizer Manual*. Other content was provided by the European Fertilizer Blenders Association (EFBA), Fertilizers Europe, the European Sustainable Phosphorus Platform (ESPP) and others.

IFS plans to develop and expand the resource in phases over time. FerTechInform is currently structured into four main parts:

- Types of fertilizer or material, such as NPK fertilizers or phosphoric acid
- Types of processes or processing, such as granulation or blending
- Enabling or support topics, such as materials analysis or life cycle analysis
- Terminology.

This first phase covers 21 topics/subject areas and comprises 72 separate webpages. During this initial phase, IFS will monitor and evaluate the level of usage, before committing additional resources. Accordingly, to encourage take up, this first phase of FerTechInform is free for all users, including membership of the discussion forum.

Get involved!

IFS will decide on the future direction and rate of development of the resource in 2023, after assessing and analysing feedback from users. If all goes well, FerTechInform will ultimately be around four times larger than phase one when complete – covering more than 40 subject areas.

The existing content should greatly interest and be highly relevant to *Fertilizer International* readers. The IFS would therefore encourage you to visit FerTechInform, get involved and judge for yourself how well it meets your needs. We'd very much welcome your feedback!

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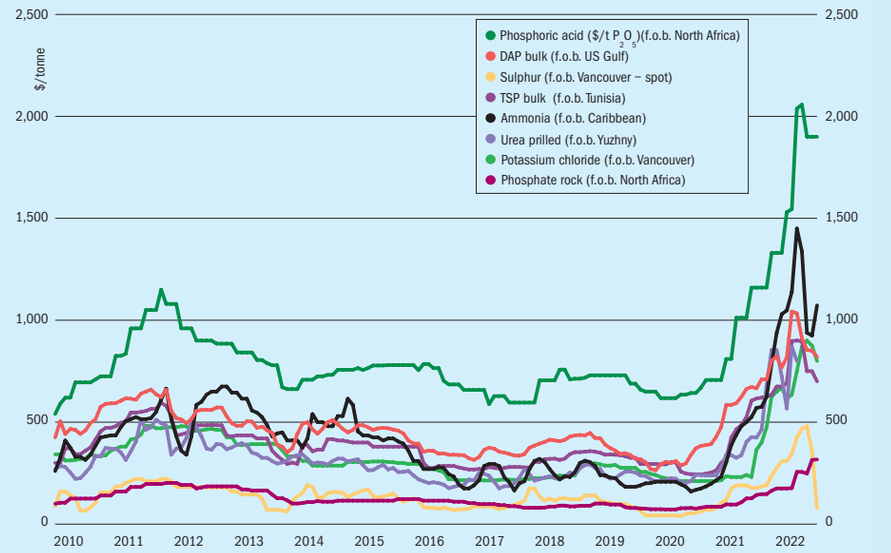
Historical price trends $/tonne



Source: BCInsight

Market Insight courtesy of Argus Media

PRICE TRENDS

Urea: Prices fell in most markets at the start of November after a sell-off in Egypt sparked a broader reset. Egyptian producers – sitting on high inventories and a meagre November sales-book – cut prices by around $55/t in early November, before rapidly regaining this lost ground as buying continued. The net result has been to clear most remaining unsold tonnes for November loading from producer inventories. Although Europe remains short of nitrogen, urea spot buying remains at a low ebb after some EU AN/CAN producers cut their prices by as much as €80/t.

Key market drivers: In Europe, increasing nitrates output and European Commission proposals to subsidise natural gas to fertilizer plants are major bear factors. India helped spark a price rally by calling its purchase tender. But the market could weaken if the tonnages booked are below expectations.

Ammonia: Prices continue to edge lower with the majority of buyers covered for the month ahead – especially in Europe where producers are ramping up production where possible. Delivered prices in northwest Europe fell $25/t to $1,140-1,150/t cfr as October ended and November began. Larger buyers are covered into early-December. Continued uncertainty over feedstock costs in Europe is preventing traders from committing to firm year-end positions. In the east, smaller export cargoes from China are covering steady pockets of demand in east Asia.

Key market drivers: In Northwest Europe, producers across the continent raised production as spot gas prices eased at the end of October. But steady import demand is expected to persist as producers are unlikely to ramp up to full capacity. An array of supply options on offer from Chinese producers are covering demand from Taiwan, the Philippines and China.

Phosphates: India has once again been the main source of activity, with prices rising slightly as November began. Indian buyers lined up 160,000 tonnes from Tunisia and Saudi Arabia. This lifted its import price by $3/t at the low end to $743-750/t cfr. In the Americas, Nola MAP prices, under pressure from Brazil, fell in early November. NOLA DAP, in contrast, rose slightly creating an unusual premium to MAP. With liquidity remaining low in Brazil and Argentina, prices for both markets remained steady in the first week of November. There was some price movement in Europe as producers – without much success – made concessions to spur demand. Ghent DAP prices declined from $890-900/t fca to $850-880/t fca at the end of October.

Key market drivers: India's government reduced the DAP subsidy by three percent for the rabi season, a move that is likely to support already strong domestic demand in the near term.

Potash: The Indian government has reduced the potash subsidy for the October 2022 to March 2023 rabi season by seven percent, down to Rs14,190/t from Rs15,186/t previously. The fall reflects potash price erosion since the previous subsidy settlement in May. Elsewhere, the market remains relatively muted. With lower prices emerging in southeast Asia, Brazil, the US and Europe, most regions are in a lull while the downwards price pressure persists.

Key market drivers: Rising China's MOP port inventories reached 2.5 million tonnes at the start of November, up from 2.15 million tonnes at the end of September. This should provide the country with a more favourable position ahead of its annual MOP contract price negotiations for 2023. Laos is capitalising on its freight rate advantage by growing its share of the southeast Asian market.

Sulphur: There is evidence of a lifting trend in the market with November Middle East prices announced in the range $149-155/t f.o.b. Qatar and Kuwait. Some netbacks from Middle East origin have shifted to even higher levels. Recent sales to Brazil, Indonesia and Africa, for example, have concluded in the range $190-205/t cfr. Delivered cfr prices to other markets such as China, India and North Africa do remain lower.

Key market drivers: Recent sales to Indonesia and Africa in $190s-200s/t cfr, and the West of Suez sale to CMOC Brazil at $190/t cfr. Curbs in FSU supply for November lifting are likely to extend into early December.

OUTLOOK

Urea: The market will remain heavy as long as Europe remains on the sidelines. However, this softer trend should evaporate if buying resumes in earnest, especially as the scale of the imports needed by Europe and the US ahead of spring will be above average.

Ammonia: A slight deterioration in pricing is expected until the end of the year. This is linked to weaker sentiment and slowing buying interest, combined with steady supply optionality.

Phosphates: Demand globally remains muted, despite some raw material price rises, with short-term demand from India and seasonal imports into Australia being the exception. Prices will be under pressure both east and west of Suez until the end of the year, once India's rabi season demand has been met.

Potash: Activity for the remainder of the year is expected to be slow. Prices are therefore expected to fall further in key regions, although the anticipated increase in European demand may stabilise prices towards the end of the year.

Sulphur: Limited availability and supply delays are lifting delivered prices for the few sulphur cargoes available. Remaining market demand is likely to lift pricing further in the coming weeks. There is, however, some downward risk going forward, if pricing becomes supportive of higher inland freight cargoes from the Black Sea. This would allow Turkmenistan and Uzbekistan and Iran to enter the market, normalise Kazakh output and release Russian product. The entry of these stockpiled tonnages could potentially see the market move rapidly into surplus from the year's end. ■

Market price summary $/tonne – End October 2022

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	1,050-1,100	565-600	f.o.b. E. Europe 250-350	f.o.b. US Gulf	756-804	-	-
f.o.b. Yuzhny	Port closed	Port closed	-	f.o.b. N. Africa	700-850	500-700	1,100-1,300
f.o.b. Middle East	890-990	546-631**	-	cfr India	690-749	-	1,175-1,200*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	575-700	-	cfr US Gulf	100-200	f.o.b. Vancouver	110-160	-
f.o.b. Middle East	600-720	-	-	-	f.o.b. Arab Gulf	103-153	-
f.o.b. Western Europe	-	950-1,125	-	-	cfr N. Africa	103-130	-
f.o.b. Baltic	570-700	-	-	-	cfr India	117-165+	-

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.*

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AUSTRALIA

Green ammonia projects progress

Yara International has approved a project to partly convert its Pilbara plant near Karratha in Western Australia to green ammonia production.

The company gave the green light for the Yuri project in a final investment decision on the 15th September. This provides the necessary go ahead for the construction of a green hydrogen plant at the Pilbara production complex.

Yuri is joint project between French utility giant ENGIE and wholly-owned Yara International subsidiary Yara Clean Ammonia. The two partners will now move ahead and develop a new renewable hydrogen plant at the Pilbara site adjacent to Yara's world-scale anhydrous ammonia production plant. A consortium of Technip Energies and Monford Group has been awarded the engineering, procurement, construction and commissioning (EPCC) contract for the project.

Yuri includes a 10 MW electrolyser, 18 MW of solar photovoltaic (PV) capacity and battery storage. Once completed, the project will be one of Australia's largest electrolysers with a green hydrogen production capacity of 640 tonnes per annum.

A limited company, Yuri Operations Pty Ltd, will construct the plant and supply the green hydrogen generated to Yara Clean Ammonia. Construction was due to start in October 2022, with project completion and start-up scheduled for 2024.

The federal Australian Government has backed the project with an AUD 47.5 million grant. This was secured via funding from the Australian Renewable Energy Agency (ARENA) for renewable hydrogen deployment. The Western Australian government has also supported Yuri with an AUD 2 million grant from its renewable hydrogen fund.

Magnus Krogh Ankarstrand, the president of Yara Clean Ammonia, said Pilbara would be the first established ammonia plant in Western Australia to use green hydrogen for clean ammonia production.

"We value this support from government which provides further validation of the Yuri project as a credible early mover in the development of renewable hydrogen," Ankarstrand said. "Yara brings to the project extensive operational experience, our company's global leadership in developing a clean ammonia market for carbon-free food production, low-emissions fuels for shipping and power, and ammonia for industrial applications."

Yara Pilbara's general manager Laurent Trost said Yuri was an exciting and transformational project for the company's Pilbara complex, which includes an ammonia plant and a technical ammonium nitrate unit. "Yuri is a key step in the decarbonization of our operations which already supply markets in Asia and Australia," Trost said.


PHOTO: INCITEC PIVOT

Incitec Pivot's Gibson Island plant, Queensland, Australia.

The development of the Yuri project also paves the way for the Pilbara ammonia plant to qualify for zero carbon certification. This will be first green ammonia project to receive certification from the Smart Energy Council. Bureau Veritas, the world leading testing, inspection and certification company, has already carried out technical assessments and pre-certified the plant.

Plans are also progressing to convert the Gibson Island ammonia plant near Brisbane, Queensland, to green ammonia production. Owner Incitec Pivot Limited (IPL) previously announced the closure of the plant at the end of 2022 when its current gas supply contract ends (*Fertilizer International* 506, p10).

However, Fortescue Future Industries, in partnership with IPL, is now proposing to decarbonise Gibson Island by building a 500 MW electrolyser at the site. This would have the capacity to produce 70,000 tonnes of renewable hydrogen annually.

Planning for Gibson Island's conversion to green ammonia is in its final stages, according to Fortescue and IPL. A front-end engineering design (FEED) study is currently underway ahead of a potential final investment decision in 2023. The first production of green ammonia could start as early as 2025, if the project is approved.

ARENA is contributing a grant of $13.7 million towards the $38 million FEED study. This will examine the technicalities and costs required to build the electrolyser and integrate it within the existing ammonia plant. The proposed electrolyser would be supplied with an external supply of renewable energy through a power purchase agreement (PPA).

If built, the Gibson Island electrolyser would be one of the world's largest and supply green hydrogen to the world's first fully decarbonised ammonia plant. ■

UNITED STATES

Nutrien selects thyssenkrupp Uhde for massive blue ammonia project

Nutrien has selected thyssenkrupp Uhde as its technology partner and provider for a large-scale blue ammonia project at the company's Geismar complex in Louisiana.

The blue ammonia project will have a world-leading single-train capacity of 3,500 t/day – equivalent to 1.2 million t/a. Carbon capture and storage (CCS) will also abate 90 percent of CO_2 emissions. With further modifications, there is even potential for the plant to move to zero emissions in future, according to Nutrien.

Conventional ammonia plant designs only achieve carbon capture rates of 70 percent maximum. Nutrien's selection of thyssenkrupp Uhde's autothermal reforming technology (ATR), however, enables much greater emission reductions. ATR produces almost CO_2-free syngas from natural gas and pure oxygen. Ammonia is then produced in a second step. The CO_2 generated from this combined reforming process is finally captured and stored, keeping emissions to a minimum.

"This partnership marks another important milestone in our commitment to provide solutions to help meet the world's decarbonization goals through leadership in clean ammonia production," said Trevor Williams, Nutrien's interim president for nitrogen and phosphate. "We are glad to have an experienced partner with both the technology and proven execution competence to join us on this journey as we strive to sustainably feed and fuel the future."

Dr Cord Landsmann, CEO thyssenkrupp Uhde replied: "We are excited to be the chosen technology partner for this project and support the execution as well. This is another proof point that the market shifts towards sustainable, clean and green ammonia. And we can deliver easy to install solutions at the necessary scale."

The proposed plant is designed to serve growing ammonia demand from agricultural, industrial and emerging energy markets. A final investment decision on the project is expected in 2023. The plant should enter production by 2027, if go ahead is given.

ExxonMobil and CF Industries partner on large-scale CCS project

ExxonMobil and CF Industries have agreed to invest $200 million in a CO_2 dehydration and compression unit at CF's Donaldsonville, Louisiana production complex. This will enable CF to ramp-up blue ammonia production at Donaldsonville in response to rising demand.

The large volumes of carbon dioxide captured at Donaldsonville, the world's biggest ammonia production complex, will then be transported via Exxon's 6,400 kilometre EnLink Midstream pipeline network to Vermilion Parish, Louisiana for permanent geological storage. Up to two million t/a of CO_2 emissions could be captured and stored in this way. This is equivalent to removing the emissions of approximately 700,000 petrol-driven vehicles, according to the project partners.

Donaldsonville has a capacity to manufacture nearly eight million t/a of nitrogen products. CF expects to market up to 1.7 million t/a of blue ammonia in future as part of its product mix, once demand starts to take off.

"This agreement ensures that we remain at the forefront of the developing clean energy economy. As we leverage proven carbon capture and sequestration technology, CF Industries will be first-to-market with a significant volume of blue ammonia," said Tony Will, CEO, CF Industries. "This will enable us to supply this low-carbon energy source to hard-to-abate industries that increasingly view it as critical to their own decarbonisation goals."

Ohio fertilizer plant starts construction

Tessenderlo Kerley held a groundbreaking ceremony at the end of August to mark the start of construction of a new liquid fertilizer plant in Defiance, Ohio.

Tessenderlo Kerley will manufacture its market leading liquid fertilizer brands, such as Thio-Sul®, KTS® and K-Row 23®, at the new production site. It will also produce sulphites for the industrial market.

The Ohio plant will serve Tessenderlo's customers in the Eastern Great Lakes region via its distribution partners and will include terminal loadouts for rail cars and tanker trucks.

The new 50,000-square-foot production plant will occupy a 50-acre site and is due to become operational in 2024.

"This facility creates more certainty in the region by ensuring farmers have access to the nutrients they need for their crops to thrive," said Russell Sides, Tessenderlo Kerley's executive vice president.

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"We look forward to joining the Defiance, Ohio community and providing stewardship to the farmers in the region. It is important that we all work together to grow the crops required for our country to flourish."

Tessenderlo has selected leading engineering, procurement and construction (EPC) contractor Jōb Industrial Services (Jōb) to design and build the greenfield fertilizer plant in Defiance, Ohio.

Brian Fox, Tessenderlo Kerley's project manager, said "We are pleased to have selected Jōb as our EPC firm for this important project in Defiance, Ohio. We know they will be a great partner in the safe execution of our vision, building a state-of-the-art facility in an area with such a great and supportive community."

Chris Tekiela, project manager for Jōb, said, "We are very excited about this opportunity to be a part of a project executed by such a reputable multi-national company. This will be huge for the local community as it promotes growth and high-paying jobs for rural communities."

Nitricity raises $20 million

Californian AgTech start-up Nitricity successfully raised $20 million in October as part of a 'Series A' capital investment round.

The fundraising round was led by Khosla Ventures and Fine Structure Ventures. Energy Impact Partners, Lowercarbon Capital and MCJ Collective also participated. Nitricity has raised $27 million in total funding to date, including this new financing.

"This fundraising round brings us one step closer towards sustainable and locally produced fertilizer," said Nicolas Pinkowski, CEO and co-founder of Nitricity. "It's time to bring this to market. We have aggressive growth plans in motion."

Nitricity's innovative technology turns air and water into nitric acid using solar energy and a plasma reactor. The nitric acid generated can then be converted into a range of liquid fertilizers by combining with other inputs such as limestone, phosphate rock and potassium hydroxide.

The company's aim is to electrify and locally distribute nitrogen fertilizer production using low-cost solar or wind. This approach disrupts the nitrogen industry's current highly centralised and fossil fuel reliant production model.

"This electrified technology provides fertilizer in a climate-smart nitrate form, designed for efficient application, allowing it to address greenhouse gas emissions beyond ammonia-based technologies," said Joshua McEnaney, president, CTO and co-founder at Nitricity. "This is an opportunity to attack not just the 1-2% of global GHG emissions in the production, but the additional 5% of GHG emissions in the application by mitigating nitrous oxide formation. We are pushing hard to scale up and implement this solution."

Nitricity has shown the potential of its new approach to fertilizer production at California State University's Center for Irrigation Technology at Fresno – where it was successfully used for the sub-surface fertigation of tomatoes. This demonstrated the ability of Nitricity's system to produce and apply nitrogen fertilizers close to the end-user.

"Today's fertilizer industry is facing the perfect storm of high GHG emissions, high fossil fuel consumption, rising costs and geopolitical disruptions," said Rajesh Swaminathan, partner at Khosla Ventures. "Nitricity's decentralized approach to manufacturing fertilizers using just air, water and renewables-based electricity was born out of a vision to completely transform a 100-year-old industry, and we are excited to be partnering with them."

"Nitricity has made rapid progress since our initial investment in their Seed round," said Allison Hinckley, senior associate at Fine Structure Ventures, a venture capital fund. "In response, we are increasing our support of the company to aid in bringing their differentiated, decarbonized fertilizer products to market in the near term."

Nitricity is working hard to bring its renewables-based technology to market and is aiming to make its system commercially-available within two years.

CANADA

Canpotex buys 1,300 new railcars from National Steel Car

Saskatoon-based potash export consortium Canpotex is acquiring 1,300 custom railcars from National Steel Car (NSC) of Hamilton, Ontario.

These new custom railcars will be added to Canpotex's existing fleet by June 2023 – increasing its total fleet size to 8,000. The railcars will be used to deliver potash from land-locked Saskatchewan to the company's three main terminals on the East and West coasts of North America. This transport investment will increase supply chain efficiency, reliability and safety, according to Canpotex.

"This acquisition demonstrates Canpotex's commitment to investing in our world-class supply chain and in global food security," says Gord McKenzie, president and CEO of Canpotex. "By adding capacity within our railcar fleet, we have greater flexibility in shipping options. This increased railcar capacity ensures our potash is reliably delivered to our customers overseas, ultimately helping the world's farmers grow higher-yielding crops on each acre of land."

The new railcars are valued at over $155 million and represent an evolution in NSC's custom design for Canpotex. One notable new feature – an enhanced steering system – will cut overall fuel consumption, reduce maintenance and enhance safety.

"We are proud to supply Canpotex with these custom railcars that are manufactured right here in Hamilton, Ontario at the largest 'single site' railcar plant in North America," said Gregory Aziz, NSC's chairman and CEO. "With NSC's commitment to engineering excellence and innovation, we are confident that these quality railcars will help Canpotex deliver on its reputation as a reliable supplier of high-quality potash."

Canpotex operates a state-of-the-art railcar maintenance facility near Lanigan, Saskatchewan. This is used to maintain its railcar fleet and improve the performance and operational efficiency of potash delivery by railcar.

BRAZIL

Indorama buys Adfert

Singapore-headquartered Indorama Corp has purchased Adfert, one of Brazil's leading speciality fertilizer and fertilizer additives manufacturers.

The buy-out – originally announced last July – was completed in early November 2022. The acquisition was made by Indorama's wholly-owned Brazilian subsidiary Indorama Holdings Brasil Ltda (IHBL).

Adfert (Adfert Aditivos Industria e Comercio Ltda) is based in Uberlândia, Minas Gerais. The company was founded in 2009 and has helped pioneer speciality fertilizers and fertilizer additives in Brazil. It has subsequently built a large portfolio of advanced, patent-protected products – and supplies both fertilizer producers and distributors.

This latest acquisition strengthens Indorama's market presence in Brazil. IHBL previously completed the purchase of Adufértil Fertilizantes Ltda (ADF) in September 2021. Based in Jundiaí, Sao Paulo, ADF is one of the country's top six distributors of granular NPKs.

NETHERLANDS

Nouryon acquires ADOB

Netherlands-based Nouryon has entered into a definitive agreement to buy ADOB Fertilizers, a leading specialty fertilizer manufacturer supplier.

Headquartered in Poznań, Poland, ADOB is a global leader in water-soluble fertilizers and chelated micronutrients. The company has been producing speciality products for agricultural and horticultural crops for more than 30 years.

Nouryon plans to use the acquisition to expand its product portfolio and broaden its offering to customers in the crop nutrition market.

"With its strong focus on technology and innovation including biodegradable micronutrients, high-solubility specialty fertilizers and custom formulations, ADOB's capabilities are an excellent complement to Nouryon's existing capabilities in crop nutrition," said Larry Ryan, executive vice president at Nouryon and president of performance formulations and the Americas.

Adam Nawrocki, the owner of ADOB and its CEO, said: "This combination is a great opportunity for ADOB to leverage a large global organization to advance to the next stage of global growth."

The transaction is expected to close by the end of 2022. The purchase price was not disclosed.

INDIA

Baruani urea plant enters production

The Barauni urea plant began urea production in mid-October, according to its owner, Hindustan Urvarak & Rasayan Ltd (HURL).

The plant, located in the Begusarai district of Bihar state, will boost Indian domestic urea production capacity by 1.27 million t/a.

HURL is a joint venture between Coal India Limited, NTPC, Indian Oil Corporation and the Fertilizer Corporation of India Ltd. The company has a mandate from the Indian government to revive domestic urea production at Barauni and two other sites – Gorakhpur in Uttar Pradesh and Sindri in in Jharkhand state – at an investment cost of around $3 billion.

MOROCCO

Bedeschi wins new OCP contract

OCP has awarded Bedeschi a new engineering, procurement and construction (EPC) contract for its Phosboucraa production complex, 30 kilometres from Laayoune.

Bedeschi will supply three new automated bulk handling and storage systems with a combined annual capacity of 300,000 tonnes. Two of these will handle fertilizers for export while the other will handle imported sulphur.

The bulk handling equipment installed at Phosboucraa as part of the contract will include three trippers, three reclaimers and

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Fertilizer International 511 | November-December 2022
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six conveyor belts with a capacity of up to 2,000 t/h. These items will be similar to those already supplied and installed by Bedeschi at OCP's massive Jorf Lasfar phosphate complex in Morocco.

UNITED KINGDOM

Worley named as preferred Woodsmith project provider

Anglo American has selected Worley as its preferred service provider for the Woodsmith polyhalite project in northeast England.

Worley has been awarded the programme management agreement (PMA) for the Woodsmith project following a selection process. Under the PMA, Worley will provide project management and concept engineering and design services to Anglo American.

The terms of the PMA will also allow Worley to provide separately-agreed engineering, procurement and construction management (EPCM) services, as the Woodsmith project progresses.

"With the breadth and depth of our global mining experience, we're well positioned to support the Woodsmith project, strengthening our partnership with Anglo American," said Chris Ashton, Worley's CEO.

Worley will execute the PMA and other project services from its UK offices, supported by the company's global 'Centres of Excellence' (CoE) located elsewhere.

Anglo American's Woodsmith project is developing a new underground mine near Whitby in North Yorkshire to extract polyhalite, a low-carbon, multi-nutrient fertilizer. The project, under its current design, include two deep shafts and a 37-kilometre underground mineral transport system (MTS). This will transport the polyhalite ore to a dedicated material handling plant and dedicated port facility at Teesside for processing and onward export. To ensure operational safety, efficiency and flexibility, all systems from mine to port will be fully integrated and automated

PHOTO: ANGLO AMERICAN

Woodsmith mine project tunnel boring machine, Wilton, UK.

IFS launches free online production resource

The International Fertiliser Society (IFS) has launched FerTechInform, a comprehensive online technical resource for fertilizer production. The new digital resource combines an information knowledge base and an interactive forum for users.

The knowledge base is designed to cover the main process routes for fertilizer production. It includes essential and introductory information on manufacturing processes, process chemistry, raw materials and process equipment. This information is augmented by links that allow users to take a 'deep dive' into more detailed digital resources. The knowledge base also connects to relevant IFS Proceedings – a large and valuable archive of technical papers held by the Society that dates back decades.

The knowledge base was developed using reputable technical sources, including the International Fertilizer Development Center's renowned *Fertilizer Manual*. This was developed by the IFDC in the late 1990s with the support of the United Nations Industrial Development Organization (UNIDO). Other content was provided by the European Fertilizer Blenders Association (EFBA), Fertilizers Europe, the European Sustainable Phosphorus Platform (ESPP) and others.

The online forum enables users to interact with one other. It is supported by a panel of experts who are on hand to answer questions.

Promising digestate additive

Digest-It, a new biological slurry additive from Origin Fertilisers, has performed well in UK anaerobic digestion (AD) trials. The new product reduced ammonia emissions from digestate applied to soils and increased ammonium nitrogen levels

Digest-It was shown to improve the nutrient availability of digestate during a trial at a 1.2MW AD plant in Lincolnshire that runs on a forage maize and rye feedstock. It was added to the slurry as a live bacterial liquid.

After a 12-week period, the ammonium nitrogen content of the digestate increased by 20 percent, while dry solids were reduced by 29 percent. This made the digestate easier to pump, which in turn reduced machinery wear, cut fuel use and shortened filling times.

The digestate's thinner consistency also made nutrient uptake by crops easier, following soil application. Consequently, plants did not have to expend as much energy searching for nitrogen. Losses through volatilisation were also reduced.

The addition of Digest-it generated a 2:1 cost benefit. It also required only one application, reducing the amount of labour required compared to additives that need repeated applications.

Commenting on the trial outcome, Callum Norman, speciality sales manager at Origin Fertilisers, said:

"We are really pleased with the results. The environmental benefits, such as reduced volatilisation due to the conversion of ammonia into ammonium, and supplying good microbes to the soil, will be a huge benefit to all farms and help contribute towards agriculture reducing its emissions.

"The treated digestate had less nitrogen content than the untreated product. The upshot here is that the same amount of land can have 13 percent more digestate spread on it before Nitrate Vulnerable Zone (NVZ) limits are reached – which could be hugely beneficial for growers on smaller acreages with excess digestate to spread."

People

CRU has appointed **Mark Jeavons** as the head of its CRU Sustainability division. He will be based out of London with a global remit.

Mark brings extensive experience and knowledge to the role, including more than 15 years in leadership positions in environmental, social and governance (ESG) and investment. Most recently, he was the head of climate change insights at Aon, a leading multinational financial services firm.

In his new role, Mark will spearhead the growth of CRU Sustainability, working closely with CRU's highly regarded team of analysts, pricing experts and consultants. This team offers guidance to businesses on major sustainability challenges, including the drive to cut carbon emissions and the shift to a circular economy, alongside market intelligence on trends and regulations for specific commodities. The overall aim is to help customers accelerate their transition to net zero – arguably the most pressing issue facing company decision-makers today.

"Mark brings a wealth of knowledge of sustainability and investment themes which is the perfect fit for CRU Sustainability as we look to consolidate our position as market-leading experts in the transition to a low-carbon world," said David Trafford, CRU's CEO. "New and existing customers alike will benefit from Mark's experience, and we are excited to welcome him to the team."

In reply, Mark Jeavons said: "This is a fantastic opportunity to use my sustainability experience to drive forward a significant business offering and bring CRU's expertise to a new component of operation for its clients. I look forward to getting to work and supporting customers to get the insights they need to support their strategic decision making."

Mark Jeavons, new head of CRU Sustainability.

The Mosaic Company elected **João Teixeira** to its board of directors in November. He was formerly the CEO of Brazilian sugar and ethanol producer Copersucar.

"Our board will benefit from João's rich experience in agriculture and financial services, and from his remarkable breadth of knowledge of Brazilian institutions," said Gregory Ebel, Mosaic's chairman.

Mr Teixeira served as CEO of Copersucar from 2018 until earlier this year. Prior to that, he founded Inviste, a private investment firm, and served as the CEO of Banco Votorantim. Mr Teixeira also held senior roles at Santander Group, ABN Amro and Dresdner Kleinwort Wasserstein earlier in his career, He holds a bachelor's degree and a master's degree from Pontifical Catholic University in Rio de Janeiro and an MBA from the London Business School.

Mr Teixeira currently serves on the boards of two other public companies.

Yara has awarded its prestigious Birkeland Prize to Dr **Kaiqi Xu** this year in recognition of his PhD thesis on artificial photosynthesis.

Yara's annual Birkeland prize recognises outstanding achievements by individuals in the field of environmental technology and interdisciplinary research and development. The NOK100,000 prize celebrates and remembers the remarkable Norwegian scientist Kristian Birkeland, 1867-1917.

"In Yara, we are extremely proud of our heritage. The science of Kristian Birkeland led to what has been called the most life-saving innovation ever – mineral fertilizers," the company said in a statement.

Dr Xu's ground-breaking renewable energy research has resulted in a new electrochemical method for splitting water into hydrogen and oxygen using sunlight. This breakthrough method successfully produces 'solar fuel' – a synthetic chemical fuel produced by solar power. This was achieved by selectively reducing carbon dioxide in an artificial photosynthesis cell. This offers a sustainable process route for producing hydrogen from the humidity in air.

Dr Xu's scientific work advances sustainable hydrogen production, according to Yara, and will have a significant impact on ongoing work to develop and commercialise artificial photosynthesis and solar fuels.

Commenting on the relevance of this year's prize, Per Knudsen, Yara's vice president for technology said: "So far this year, 400 million more people have become food insecure. And we have seen world leaders suddenly speaking about the importance of fertilizers and keeping food production high."

Calendar 2022/2023

DECEMBER

7-9

2022 IFS 75th Anniversary Conference, CAMBRIDGE, UK
Contact: Secretary, International Fertiliser Society
Tel: +44 (0)1206 851 819
Email: secretary@fertiliser-society.org

JANUARY 2023

30-1 FEBRUARY

CRU Argus Fertilizer Latino Americano 2023, RIO DE JANEIRO, Brazil
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

FEBRUARY

6-8

IFA Smart & Green, VIRTUAL
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

27-1 MARCH

CRU Phosphates 2023 Conference & Exhibition, ISTANBUL, Turkey
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

MARCH

6-8

CRU Nitrogen+Syngas 2023 Conference & Exhibition, BARCELONA, Spain
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

27-29

IFA Global Sustainability Conference, VIRTUAL
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Tel: +33 1 53 93 05 00
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FERTILIZER INTERNATIONAL
ISSUE 511
NOVEMBER-DECEMBER 2022

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The conference venue: the Sheraton Grand Rio Hotel & Resort.

PHOTO: SHERATON

CRU Fertilizer Latino Americano 2023

CRU Events will host the 2023 Fertilizer Latino Americano conference at the Sheraton Grand Rio Hotel & Resort, Rio de Janeiro, 29 January to 1 February.

The ocean city of Rio de Janeiro is the vibrant setting for the 2023 Fertilizer Latino Americano conference. The event is the longest established and most influential fertilizer industry meeting in Latin America – and is celebrating its 34th anniversary in 2023.

Fertilizer Latino Americano is a CRU and Argus collaboration and attracted more than 750 delegates to Miami in March 2022. The conference offers excellent networking opportunities and is aimed at senior executives from across the international fertilizer supply chain, with leading producers, traders, distributors and consumers all represented.

As its name suggests, Fertilizer Latino Americano has a particular focus on Latin America, while at the same time having a global reach with attendance from over 50 countries. The event promotes commerce, investment, partnership and innovation across the Latin American market. A large-scale exhibition and numerous networking events also provide extensive business opportunities throughout the conference.

By allowing fertilizer companies to meet, negotiate and do business at the very start of the year, Fertilizer Latino Americano's timing in January has always been an advantage. The return to Brazil in 2023 is generating extra industry interest – as it offers attendees access to key players operating in one of the world's largest fertilizer markets.

Dominic Halahan, CRU's portfolio director, anticipates a record attendance for the 34th edition of the region's most influential and prestigious fertilizer gathering:

"Fertilizer prices have been turbulent, and nowhere has this been more evident than in Latin America. Its dependence on supply from Russia has been in the spotlight following the breakout of war in Ukraine. But the market has quickly adjusted. Not only has product from Russia continued to flow, buyers have also diversified their sourcing strategies and product mix. Supply has outweighed demand as a result.

"As we enter 2023 with falling prices, high inventories, suppressed demand, a third straight La Niña weather event, improving supply and volatile energy markets, the Fertilizer Latino Americano conference comes at an opportune time. Meet with CRU's industry experts and a huge industry audience to gauge the direction of the market, be informed, network and negotiate. We look forward to welcoming everyone to beautiful Rio in early 2023."

Agenda and key speakers

The event's three-day agenda offers comprehensive market coverage. This year, there will be a particular focus on speciality fertilizers, biostimulants and digital farming. A series of panel discussions will also address key current issues – including sustainability in agriculture, biofuels, and blue and green ammonia. Country-specific and regional topics and trends will be widely discussed too.

CRU's expert analysts will be present to offer their insights into global supply and demand trends across all the key markets. Updates will be provided on the global economic outlook for the industry. The influence of key economic indicators – such as inflation, energy markets, and the continued effects of the war in Ukraine – will also be covered.

This year, CRU is proud to have support from leading fertilizer organizations in Latin America including: Abisolo, Fertilizar Anacofer, IBRAM, ANDA, abimilho, Siacesp and AMA Brasil. The conference is also joined by Anglo American, Koch, Verdesian and Quest Group as platinum sponsors, alongside ICL, US Borax and Omya.

CONFIRMED TOP-TIER SPEAKERS

- **Gustavo Branco**, General Director, Haifa South America
- **Mauricio Medici**, Licensing Manager/ Area Sales Manager, Stamicarbon
- **María Fernanda Gonzalez Sanjuan**, Executive Manager, Fertilizar
- **John Sinden**, Senior Partner, JSA Ltd
- **Enrique Hahn**, President, Sustentap
- **Professor Miguel Taboada**, Edafología Facultad de Agronomía, UBA
- **Bruno Caligaris**, Diretor de Projetos Estratégicos na Secretaria de Assuntos Estratégicos, Presidência da República
- **Kelly Johnson**, Senior Investment Officer, International Finance Corp.
- **Cleiton de Sequeira**, Director of Business Development, Nitricity Inc.
- **Carlos Vilhena**, Partner, Pinheiro Neto Advogados
- **Chris Ferreira**, Business Development Manager, Latin America, Verdesian
- **Claudio Nascimento**, Plant Manager, CF Industries
- **Patricio Gutierrez**, Director Innovation and Research, Dole Tropical Products
- **Mario Duffriti**, Commercial Manager, Profertil
- **Stan Bharti**, Founder, Forbes Manhattan
- **Jonas Hipolito**, Diretor de Estratégia e I&D, Biotrop

See you in Rio!

Fertilizer International magazine is pleased once again to be CRU's official media partner for Fertilizer Latino Americano in 2023. We will be exhibiting at the event and are very much looking forward to meeting industry friends, both old and new. ■

A challenging year for Brazil's fertilizer market

The Russian-Ukraine conflict and price volatility have affected the supply/demand dynamics of the Brazilian fertilizer market and the buying behaviour of growers. As a consequence, Brazil's fertilizer consumption is expected to fall for the first time in eight years. **Debora Simoes** and **Cleber Vieira** of leading consultancy Agroconsult offers their key market insights.

Coffee bean harvest, Brazil.

PHOTO: WSRURLAN/ISTOCKPHOTO.COM

Year starts with logistic problems and supply restrictions

The year began with higher-than-average fertilizer prices and constraints on fertilizer supplies from China, Russia, Belarus and Europe. At the time, Brazil was not so affected by these limitations – except for the higher prices – due to the country's ability to source fertilizers from other countries. The second quarter half of the year can be, in any case, a period when global producers idle their capacities.

At the time, Agroconsult didn't believe there would be domestic fertilizer supply shortages. Yes, it was true that some European production plants were closed or operating at low rates. But domestic Brazilian producer Unigel, for example, responded by raising the production of urea. Other nitrogen production plants in Bolivia and Nigeria also resumed operations, while India was also expected to produce additional nitrogen fertilizer volumes in 2022. Regarding phosphates availability, a range of market producers were likely to step up and meet global demand, in our view, despite the expected reduction in Chinese exports in 2022.

In the first quarter, Agroconsult was forecasting that Brazil's fertilizer deliveries would reach 46.5 million tonnes in 2022 – a rise of 1.5 percent on the previous year. The modest year-on-year growth in fertilizer consumption was expected to be largely driven by expansions in the crop planting area, with average fertilizer application rates expected to remain flat or even slightly lower for some crops and locations. This slightly upwards trend was based on expectations of fertilizer input prices remaining at high levels, hurting barter ratios.

The Russia-Ukraine conflict and consequent supply risks

At the end of February, due to the insecurity and uncertainty provoked by the Russia-Ukraine conflict, fertilizer prices began to move strongly upwards to ultimately reach historic highs in March (*Fertilizer*

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ISSUE 511
NOVEMBER-DECEMBER 2022

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International 508, p4). Additionally, due to worsening trade terms for producers, there were huge doubts about Russia's ability to export volumes to Brazil, especially for potash.

Around this time, the recurring question was: would Brazil suffer from a lack of fertilizer availability? It is important to remember that Russia is a key fertilizer supplier to Brazil and – together with Belarus – accounted for more than one third of the country's fertilizer imports in 2021 (*Fertilizer International* 507, p16).

Responding to this expected fertilizer availability problem, many players in Brazil's supply chain for agricultural inputs – from NPK blending companies to fertilizer distributors and rural producers – made huge efforts to ensure adequate supplies in 2022, no matter what the price of fertilizers at any given moment.

Indeed, contrary to the downbeat market mood, Brazil's fertilizer imports actually hit a new three-month record in the first quarter of 2022, reaching 8.67 million tonnes. This was 24.4 percent higher than January-March 2021 import volumes. Remarkably, first quarter potash imports – the fertilizer commodity that was the focus of most supply and availability fears – actually grew by 42 percent, a confirmation of robust market activity.

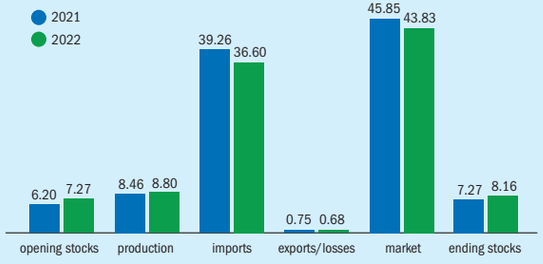
On this basis, if market supply continued to be strong enough, there was a view that fertilizer deliveries in 2022 were unlikely to be at overall risk – taking into account initial stock levels, domestic production volumes, and imports, all of which were higher than in 2021.

Nevertheless, Agroconsult revised Brazil's 2022 fertilizer consumption forecast downwards in the second quarter to 45.1 million tonnes, mainly due to the negative effect of high fertilizer prices on the barter ratio. Factoring in January-June 2022 import figures, we concluded that a further 17.45 million tonnes of fertilizers would need to imported into Brazil during July-December to meet the country's expected annual fertilizer consumption.

Although this import volume was 3.44 million tonnes lower than in the second half of 2021, it remains a significant overall challenge. Adding to the complexity, individual fertilizer commodities were also affected by different supply and availability factors:

- **Potash occupies the most comfortable position.** We estimate that approximately 4.8 million tonnes needs to be imported during July-December to meet Brazil's consumption needs, a much smaller volume than in 2021. With no major market supply problems anticipated, imports and trading are likely to slow down from June onwards.
- **Nitrogen fertilizer availability is also relatively tranquil and within normal ranges.** Ammonium sulphate supply is good, for example, while urea volumes are increasing. Nitrogen fertilizer imports for the last six months of 2022 are expected to be broadly similar to the second half of the previous year – volumes that Brazil was able to secure without any mishaps in 2021.
- **The phosphates supply situation is more challenging.** First-half imports of monoammonium phosphate (MAP) in 2022 grew modestly year-on-year, whereas imports were significantly higher for single superphosphate (SSP) and triple superphosphate (TSP), while NP imports from China were well below normal. Consequently, phosphate supply is a major challenge, in our view, with market participants needing to pay particular attention to MAP purchases. This is necessary to ensure adequate phosphorus for the summer grain crop and winter corn planted in September-December time.

Fig. 1: **Brazil's fertilizer supply and demand (million t), 2022* versus 2021**



** Forecast, September 2021*
Source: Agroconsult

Farmers delay buying

The fertilizer market was emitting contrary signals as the second half of 2022 began. Fertilizer statistics, for example, revealed slowing deliveries and industry activity in sharp decline. Agricultural producers, meanwhile, were still expanding their planted areas. According to them, there was no shortage of fertilizers – and neither would there be significant reductions in average fertilizer application rates.

Being aware of the fertilizer volumes already imported, farmers have chosen to wait a little longer to purchase their fertilizer inputs on the expectation that prices could drop significantly. So far, fertilizers sales for Brazil's summer crop – with planting scheduled to begin from September onwards – have progressed more slowly than in 2021. This has increased speculation about the possibility of a last-minute bump in demand and led to strong questions about the overall scale of fertilizer deliveries.

Brazil is storing around 12 million tonnes of fertilizers currently, according to estimates, about two million tonnes above what is typical for this time of the year.

September market information

New information on market supply and availability was revealed in a mid-September report released by ANDA, Brazil's national fertilizer association. The headline findings together with our own market analysis is as follows:

First-half fertilizer deliveries closed at 18.18 million tonnes in 2022, down 3.1 percent year-on-year, with poor performance in June outweighing the cumulative growth in deliveries from January to May.

The downward trajectory in fertilizer deliveries continued in July 2022. Fertilizer blenders supplied farmers with just 3.57 million tonnes during the month, 29 percent lower than in the previous July. A fall of this magnitude means that deliveries will now be unable to recover in time for the summer crop, whose planting had already started by this point.

At the same time, the fertilizer portfolio for second crop corn between now and the end of 2022, in our view, is not robust enough to compensate for the shortfall in deliveries. Therefore, based on January-August market behaviour, **Agroconsult has further downgraded its 2022 fertilizer delivery estimate for Brazil from 45.1 million to 43.8 million tonnes.**

Consequently, **carryover stock is now expected to exceed 8 million tonnes** – the largest in history – due to the further reduction in deliveries. Whether that estimate for transit stock is actually realised depends on two factors:

- Firstly, whether national fertilizer production output continues to be maintained at current levels.
- Secondly, in addition to the 4.4 million tonnes of fertilizers already landed, if another 7 million tonnes ends up being imported from September until the end of 2022. This is much smaller volume than the 11 million tonnes imported during September-December 2021.

It should be noted that, with the prospect of lower than usual fertilizer imports until the end of the year, port waiting times have been decreasing and are already lower than in 2021: only 15 percent of the volume in the line-up is facing a landing time of more than 30 days.

Year-on-year, there is also a clear contrast between the volumes of imports arriving through different ports. Compared to the same period in 2021, for example, imports through the port of Rio Grande dropped by a significant 14 percent and by 2.4 percent through Vitória. Meanwhile, there has been strong growth in import volumes elsewhere – rising by 6.4 percent at the port of Santos, 5.7 percent at the Paranaguá-São Francisco port complex and by 5.7 percent at the Arco Norte ports.

Summing up

On the supply side, our reading of the market indicates **there is a lot of fertilizer product available internally in Brazil ready to be delivered.** We are also seeing evidence that farmers – while leaving their decisions late – are gradually returning to make purchases. In addition to these positive indications on fertilizer buying, there is a strong impetus for farmers to expand the cultivated area of soybeans, cotton and second crop corn. There are also reports that agricultural producers are reversing their decisions to reduce average fertilization rates to avoid a drop in crop productivity. This change in decision making has even been happening in the south of Brazil (although very late). **We therefore believe there could be a good volume of fertilizer deliveries in the last quarter of 2022** – possibly exceeding current expectations and helping reduce present estimates for ending inventories. ■

Author's note: *Agroconsult corrected its 2022 fertilizer delivery estimate for Brazil downwards to 42.4 million tonnes at the the start of November. Definitive information on Brazil's fertilizer imports and deliveries will, however, not be available until early 2023.*

BRAZIL MARKET REPORT

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Fertilizers for small fruits

PHOTO: TESSENDERLO KERLEY INTERNATIONAL

Strawberries take an average of 30 days to mature from flower to fruit.

Small, soft fruits such as blueberries, raspberries and strawberries thrive on fertile, well-drained soils rich in organic matter. Their nutrient needs can vary widely according to yield expectations and soil characteristics.

Blueberries, raspberries and strawberries are widely consumed as fresh fruit or in preserves (jams), juices and cordials. In response to their growing popularity, world production of small fruits is on the rise – thanks to a larger global cropping area, new varieties and better use of fertilizers and other crop inputs.

For small fruits, the length of the growing season depends on factors such as berry type, the particular cultivar and the individual climate of each growing region. Nutrient needs can vary widely, being influenced by both the cropping system and yield expectations.

In general, small fruits typically prefer fertile, well-drained sandy loam or silt loam soils which are rich in organic matter and of neutral-to-acid soil pH. Surface water drainage and air drainage away from plantings are also important.

Fertilization practices for strawberry – the most widely cultivated small fruit – are correspondingly the best documented. Importantly, small fruit are typically chloride-sensitive (particularly gooseberries, currant varieties and strawberries) and applying chloride-containing fertilizers to many types of berry is therefore best avoided.

This article provides an overview of the fertilization of three small fruits, blueberries, raspberries and strawberries, with a focus on outdoor growing in soil.

Blueberry – the superfood

The popularity of blueberries (Vaccinium sp.) is linked to its reputation as a 'superfood' and its widely reported nutritional qualities. These include exceptional richness in vitamins, mineral salts, fibre and polyphenols (oxoflavoids and anthocyanins in particular). In addition, blueberries have the highest antioxidant content of any fruit apart from prunes and raisins.

Blueberries are a deciduous fruiting plant native to North America. They can live beyond 15 years and still be productive before re-planting is necessary. Cultivated blueberries are generally of the 'highbush' variety. These have larger berries growing on taller bushes. Blueberries are pale greenish at first, then, during the maturation process, they become reddish-purple, before finally turning dark purple on ripening. Mature berries have a sweet taste with variable acidity. Fruiting times are dependent on local conditions including the climate.

Bushes prefer an acidic soil ideally below pH 5.5. Soil pH can be corrected, if necessary, prior to planting or during establishment. Fertilizers are usually applied at the start of spring growth and immediately after harvest.

Fertigation with water soluble fertilizers needs to be carried out with care as blueberry plants can be sensitive to excessive nutrient levels. Because of this, sufficient water needs to be applied during the fertigation process to limit the concentration of nutrients in solution. Ammonium is often the preferred nitrogen source due to its soil acidification effect. The optimal fertilization balance for blueberry is around 1 N – 0.6 P_2O_5 – 0.75 K_2O.

Low calcium content contributes to poor storage quality in soft fruit. Calcium fertilization is therefore necessary when Ca availability and uptake need to be improved (see box). Blueberries can be prone to calcium deficiency due to their cultivation in acidic soils and soils with a low cation exchange capacity (CEC). Although rare, deficiency symptoms include interveinal chlorosis of younger leaves and scorching of the margins of older leaves. For these reasons, calcium supply and deficiency need to be monitored and corrected for, if necessary.

PHOTO: TESSENDERLO KERLEY INTERNATIONAL

Greenhouse growing is a popular cropping system for strawberries.

Ever-popular strawberries

Strawberry (Fragaria x ananassa) is a small and fleshy fruit popular in many countries globally. Strawberries are mostly eaten fresh but are also enjoyed preserved with sugar in the form of jam. They are also consumed in cakes and pastries and as a flavouring in drinks and deserts such as milkshake and ice cream.

Consumer interest in berries and their health benefits has grown dramatically in recent years. Strawberries are rich in antioxidants and are also an excellent source of fibre, vitamins, folic acid, fatty acids, polyphenols and minerals.

Strawberries take an average of 30 days to mature from flower to fruit. Berries are generally picked every three days and fields must be re-planted every year. Strawberries thrive best in nearly neutral soils (pH 6-6.5) and need moderate levels of fertilization and irrigation.

Strawberry's fertilizer needs are primarily determined by the export of nutrients in the fruit. One tonne of strawberries typically removes:

- 2 kg of potash (K_2O)
- 1 kg of nitrogen (N)
- 0.5 kg of phosphate (P_2O_5)
- 0.3 kg of calcium (CaO)
- 0.2 kg of magnesium (MgO).

In general, the preferred fertilization formula for strawberries is: 1 N – 0.5 P_2O_5 – 1.5 K_2O – 0.2 MgO – 0.6 CaO.

Raspberry – two cultivars

Raspberries are an important commercial fruit crop and are widely grown in many of the world's temperate regions. As with other small fruits, interest in the claimed health benefits of raspberries has grown in recent years. Red raspberries contain a range of strong antioxidants such as vitamin C, quercetin and gallic acid. These have anti-inflammatory properties and are said to have a role in the prevention of cancer and cardiovascular disease.

Raspberries prefer well-drained, sandy loam soils which are rich in organic matter. They do not grow well in waterlogged soils or shallow chalky soils. Two types are grown:

- **Summer-bearing cultivars (non-rising varieties).** These produce fruit only on second-year canes (floricanes) during a relatively short period during the summer. Such varieties are generally preferred by commercial grwers as they can be efficiently harvested at a lower labour cost.
- **Double- or ever-bearing cultivars (rising varieties).** These cultivars, as well as bearing summer fruit on second-year floricanes, also bear some fruit on first-year canes (primocanes) in late summer and autumn.

Raspberries prefer a soil pH of between 5.6-6.2. The fruit is ready to harvest when the fruit has turned a deep colour and easily comes off its receptacle. Splitting fertilizer applications (NPK) into three equal parts is recommended in new plantings – with the first part applied two weeks after planting, the second one month later, and the third part one month after the second. Fertigation is also a useful way of ensuring that the total fertilizer requirement is applied incrementally in phases. The optimal balance for raspberry fertilization is around: 1 N – 1.3 P_2O_5 – 2.4 K_2O.

General fertilization guidance

University agricultural extension services in North America provide good general guidance on small fruit fertilization. These provide the following growing advice[1]:

- Good drainage and correct soil pH are important for all berry crops. Blueberries grow best on at pH 4.5-5.5, raspberries at pH 5.6-6.5 and strawberries at pH 5.0-6.5.
- Most fruit plants are fertilized in spring at flowering. Strawberries are the exception – being fertilized in August.
- Annual applications of nitrogen, phosphorus, and sulphur will be required to produce maximum yields and promote stand longevity. Soil levels of magnesium, potassium, and boron should be monitored.
- Granular fertilizers should be broadcast over the root zone when foliage is dry and then watered in if rainfall is not expected. Any residual fertilizer should be brushed from leaves.
- Move mulch away from plants when

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Table 1: **Nutrient requirements of berries**

	Nutrient requirements		
	Blueberry* (kg/ha)	**Strawberry (kg/ha)**	**Raspberry (kg/ha)**
Nitrogen (N)	50-100	90-180	80-120
Phosphorus (P_2O_5)	25-50	55-110	60-90
Potassium (K_2O)	100-200	140-280	120-180
Sulphur (SO_3)	45-90	45-90	50-75
Calcium (CaO)	5-10	40-75	80-120
Magnesium (MgO)	20-40	20-45	20-40

** From the third year onwards.* *Source: Tessenderlo Kerley International (Small fruits brochure)*

applying fertilizers to ensure direct contact with soil – and then reapply mulch after fertilizing.

- Keep fertilizers from contacting the crowns (base) and lower stems of small fruit plants.
- Once plants are in the ground, do not disturb shallow roots by working fertilizer into the soil.
- Fertilization regimes for establishing plants are different from those for fruit-producing plants.
- Late summer and autumn fertilization – except for strawberries – interferes with the hardening-off process and can lead to winter damage of tender growth.
- Good insect, disease, and weed control all help to ensure maximum yields.

Typical nutrient requirements of small fruit are shown in Table 1. The contrasting nutrient uptake curves for blueberry, strawberry and raspberries during vegetative growth, fruit set, fruit development and ripening are shown in Figures 1-3, respectively.

The following fertilization recommendations and nutrient needs are based on North American growing practice for small fruits[1].

Nitrogen for growth

Nitrogen is necessary for:

- Vigorous vegetative growth
- Fruit bud initiation
- Fruit set.

Small fruit plants respond readily to nitrogen and annual applications are necessary. Too little nitrogen results in poor growth, spindly plants and poor yields. While too much nitrogen results in excessive shoot and foliage growth, and soft, poorly coloured fruit which can be susceptible to rot.

Small fruits require continuous nitrogen supply. Around 50 percent of nitrogen uptake eventually accumulates in the fruit. Excessive nitrogen availability during later growth stages should be avoided as it can soften the fruit and delay ripening. Regular nitrogen applications throughout the growing season are therefore recommended as best practice.

Blueberries have a higher nitrogen need than other berry crops, being essential for optimum plant growth, production of fruiting wood, and desirable berry size. Ammonium sulphate (21-0-0-24) or urea (45-0-0) are generally applied. The total amount of applied N is split between three separate applications during the growing season[1]:

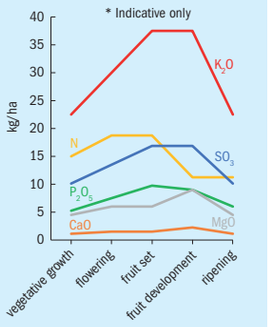
- 50 percent should be applied at bud break alongside all of the P and K requirement
- 30 percent in late spring. e.g., late May
- And the remaining 20 percent in mid-summer, e.g., early July.

Winterkill can result when fertilizer is applied too late in the season.

Around 85-110 Kg/ha (75-100 lb/ac) of nitrogen is required for good blueberry yields, with amounts adjusted up or down according to yearly plant growth. In general, blueberry plants need to produce strong, new unbranched shoots each year to replace old canes and the weak 'twiggy' growth removed during annual pruning. This usually translates to at least three-to-five strong canes arising from the base of the plant or halfway up the old canes[1].

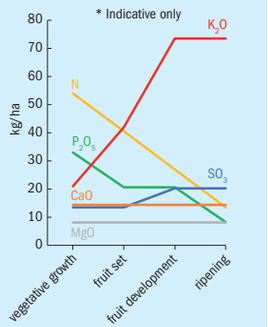
Nitrogen should be applied to established strawberries at around 40-45 kg/ha (35-50 lb/ac) in late summer to early autumn, e.g., between mid-August and

Fig. 1: **Nutrition uptake curve for blueberry***



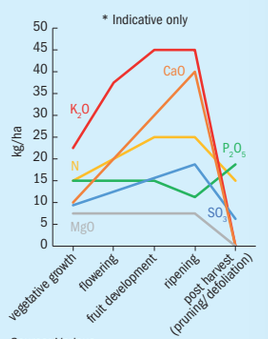
Source: Various

Fig. 2: **Nutrition uptake curve for strawberry***



Source: Various

Fig. 3: **Nutrition uptake curve for raspberry***



Source: Various

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early September. During a fruiting year, nitrogen should not be applied in the spring as it will often cause excessive foliage, soft berries, and increased fruit rot. However, if plants do show a need for spring N, then no more than 20 kg/ha (around 15 lb/ac) should be applied[1].

An annual nitrogen application of around 55-75 kg/ha (50-65 lb/ac) is recommended for raspberries. This is applied to the soil surface in the spring along the row or banded with the required P application. Nitrogen is the most important factor controlling internodal length and more N can therefore be applied (around 75-85 kg/ha, 65-75 lb/ac) if cane growth is inadequate and internodal length is less than the ideal distance of 10 centimetres (4 inches)[1].

> **Annual applications of nitrogen, phosphorus, and sulphur will be required to produce maximum yields and promote longevity?**

Phosphorus for crop development

Phosphorus is important for ensuring good rooting and leaf growth during early crop development stages. In productive plants, internal redistribution of P takes place during fruit development, with around 40 percent of total uptake ending up in the berry.

All berries will respond to a band applications of phosphate fertilizers if soil tests reveal low P levels in the upper soil profile. Phosphorus is spring-applied for blueberries and strawberries and autumn-applied for raspberries. Application rates (P_2O_5) as high as 100-150 kg/ha (90-135 lb/ac) can be necessary[1].

Potassium for fruiting

Berries require potassium in large quantities – showing a potassium need above that of nitrogen – with almost 60 percent of the K requirement found in the fruit at harvest. Potassium demand peaks, with uptake exceeding that of any other nutrient, from the early fruit formation stage through to maturity.

For maximum yields, blueberries, raspberries and strawberries all require adequate potassium availability, as determined by soil testing. Application rates (K_2O) of 90-100 kg/ha (80-90 lb/a) can be necessary[1].

SOP (sulphate of potash, K_2SO_4) or other low chloride K sources are generally recommended for berries, and blueberry in particular, due to chloride toxicity. Potash is spring applied in raspberry and blueberry, and autumn applied in strawberry. Potassium fertilizers can be broadcast between the rows or banded with P and N fertilizers[1].

Secondary and micronutrients

Sulphur can be applied as elemental sulphur, ammonium sulphate, gypsum, SOP or thiosulphate with rates of around 30-35 kg/ha (25-30 lb/ac) being required annually. The application of magnesium (e.g., as magnesium sulphate or potassium magnesium sulphate) at rates of around 550 kg/ha (500 lb/ac) is recommended for Mg-deficient soils. Boron fertilization (up to 1 kg/ha) is also advised for both raspberries and strawberries if testing reveals low B levels (less than 0.5 ppm) in the soil profile[1].

Products and producers

Specific products, crop guides and fertilization recommendations for berry crops are available from leading speciality fertilizer producers, including:

- Haifa
- ICL
- Omex
- SQM
- Tessenderlo Kerley International
- Yara International.

Tessenderlo Kerley International offers a wide range of thiosulphate and SOP products for berry crops. These can be supply nutrients such as nitrogen, potassium, calcium and sulphur at different growth stages using a variety of methods, including fertigation, foliar and soil application (Table 2).

For blueberry, liquid fertilization with potassium thiosulphate (KTS®) as a potassium source can deliver substantial benefits compared to traditional fertilization. In a 2018 trial on drip irrigated Biloxi blueberry plants in Isidro Mazatepec, Jalicso, Mexico, the grower observed that the number of harvested berries increased from 300 to 400 boxes per hectare after the first week of KTS® application. This translated to a yield increase of 1.4 t/ha with thiosulphate applications, providing the grower with substantial extra income.

Table 2: **Tessenderlo Kerley International's liquid thiosulphate and potassium sulphate product range can be applied to berry crops at different growth stages using a variety of application methods**

Product	Vegetative growth	Flowering	Fruit set	Ripening
Liquid thiosulphate products				
Thio-Sul® (Ammonium thiosulphate)	Soil application or fertigation	Fertigation	Fertigation	Fertigation
KTS® (Potassium thiosulphate)	Soil application or fertigation	Fertigation	Fertigation	Fertigation
CaTs® (Calcium thiosulphate)	Soil application or fertigation	Fertigation or foliar application	Fertigation or foliar application	Fertigation or foliar application
Potassium sulphate (SOP) products				
K-Leaf®		Foliar application	Foliar application	Foliar application
SoluPotasse®	Fertigation	Fertigation	Fertigation	Fertigation
GranuPotasse®	Soil application			

Source: Tessenderlo Kerley International

Supercharged calcium for blueberry

Applying Omex's Calmax Gold foliar fertilizer to blueberry plants improves overall uniformity of fruit ripening. Beneficially, this shortens the harvesting period by reducing the number of fruit pickings required. Dr Terry Mabbett outlines how foliar-applied calcium can increase yields and improve the quality of this 'superfruit' – as well as helping to prevent plant disease.

Recent years have seen blueberry take on the mantle of the world's 'superfruit'. Primarily due to the exceptionally high antioxidant content of this small fruit, but more generally because berries are rich in a range of mineral nutrients and vitamins, as well as being a good source of fibre.

Maintenance of these qualities in commercial fruit growing requires strict adherence to crop nutrition requirements. This means providing blueberry plants with all the essential nutrients, including: the macronutrients (nitrogen, phosphorous and potassium); micronutrients such as manganese, copper, and zinc; and so-called secondary nutrients like calcium and magnesium.

Raw blueberries are exceptionally rich in manganese while containing generous amounts of phosphorous, magnesium and calcium. These nutrients, especially calcium and phosphorous, have important roles in fruit quality and boosting the resilience of crop plants to disease. Calcium is arguably the most important and intriguing nutrient in this respect.

Fight the fungus

Blueberries have only been under intense cultivation for a relatively short period of time. But this has not stopped a range of plant diseases evolving alongside the crop to cause potentially serious economic levels of crop damage and loss.

The most widespread and serious of these is is root rot. This is caused by a fungus-like pathogen called *Phytophthora cinnamomi*. Like other root infecting pathogens, this resides on debris in the soil and is therefore a pernicious problem for perennial bush crops like blueberry which – by their very nature – will spend many years growing and yielding in the same soil.

Root rot of blueberries has traditionally been managed by using systemic, site-specific chemical fungicides, but such options are decreasing as established products lose their approval and are removed from the market. Furthermore, chemical fungicides have been shown to degrade fruit quality.

Blueberries have a pale waxy coating which acts as a natural barrier against fungus and helps preserve the fruit's moisture. Many agrochemicals wash off this protective coverage, reducing the quality of the fruit. Foliar fertilisers such as Calmax Gold, in contrast, do not affect this natural barrier and so help keep blueberries fresher for longer.

Furthermore, consumers are increasingly demanding organically produced fruit and vegetables requiring zero use of chemical fungicide. For organic growers and consumers, there's little point in producing and eating blueberries for health reasons if this requires treatment with chemical fungicide.

Strengthening the blueberry

Fortunately, alternative disease avoidance and management options are now available to growers – making blueberry cultivation and production without fungicide a reality. Research shows that the manipulation of blueberry crop nutrition, for example, can be highly effective at managing diseases like root rot. All essential nutrients are required for proper plant growth and development. But one stands out from the rest in blueberry cultivation and that nutrient is calcium.

Soil calcium has been shown to disrupt the root infection process of northern highbush blueberries in the United States. However, relying on soil calcium alone is not a fail-safe option. While the soil may well record high levels of calcium, a lower proportion is likely to be present in a soluble form available to the roots.

Typically, a high proportion of soil calcium is 'locked up' as insoluble salts such as calcium phosphate, especially when soils are alkaline with a correspondingly high pH. Neither is supplementing the soil with an applied calcium fertilizer the best option because most granular calcium compounds, like agricultural lime (ground limestone) for example, will raise soil pH – to the dislike and detriment of 'acid loving' blueberries.

Blueberry growers in Chile, Mexico and Peru have achieved successful results using the foliar fertilizer CalMax Gold.

The foliar solution

With blueberry, the foliar application of soluble calcium, which results in rapid nutrient uptake by plant leaves, is the secret to success. This provides sufficient calcium to blueberry bush crops, and is an efficient way of suppling what is otherwise a poorly mobile nutrient.

Omex's CalMax foliar range will correct any calcium deficiency, improve fruit set, enhance yield, and assist in maximising fruit firmness, storability, fruit colour and finish.

The latest field trial results from Chile, one of the fastest growing producers of this berry fruit and a world-leading exporter of blueberries, clearly show the benefits of foliar feeding with CalMax Gold, a high-calcium liquid formulation. Three applications of CalMax Gold (300 ml product in 100 litres water) were applied to the blueberry variety 'Brigitta' (*Vaccinium corymbosum* – highbush blueberry), first at the beginning of blossoming, second at 50 percent bloom and the third at full bloom.

Compared with the 'no treatment' control, CalMax Gold showed the following benefits:

- Increased number of fruits borne on each spur
- Higher yield by achieving more uniform fruit ripening
- Shortening of the harvest period by 2-3 weeks
- Reduction in the number of fruit pickings required
- Significant improvements in fruit quality
- Better fruit firmness even after a six-month storage period. ■

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PHOTO: TESSENDERLO KERLEY INTERNATIONAL

Liquid fertilization of blueberries with potassium thiosulphate (KTS®) can deliver significant yield increases and higher incomes for growers.

Quality parameters such as brix, firmness and size are of key importance for berry growers, suggests Tessenderlo, due to their ability to add value to small fruits. These valued characteristics are all influenced by crop fertilization.

Foliar applications of Tessenderlo's SOP product K-Leaf®, for example, have been shown to increase blueberry, raspberry and strawberry fruit size. The company's calcium thiosulphate product CaTs® should also increase berry firmness, as has been shown with other fruit types. Excessively high nitrogen levels should be avoided, suggests Tessenderlo, as these are likely to decrease brix. Using MOP as a potassium source for small fruits is also not advised due to their chloride sensitivity. There is also evidence that MOP has a negative impact on strawberry firmness.

Fertilization practices for small fruits are influenced by growing practice, particularly whether plants are grown in open field or under plastic and in glasshouses. Growing in tunnels typically favours fertigation, reports Tessenderlo, due to the need for frequent watering. This makes it practical to provide plants with small amounts of nutrients with each watering. Combining watering with fertigation is also favoured when growing in a substrate, especially in tunnels, since plants have a limited root zone.

Chile's **SQM** is a world-leading primary producer of potassium nitrate (KNO_3), The company reports that using potassium nitrate – commonly known as NOP (nitrate of potash) – in strawberry nutrient management results in higher yields and stronger plants[2,3]. Other research shows how the use of potassium nitrate and calcium nitrate can ameliorate the negative effects of salinity on strawberry plants[4].

In trials, NOP was found to promote earlier bud break and more rapid flower development, leading to quicker fruit setting and larger size fruit. Feeding strawberries with nitrate via fertigation also promotes greater yields by increasing biomass and raising carboxylate and calcium content. Foliar NOP applications, meanwhile, are linked to greater plant leaf area, longer root and petiole length, and higher chlorophyll content. The use of chloride-free NOP also prevents injury to chloride sensitive strawberry plants.

Crop trial evidence suggests that foliar applied NOP, because it is effective at inducing bud break, has a beneficial effect on strawberry plant growth and development. Applying doses of NOP via a foliar spray, by outperforming other dormancy breaking agents, increased strawberry plant flowering and fruit weight.

Similarly, SQM reports that foliar NOP treatments are highly effective at increasing firmness, fruit diameter and fruit weight in blueberries.

SQM's provides a range of water soluble and micronutrient-enriched NPK fertilizers for fertigation use with berries. These include:

- Ultrasol® Berries Soil – a formulation specifically designed to enhance nutrient uptake for raspberry, blackberry and cranberry
- Ultrasol® Strawberry Soil – a formulation specifically designed for strawberry crop nutrition
- Ultrasol® Blueberry Soil – a formulation tailored for blueberry growing.

The Ultrasol® strawberry formula provides this berry type with potassium and nitrogen at an ideal N:K ratio of 1:1.5. The blueberry formula, meanwhile, is acidified to enhance the nutrient uptake by this acid-loving berry. ■

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PHOTO: CRU

CRU Fertilizer AgriTech Forum

An eclectic mix of delegates from established fertilizer companies and technology start-ups gathered in Dallas, Texas in September for CRU's inaugural AgriTech Forum. We report on the highlights of this lively networking event.

Why fertilizer AgriTech?

Chris Lawson, CRU's head of fertilizers, opened the event by asking: "In a higher interest rate/inflationary/recessionary environment – is AgriTech a safer bet?"

2022 has certainly been a year of dramatic market change. CRU's fertilizer price index (FPI) reached an all-time record in March. These sky rocketing prices have opened the floodgates to higher cashflows and record earnings, particularly for North America fertilizer producers (*Fertilizer International* 510, p4). At the same time, fertilizer companies – to some extent – are holding back on their traditional capital investments, suggested Lawson.

Within the industry, high prices are also forcing innovation downstream. In effect, farmers are demanding more 'bang for their buck' from fertilizers as their input costs balloon. Fertilizers have also been making headlines as food security concerns have moved up the news agenda.

Despite recent price declines, fertilizers remain relatively unaffordable – a fact that has hampered demand in 2022. This has led farmers to look for alternatives, which, overall, is a positive for the fertilizer AgriTech market.

Given current developments, CRU believes there is room for an AgriTech conference dedicated to crop nutrition. "We aim to provide a focused, networking-heavy event to facilitate innovation in this critical industry," comments Lawson.

He provided a hypothetical scenario to illustrate AgriTech's disruptive potential:

What if, for example, the introduction of an innovative microbial product – claiming to deliver a nitrogen application rate saving of 45 kg/ha (40 lb/ac) on corn crops – eventually achieved a penetration rate of around 80 percent of the total US planted corn area. (This is similar to the current rate achieved by genetically engineered corn in the US.) In this scenario, annual North American nitrogen (N) consumption would eventually be cut by 1.4 million nutrient tonnes by 2045, equivalent to a CO_2 saving of 3.4 million tonnes. This would herald a major market step change in nitrogen usage and efficiency.

Summing up, Chris argued that 2022 will "absolutely" be a pivotal year of change for the crop nutrient industry. Yes, prices being cyclical will drop. But don't expect them to return to previous lows, he said, as raw materials costs and environmental compliance look set to keep prices higher. Inevitably, fertilizer producers will also shift their focus onto new growth markets.

Looking ahead, promising AgriTech will undoubtedly make its impact felt, yet commodity fertilizers will still be required in large quantities. This suggests that a symbiosis is required between AgriTech start-ups and the industry's incumbent major producers.

AgriTech investment accelerates

"Today is the best time" to invest in North American AgriTech, suggested **Matt Foley**, programme director of Invest Nebraska. This was due to the financial support from two financial tailwinds:

- The increase in capital being deployed by private markets
- The focus of government programmes on soil health and nutrient management.

Invest Nebraska has been investing in tech companies since 2011. It currently makes 20-25 seed stage investments each year, typically awarding a cheque of around $250,000 to individual companies. Two of its notable ag tech investments include Sentinel Fertigation and Monolith.

Sentinel has gone through a successful $1 million seed round through Invest Nebraska. Its technology is now commercially available across the state and delivers an average nitrogen saving of 43 lb/ac to farmers. Monolith, the recent beneficiary of a $1 billion loan from the US Department of Energy, is building a commercial scale 'turquoise' ammonia production plant in Hallam, Nebraska. This is expected to produce around 319,000 t/a of ammonia, primarily for on-farm use.

AgriTech start-ups are becoming increasingly attractive to investors. Globally, around $4.1 billion has been raised for 527 fertilizer technology investment deals in the past five years. These include:

- 272 deals totalling $2.7 billion for innovations in biology and chemistry
- 137 deals totalling $233 million for innovations in software
- 80 deals totalling $96 million for innovations in hardware and sensing
- 38 deals totalling $987 million for innovative business models.

In the US, government support includes the USDA's $1 billion pilot programme for climate-smart commodities and the small business innovation research (SBIR) programme. SBIR has awarded $54 million to fertilizer technology start ups in the past decade. Beneficiaries have included Midwestern Bioag and Nitricity.

Hurdles to AgriTech adoption

Convincing farmers to adopt AgriTech requires them to vault two hurdles, suggested **Sam Taylor**, executive director, Rabobank. Firstly, growers need to be convinced they need to change and, secondly, they also need to be taught how to use new products effectively.

In Taylor's view, the successful adoption of new products requires farmers to be led "through the retail landscape" along the following pathway:

- Persuasion – though the use of education and evidence
- Influencing decision-making – to avoid rejection as a possibility
- Acceptance and purchasing – including viable financing options
- Successful use – as negative experiences my lead to discontinuation and the warning-off of others.

How many times a year the grower makes a purchasing decision will also hold the key to AgriTech adoption and growth, suggested Taylor.

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Sustainability was identified as *the* great agricultural disruptor by a panel of industry executives at an event hosted by Rabobank in 2021 – who placed it ahead of e-commerce, new breeding technologies, precision agriculture and biologicals. Among industry executives, there was a view that 'biologicals' would become a major purchasing area for corn/soybean production, being likely to account for 10-20 percent of the farmer's wallet by the end of the decade.

Within the industry, climate change, consumer demand, technology and social innovation are seen by executives as the main catalysts for agricultural change – including farming practice. While climate change and consumer demand will push changes to farming practice, technology and social innovation are pull factors that will act as enablers to deliver the necessary change.

"Pushed and pulled by a mix of factors, the book of farming will be rewritten again in the years and decades to come," commented Taylor. Among executives, however, the jury remains evenly split over whether the Russia-Ukraine conflict will ultimately decelerate or accelerate the drive for agricultural sustainability.

Sharing the desire to win

The Mosaic Company is dedicated to the pursuit of a "healthy soil", according to **Kim Nicholson**, the company's VP for AgriTech & innovation. Balanced crop nutrition, through pioneering speciality products such as MicroEssentials, K-Mag and Aspire, forms the foundation of Mosaic's overall business approach.

The company has also moved into advanced crop nutrition via strategic partnerships with innovative market entrants such as AgBiome, BioConsortia and Sound. To consolidate its position in the biostimulants market, Mosaic recently bought the biological-based crop input company Plant Response, its first major acquisition in five years.

The key to successful AgriTech partnership, suggested Nicholson, was a shared vision and an agreed definition of success. Both parties also need to understand their respective roles, contributions to the partnership, and different strengths/weaknesses. Neither should the partnership be overly competitive.

"The focus is on a shared desire to win – not who is the winner. It really needs to lift both boats," said Nicholson.

Mosaic remains interested in new AgriTech partnerships and acquisitions. "We're still out there looking for technology," Nicholson confirmed. Areas of interest include:

- Sensors and software for measuring nutrient use efficiency
- Novel crop nutrition products and equipment.

Joint ventures – engines of innovation and R&D

Two of OCP's high impact joint ventures (JVs) were highlighted by **Zach Hedge** of OCP North America. The company's involvement in JVs dates back to its partnership with Jacobs (now Worley) in 2011. OCP subsequently established partnerships with Spain's Fertinagro in 2019 and China's Forbon in 2021.

OCP's partnership with Fertinagro – OCP Fertinagro Advanced Solutions (OFAS) – is developing and manufacturing innovative speciality fertilizer products tailored to specific farming conditions and individual crop requirements. The Forbon JV, in contrast, is an R&D partnership developing next generation technologies for fertilizers and 'smart' agriculture.

Becoming nature-positive

Nutrien's senior director **Ryan Bond** sits on the retail side of the business where he leads the company's soil health team. He said his job is: "To deploy capital, deploy resources to get to nature-positive."

Nutrien's current sustainability offerings and capabilities include:

- C^2 biological nutrient use efficiency technology
- Dynagro cover crops
- ESN enhanced efficiency fertilizers EEFs)
- Echeleon variable rate application (VRA) technology
- Agrible precision farming app.

The company is continuing to invest in new technologies and is pursuing the transition to low-carbon fertilizers as part of its 2030 'Feeding the Future' plan.

Ryan offered two takes on AgriTech: "You don't need data – our 500,000 growers will tell you they're drowning in data. You need insights, not data." He also directly quoted Nutrien's CEO: "Innovation is worthless without adoption!"

This plays to Nutrien's strengths, as the company can act as an accelerator by working at scale through its digital retail platform, network of 3,500 agronomists and half a million grower accounts.

Embracing external innovation

Hedar Sutovsky, ICL's VP for external innovation, set up ICL Panet, an external start-up hub in 2021. The hub is used to form partnerships with start-ups who have already developed a product, but are poised at the intermediate pilot or market-ready stage.

ICL Planet is part of a wider set of ICL innovation initiatives that also include:

- BIG – the company's internal innovation accelerator
- An operational excellence unit – pursuing 'Industry 4.0' production technology
- ICL Ag start-ups – Agmatix and Growers
- An open innovation platform.

This 'ecosystem' at ICL is fast-tracking company-wide innovations in areas such as food tech, eMobility, next generation fertilizers, digital agriculture and novel materials.

Being disruptive

Creative disruption is at the heart of Koch Agronomic Services (KAS), says **Greg Schwab**, the company's VP for innovation & agronomy. KAS itself was set by Koch to disrupt its core fertilizer commodity business – with Greg being recruited as its fourth employee!

Greg highlighted Protivate, the latest innovation from KAS. This novel seed enhancer provides both primary nutrients and micronutrients and is applicable to corn, soybean or wheat. The Protivate range includes:

- NU4-DRI (2% N, 12% P_2O_5, 9% Zn, 2% Mn). This is applied at the planter box or in downstream/retail applications.
- NU5-DRI (10.5% Zn, 5% P_2O_5, 3% Mn, 2.5% Mo, 1% Fe). Also applied at the planter box or in downstream/retail applications.
- NU5-LUX (17% Zn, 5% P_2O_5, 3% Mn, 2.5% Mo, 1% Fe). This is used in retail seed-treated applications.

These enhancers also improve seed flowability and encourage better seed singulation – so eliminating the need for talc. Trials on corn with NU4-DRI have demonstrated a 4 bu/ac yield advantage over talc/graphite seed treatments. This could typically deliver a net return to farmers of almost $20/ac, calculates KAS.

Listening to tree heartbeats

Phytech originally offered drip irrigation technology before moving into plant nutrition and then pest disease and control. The company now manufactures sensors which are attached to the trunks of trees to measure their daily cycle of contraction and expansion, explained **Oz Ben-David**, the company's VP.

This daily cycle measures trees stress levels and indicates when to irrigate – to maximise yields – while minimising costs and environmental impacts. Phytech's technology combines multiple sensors for 4Rs nutrient management. These include:

- Soil probes
- Irrigation flow sensors
- Weather sensors
- Fruit growth sensors
- Trunk sensors.

Data from these sensor arrays ensure that fertigation is performed efficiently with no leaching, as water and crop nutrients are placed precisely within the active root zone in the required amounts.

Phytech says its technology powers more than 850 of the world's top tier agricultural growers. The company has an almost 40 percent share of California's large almond-growing market, for example.

START-UP SHOWCASE

The second day of the event was dedicated to pitches from the following AgriTech start-ups:

Diego Angelo, **ucrop.it**. This platform monetises and rewards sustainable farming behaviour and acts as a trusted and reliable intermediary between farmers and major AgriFood players such as Cargill, BASF, Profertil and Bayer. ucrop.it functions as a 'track and trace' system that collates, verifies and certifies on-farm information such as crop yields and nutrient use efficiency. Certified growers can generate incomes of up to $1.50/ac. The system operates in Argentina, Uruguay, Paraguay and is being rolled out in Brazil. The platform is used by more than 500 large scale farmers and 200 corporate partners in the Americas and certifies around three million acres currently.

Joe Brooker, **Stable**. This UK-based, venture capital backed company was founded in 2016. It solves the problem of unmanaged price volatility and ill-liquidity for agricultural commodity where conventional futures contracts have failed. The company's commodity contracts address a market gap and failure. For example, only 16 percent of ag products are covered by futures contracts currently, leaving 173 products whose risks cannot be hedged or managed. These include onions, barley, wine, broilers, boneless beef, potatoes and apples. Sable's simplified hedging model works by pricing unpriced commodity risks and providing new sources of liquidity. The company employs 50 staff and operates out of New York, Chicago, London and Hamilton.

Keith Driver, **Replenish Nutrients**. This Alberta-based company manufactures innovative regenerative (NPK+S) fertilizer products for sustainable farming. These build soil organic matter, restore soil biodiversity, activate microbes and strengthen the natural defences of plants. They also meet regenerative agriculture goals by maintaining yields while restoring soil carbon. Products include a soil probiotic (HESO, 0-9-20-20), a potassium builder (Super KS 0-0-35-30) and a phosphate builder (Rebuilder, 0-17-0-12). The company currently operates a 20,000 tonne capacity production plant in Beiseker, Alberta. An additional 50,000 tonne capacity granulation plant is due to come online in Debolt, Alberta in 2023. Meanwhile, another 200,000 tonne capacity granulation plant, co-located at K+S's Bethune mine site in Saskatchewan, is at the project engineering stage.

Peter Gross, **Lucent Bio**. Novel technology developed by Lucent Bio transforms food processing co-products (lentil and pea hulls) into a sustainable, high-performance fertilizer marketed as Soileos. The company's technology binds micronutrients to bio-activated cellulose. The resulting 'climate positive' fertilizer improves soil carbon and acts as a source of zinc. Soileos has been tested in 149 trials on both broad acre and speciality crops. It was found to deliver a 20-25 percent yield improvement for tomato, lettuce and strawberries and a 5-12 percent yield improvement in soybeans, wheat and corn. Lucent is building a 7,000-tonne capacity production plant to manufacture Soileos at Rosetown, Saskatchewan, Canada. This $20 million project is due to be completed by the end of 2022.

Nicolas Pinkowski, **Nitricity**. This start-up's ambition is to electrify and distribute global fertilizer production locally – with the dual aim of cutting GHG emissions and improving the equity of global food supply. Nitricity's technology turns air and water into nitric acid using solar energy and a plasma reactor. The nitric acid can be converted into a range of liquid fertilizers by combining with other inputs such as limestone, phosphate rock and potassium hydroxide. Nitricity has already operated an on-farm solar fertilizer project at a fertigated 75-acre plot for bell peppers and tomatoes in Fresno, California. Having linked up with terranova ranch in 2021, the company began a new project with IFDC and khosla ventures in 2022.

Jane Fife, **3Bar Biologics**. Biofertilizers do not 'travel well' due to the decrease in microbe viability over time and distance. Although well known, this problem persists as the industry's current answers – the overloading of microbes, cold storage and expiration dates – are only partially effective. 3Bar has taken a very different approach. Its innovation places research-quality microbes in the hands of famers using just-in-time fermentation. 3Bar's portable containerized fermentation system uses a push-button mechanism to release microbes from a sealed storage chamber into a rich nutrient broth. The microbes grow exponentially within a small container over the next 24-48 hours – and are then ready to apply for several months.

Hunter Swisher, **Phospholutions**. RhizoSorb is a granular fertilizer additive developed by Phospholutions. It increases the phosphorus (P) efficiency of fertilizers and, according to the company, allows farmers to achieve the same or better yields with half the fertilizer application. Essentially, the product acts as a reservoir for P, only releasing this nutrient when it is needed by the plant. RhizoSorb has been demonstrated on 2,500 acres of crop land and been shown to maintain yields while at the same time reducing P use by 50 percent. Phospholutions is preparing for a pilot launch with retail partners in 2023.

Jared Criscuolo, **Upcycle & Company**. Upcycle's 'active' fertilizer triggers and supports the microbes necessary for resilient soils and plants – while providing supplementary nutrients, organic matter and carbon in a single treatment. In a trial on turf, the product increased plant growth and zinc transport pathways and reduced water stress and disease pressure, in comparison to polymer-coated urea (PCU). The company's production process upcycles organic waste using renewable power. To date, it has received $1.5 million from angel investors and is seeking further funding to allow it to move aggressively into the agricultural market.

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Verdesian Life Sciences: the nutrient use efficiency people

PHOTO: VERDESIAN LIFE SCIENCES

Verdesian's Cape Girardeau manufacturing plant in Missouri.

After just 10 short years in business, there is a reason why Verdesian Life Sciences has lived up to its mantra 'the Nutrient Use Efficiency People'. This is not just a slogan – it defines the company's philosophy and culture. It also sums up Verdesian's mission to help the world's farmers do more with less through the company's broad portfolio of sustainable nutrient efficiency products.

Originally founded in 2012, Verdesian was formed with the sole intention of offering innovative plant health and nutrition technologies. Fertilizer efficiency products have always been at the heart of the company. A decade later, and after multiple acquisitions and a plethora of new product offerings – see the timeline below – that dedication to fertilizer efficiency has not changed.

Verdesian's diverse product portfolio, protected by more than 300 patents, is designed to enhance crop uptake, reduce nutrient losses to the environment, and improve yields for all growers across the globe. In short, Verdesian is committed to researching and developing nutrient use efficiency technologies to make farming more efficient, more sustainable, and more profitable.

Not resting on its laurels

Kenneth Avery has been the company's CEO since 2016. There's been a step change since his appointment, with Verdesian developing new iterations of its original fertilizer enhancer products. Firstly with N-Charge G, and more recently with Trident, Verdesian has provided the agricultural market with industry-leading nitrogen fertilizer enhancers.

N-Charge G provides proven increases in nutrient use efficiency for treated granular nitrogen fertilizers. Its innovative formulation keeps more nitrogen in the root zone longer, allowing plants to absorb essential nutrients where and when they are needed most.

Trident is the most complete solution on the market for nitrogen loss. It comprises of a series of nitrogen stabilisers that protect against all three forms of nitrogen loss: volatilisation, nitrification, and denitrification.

Trident offers a flexible application rate for urea and urea ammonium nitrate (UAN) and provides nitrogen protection in any environment and at every stage of the growing season. It combines time-tested technology with a patent-pending co-polymer solvent blend that improves the efficacy of NBPT and DCD. Trident is also classed as an enhanced efficiency fertilizer (EEF) product suitable for use in conservation stewardship programmes (CSPs).

With the addition of Trident to its product range, Verdesian Life Sciences says it now has the most complete line-up of nitrogen stabilisers in the fertilizer industry.

For phosphorus (P) crop nutrition, Verdesian offers **AVAIL T5** – the latest optimised iteration in a long line of P efficiency products. AVAIL T5 uses all-new patented T5 polymer technology to reduce the fixation of applied phosphorus, keeping more P available for plant uptake, speeding early growth and improving crop health and yield potential.

AVAIL T5 makes more applied P available, regardless of source or timing, increasing phosphorus efficiency and uptake by the plant. As a result, up to 45 percent more P is accessible to crops, according to Verdesian. This has environmental benefits as more phosphorus uptake by the plant means less P build-up in the soil and less P losses to streams, rivers, lakes, and bays.

Being a good steward

This emphasis on being a good steward of the soil and water goes beyond just agricultural sustainability. It is a strategic choice for Verdesian and a key pillar of its current and future approach to business, with the company placing major emphasis on environmental, social and governance (ESG) issues.

One example of Verdesian's commitment to ESG is its focus on greenhouse gas emissions. Nitrous oxide represents only seven percent of all greenhouse gas emissions but is 300 times more potent than carbon dioxide. Agriculture alone contributes 74 percent to global N_2O emissions. Verdesian, however, sees this as a great opportunity due to the enormous positive impact its nitrogen fertilizer products can make in driving down emissions. These products also keep more carbon where it needs to be, by helping to sequester CO_2 and increasing soil organic carbon.

From a water quality standpoint, many will be aware of algae blooms in the Lake Erie basin or the Gulf of Mexico, and the phosphorus runoff issues in the Chesapeake Bay area. These problems have forced farmers across North America to explore technologies that reduce nutrient losses – while maintaining the ability to produce food for a growing world. AVAIL T5 is one product offering farmers help with excess environmental P. By allowing more phosphorus to be taken up by the crop, correspondingly less P ends up leaching into groundwater, streams, or other water sources. ■

VERDESIAN LIFE SCIENCES TIMELINE

- **2011** Paine Schwartz Partners teams up with industry executives to build an innovative plant health and nutrition platform
- **2012** Verdesian acquires Biagro Western
- **2013** Verdesian acquires Northwest Agri Products (NAP), INTX and Plant Syence
- **2014** Verdesian acquires SFP and QC Corp.
- **2016** Appointment of Kenneth Avery, CEO
- **2018-20** Commercial launches of AVAIL T5 and N-Charge G
- **2021** Verdesian acquired by AEA Verdesian acquires Cytozyme, Inc. Launch of Trident

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Making fertilizer plant construction safer

The fertilizer industry's leading engineering, procurement and construction (EPC) companies, by setting zero incident safety goals, are making construction sites across world safer. In this article, we highlight the safety advantages of modular construction and digital approaches to safety at construction sites.

THYSSENKRUPP INDUSTRIAL SOLUTIONS (THAILAND) LTD

Modularisation: the safer construction option

Tobias Birwe

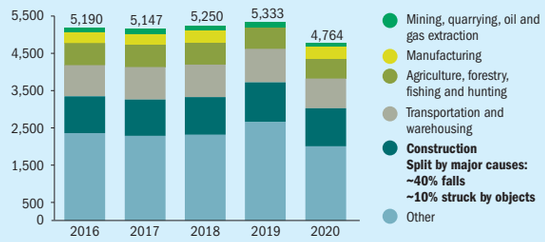
Construction site safety is always a top concern. Given that construction is a comparatively high risk activity, it comes as no surprise that the industry's fatalities accounted for around one-fifth of all deaths at work in the United States from 2016 to 2020, corresponding to around 1,000 lost lives annually (Figure 1).

Half of these fatalities are caused by falls and people getting struck by objects. Fortunately, both of these incident types can be significantly mitigated by using modularisation in construction. Modularisation offers safety benefits by shifting work from construction sites to more controlled areas in fabrication yards and by moving construction activity from higher elevations to ground level.

PHOTO: THYSSENKRUPP INDUSTRIAL SOLUTIONS

'Gemba' on-site safety walk with CEO of thyssenkrupp Industrial Solutions (Thailand) Ltd.

Fig. 1: **Fatal occupational injuries in the US for selected industries, 2016-20**



Source: US Bureau of Labor Statistics

Safety culture

thyssenkrupp Industrial Solutions (Thailand) Ltd is committed to a 'zero accidents' philosophy to protect the health and safety of its employees, our most valuable asset. Our safety mantra is: "Make sure everyone goes home safely, every day to their loved ones and families."

Company safety culture is further enhanced by operating HSE programmes based on behaviour-based safety (BBS) principles. Our 'Spot safety recognition programme', for example, increases on-site housekeeping standards through a weekly cleaning routine. This is positively reinforced by free lunch packages and drinks for the participants. Good house-

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keeping practice enables us to mitigate several risks. The risk from falling objects, for example, can be reduced by removing unused materials from work areas and storing these in a proper and safe location.

The positive safety behaviour of our site staff is regularly rewarded by safety certificates which highlight and recognise safe working. Leadership participation is also seen as one of our key success factors. thyssenkrupp Industrial Solutions (Thailand) Ltd therefore conducts monthly 'Gemba' safety walks on our sites with our top management (see photo).

As a result, we are extremely proud of our safety performance. To date, we have accumulated over 42.4 million project work hours without a single lost time incident (LTI).

Safety is also one reason why modularisation is at the core of our project execution strategy. Our full range of in-house modularisation services covers:

- Project management
- Concept planning
- Preliminary engineering
- Detailed design
- Procurement
- Construction management
- Commissioning.

What is modularisation?

The term modularisation includes prefabrication, preassembly, modularisation and offsite fabrication (PPMOF) activities and typically encompasses four distinct categories:

- **PAU/PAM**: pre-assembled units/modules
- **PAR**: pre-assembled racks
- **VAU**: vendor assembled unit
- **VPU**: vendor packaged unit

Other aspects of PPMOF include precast concrete, dressed columns and prefabricated buildings.

Modules consist of equipment items arranged in modular steel structures and buildings that can be assembled off-site. These are then transported to the site and lifted into place. Modularisation includes the following activities:

- Equipment is connected with piping
- Instrumentation is installed and cabled to junction boxes
- Lighting and cabling is installed
- Steelwork is fireproofed up to the connection points
- Tracing and insulation on equipment and piping are completed
- Painting is carried out.

Safety and other benefits

Compared to on-site construction, modularisation works can be executed at a higher number of parallel work-fronts closer to ground level, reducing scaffolding requirements and lifting activities. Modularisation also results in a shift from a higher number of smaller lifting activities to a smaller number of heavy lifts performed under more tightly controlled conditions using exclusion zones.

Apart from creating safer work environments on construction sites, modularisation delivers several other benefits to customers. Modular construction is a very effective way of improving quality and productivity and can deliver cost savings by shifting potentially expensive site hours to cheaper workshop hours with higher productivity. Modularisation also increases the reliability of construction schedules and mitigates other site risks such as industrial relations performance. Furthermore, modularisation results in more sustainable project delivery by reducing the impacts of construction on local communities and infrastructure.

TOYO ENGINEERING CORPORATION (TOYO)

Improving safety with digital technology

Kenji Yoshimoto

The rapid worldwide spread of digital technology is influencing work on construction sites and the EPC contracting industry. Japan's Toyo Engineering Corporation (Toyo) is embracing this digital transformation and the new approaches to safety it offers, including:

- Smartphones
- Digital signage
- Artificial intelligence (AI) speakers

These are highlighted below.

Smartphones

Toyo has been working continuously to implement and improve Health, Safety, Security and Environment (HSSE) at construction sites to protect its workers. Previously, the company's standard HSSE procedure was developed from past knowledge and experiences. But it was recognised that a new paperless procedure would be needed in future to replace the traditional paper-based approach.

To achieve this, Toyo's turned to Microsoft Power Apps. This standard tool creates new paperless apps that can be used easily without any special skills. These apps are helping Toyo achieve a dynamic change of culture at construction sites and the desired switch to paperless working.

As a first step, Toyo recently developed a new app named BBO (Behaviour Based Observation) Report Application (Figure 1). This app is designed to eliminate the paperwork associated with reporting near miss accident reports at construction sites. Previously, BBO reports were submitted in a paper format by workers, supervisors and site personnel, and then registered digitally on Microsoft Excel spreadsheets by a data entry clerk. The task took a long time to complete and was occasionally prone to input errors.

The new app has features which allow users to take photos and input information using a dropdown menu on a smartphone, tablet and/or laptop etc. Entered information is submitted directly to a database. This database information is then analysed by Microsoft Power BI, a business analytic service offered by Microsoft. This allows anyone at the construction site to check event trends and use the data to prepare HSE flash reports, weekly reports and safety awareness posters etc.

The new app target 500+ members of staff directly employed by Toyo and has resulted in three unanticipated positive benefits:

- Automatically provides an accurate log from users (staff) during working hours
- Offers time savings for both the applicant and administrators
- Prevents submissions and actions from being overlooked.

The switch from a paper-based system to the new paperless app – by providing an easy and timely method of collecting data on field activities and behaviour – can be used to implement preventative HSSE measures. Consequently, Toyo is now recommending the adoption of this paperless system at all its construction sites.

Toyo is also making use of several other apps at construction sites. These can be used to request personal protective equipment (PPE), for transportation requests, and to input timesheets, for example. There is even an app which allows construction workers to request lunch boxes/midnight snacks from anywhere on site, making life more comfortable for everyone. This is clearly good for human health and has a positive effect on the performance of daily tasks (Figure 2).

Digital signage

Throughout its EPC projects, Toyo has always recognised the truth and importance of two sayings: 'seeing is believing and 'a picture is worth a thousand words'. In our experience, presenting information visually is usually the most effective form of communication. The use of moving images, such as movies or videos, is also becoming increasingly popular.

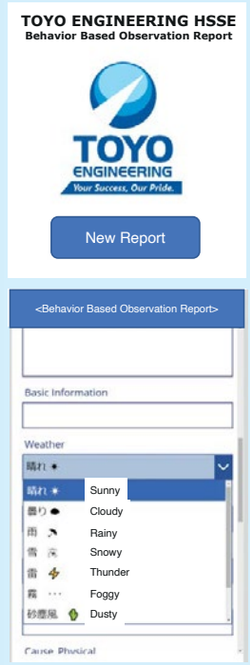
The use of digital display boards at construction sites is helpful in situations where people need to deliver and visualise messages more clearly. The use of better visual tools also has an important and positive impact on HSSE management for staff at EPC construction sites.

To meet HSSE requirements, Toyo recently launched electronic displays – so-called digital signage – at a construction site in Japan. This displays the important HSSE information announced daily to all staff members at their morning toolbox meeting. At given times, the digital sign can:

- Display construction progress with drone aerial video
- Alert staff and workers to prevent personnel from entering restricted areas by showing a map
- Announce major activities or site events such as heavy lifting, power receiving, steam blowing, or VIP visits.

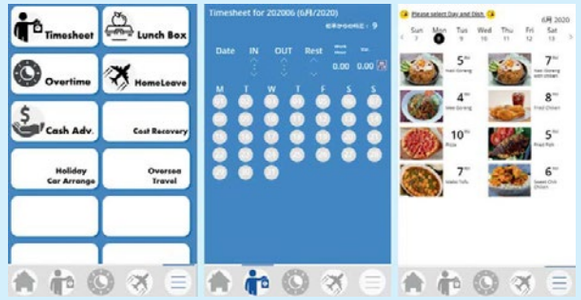
Digital signage allows the relevant information to be shown effectively in a visual manner – whereas conventionally in toolbox meetings messages were delivered via voice messages only. Because it was necessary to translate messages into all the different languages spoken by site personnel (Japanese, English, Bangladeshi, Malaysian, Singaporean, Chinese etc.), in some cases it was quite difficult to provide a clear message to all staff. Visualisation using digital signage was found to

Fig. 1: **Main display of the BBO report app**



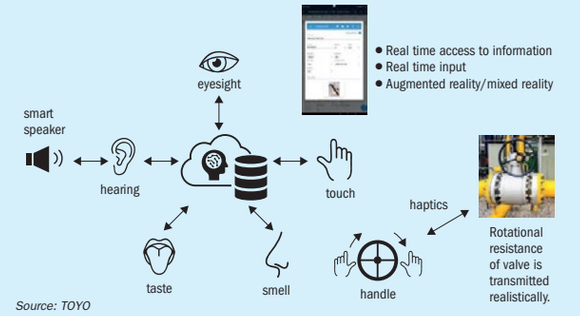
Source: TOYO

Fig. 2: **Main display of the new 'site life' application**



Source: TOYO

Fig. 3: **Toyo's smart speaker concept at sites**



Source: TOYO

PROJECT SAFETY

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NOVEMBER-DECEMBER 2022

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be a much more effective way of providing information that avoided some of these language and translation concerns. Toyo also plans to use projection mapping in the near future. This should make messages even more powerful and keep construction site workers safe by ensuring good communications.

AI speaker (Safety Smart Speaker)

Thanks to recent advances in the internet of things (IoT) and artificial intelligence (AI), information and communications technology (ICT) is now available that can interact with all five human senses. Speaking to smart speakers has been identified as a particularly useful and effective form of hands-free communication, especially at construction sites. From a safety point of view, it is important that construction crews can receive information without picking up paper, documents, or mobile phones. Usefully, smart speakers can also use voice recognition to identify different individuals in the construction crew.

Toyo's smart speaker concept for construction sites is shown in Figure 3. The company built a prototype Safety Smart Speaker in 2021. When users say certain keywords, this speaker responds by giving highly relevant alerts/reminders by showing past incident cases with appropriate safety measures. The speaker provides a voice reading of incident cases as well as displaying the information.

> **"Toyo is developing powerful digital technologies that can improve safety culture by appealing to our five senses."**

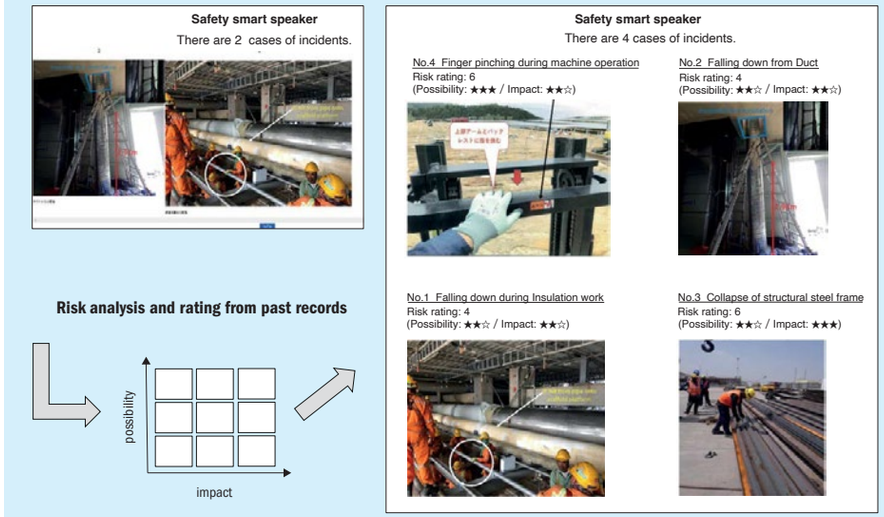
Currently, the screen for showing past incident cases is being improved to enable the display of a risk ranking alongside search results (Figure 4).

Smart speakers can be used in the following situations:

- **At the safety training centre:** Instead of passively reading a paper bulletin, workers can easily increase their safety awareness by talking to a Safety Smart Speaker and getting a reply.
- **For regular inspections:** The Safety Smart Speaker can also be used for regular inspections as well as for safety. The speaker enables inspectors to continue to work using the inspection tools in their hands by providing a hands-free voice checklist. This saves times as, previously, the inspectors needed to stop working to pick up the paper checklist.
- **Receiving site feedback:** Workers can send feedback through the Safety Smart Speaker. This is an effective way of proactively raising safety awareness on-site, and not just give workers information on past incidents.

Toyo is planning to introduce Safety Smart Speakers as standard in the above three work settings soon. The company is continuing to develop powerful digital technologies that can promote and improve safety culture by appealing to our five senses. ■

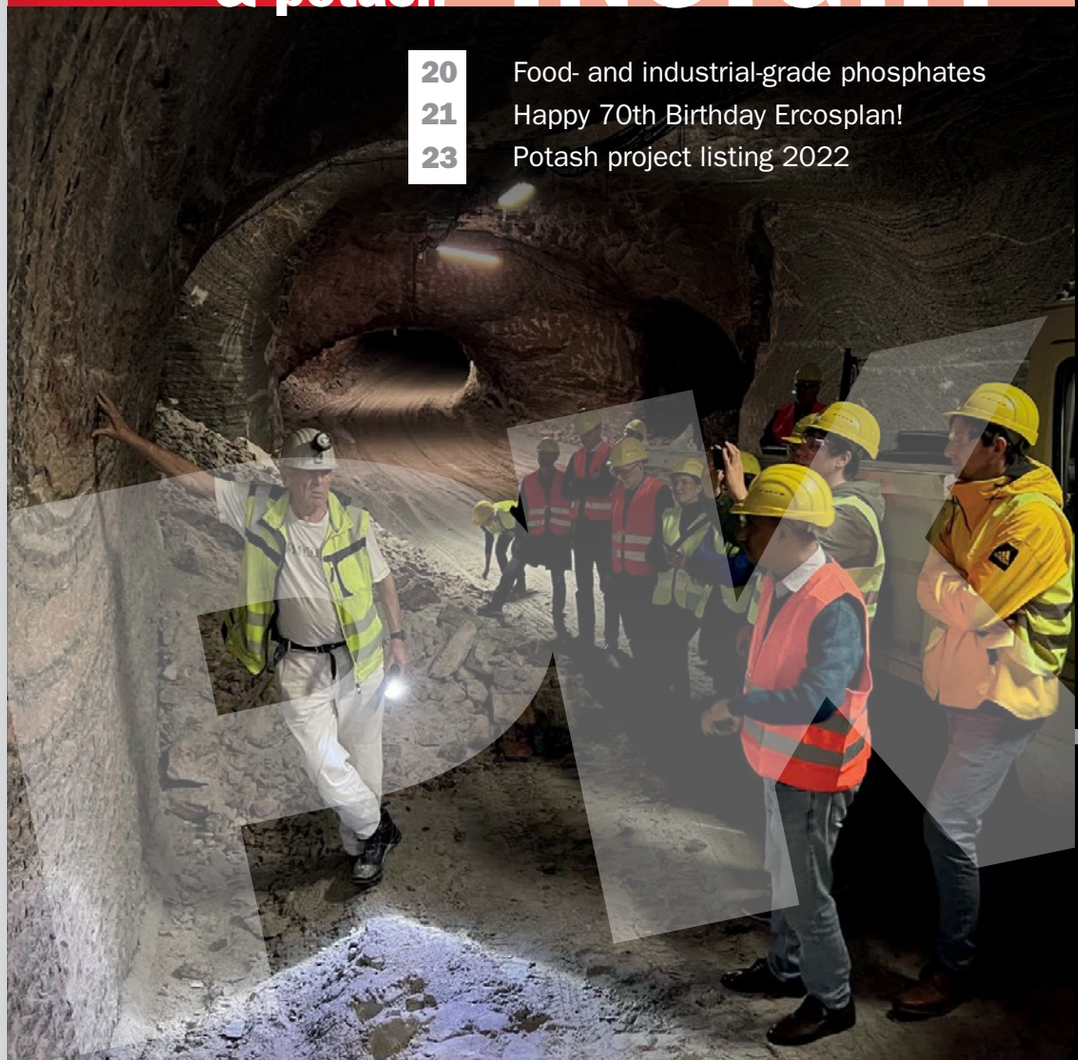
Fig. 4: **New screen for the proposed safety smart speaker**



Source: TOYO

November-December 2022

phosphates & potash INSIGHT



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Food- and industrial-grade phosphates

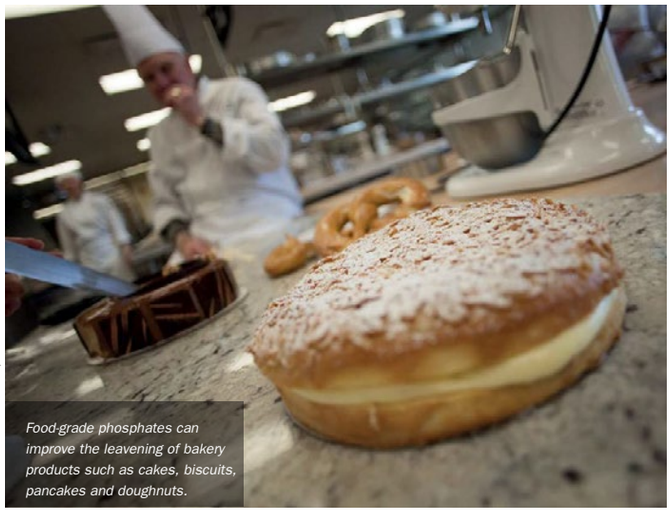

PHOTO: COLLEGE OF DUPAGE/FLICKR

Food-grade phosphates can improve the leavening of bakery products such as cakes, biscuits, pancakes and doughnuts.

Industrial end-markets and food manufacturing provide significant global demand for pure and high value phosphate products. The growth potential for lithium iron phosphate (LFP) used in vehicle batteries is also a major industry talking point currently, as **Alberto Persona**, Fertecon's principal phosphates analyst, explains.

Climate change adaptation and mitigation are two topics that won't have eluded readers of this magazine. Within the fertilizer world, adaptation has been a prominent and widely discussed issue in recent years – for example, 'climate-smart' products that can help stabilise crop yields in response to ever-changing and more extreme weather.

Mitigation has also risen up the policy agenda, with some governments moving more quickly than others in setting CO_2 emissions reduction targets. Here, our industry is also beginning to act and contribute by pursuing the decarbonisation of ammonia production.

While nitrogen fertilizer producers clearly have an imperative to move away from natural gas and other fossil fuel feedstocks, the phosphate industry also has important climate and environmental obligations. Phosphate fertilizers have a role to play in limiting land use conversion from forests to cropland, for example, and in supporting investments in fertigation in arid regions. But industrial-grade and food-grade phosphates – a less discussed segment of the phosphate market – could also deliver positive climate benefits due to their incorporation in electric vehicle batteries.

Phosphate market fundamentals

First things first, though: some information on market size. Overall, the global phosphates industry produces around 60 million tonnes (P_2O_5) of various downstream products annually. At around 85-90 percent of the total, fertilizers represent the largest share by far, while feed-grade supplements account for a further 3-5 percent, with industrial- and food-grade phosphates making up the remaining 5-10 percent share. Fertecon data indicate that around 5.2 million tonnes (P_2O_5) of industrial/food phosphates were manufactured in 2021.

The terms 'industrial-grade' and 'food-grade' cover a large series of phosphate products that cater for disparate end-uses. Major end-use categories (and their respective sub-categories) include:

- Consumer goods (detergents, toothpaste)
- Pesticides
- Industrial applications (metal bright-dipping, semiconductors, industrial cleaners)
- Flame retardants
- Processed food (cola manufacture, meat and dairy, sugar refining, leavening agents).

An additional niche sector, one that requires exceptional product purity, is the pharmaceutical industry. Monocalcium phosphate, for example, is a component in most vaccines, including those developed to fight the SARS-Covid19 virus.

Industrial and food phosphates are also commonly classified by their chemical composition. This takes into account the additional raw materials used in their manufacture and includes:

- Phosphorus chlorides
- Phosphorus sulphites
- Phosphinates and phosphonates
- Ammoniated phosphates
- Calcium phosphates
- Potassium phosphates
- Sodium phosphates
- Metal phosphates.

Manufacturing routes

The third way of segmenting the food and industrial phosphate market is classifying products by their production process. Broadly speaking, the market divides between two main processes – the thermal route and the wet route.

The **wet route** is part of the traditional phosphate value chain, being based on the production of phosphoric acid via the reaction of phosphate rock with (commonly) sulphuric acid. A series of purification steps are then necessary, as most of the impurities present in the original rock feedstock end up being transferred to the acid product generated. Common processes for purifying phosphoric acid include:

- Gas or ammonia scrubbing to remove fluorine and metal oxides
- Filtration
- Crystallisation
- Solvent extraction.

While the additional cash cost of removing impurities is factored into product pricing, developing commercial purification processes requires extensive R&D and expert control is necessary for their successful operation. Companies offering purification technologies are also highly protective of their intellectual property and are very active patent publishers. All of these factors combined create a market barrier to new entrants. Consequently, producers of purified phosphoric acid (PPA) with access to their own proprietary technology tend to dominate – and are in a position to impose significant licensing costs on other players wishing to enter the market.

The **thermal route** starts with the production of elemental phosphorus in an electric-arc furnace. Phosphate rock is firstly blended with thermal coal and silica. This mixture is heated until phosphorus reaches its volatilisation temperature and turns into a gas. Volatilised phosphorus is then recovered as a highly flammable white/yellow solid. Elemental phosphorus in this form needs to be stored carefully due to its low ignition point.

By controlling the overall reaction temperature, or calcining phosphate rock, impurities with a lower volatilisation point than phosphorus – notably arsenic – can be removed relatively easily. Elemental phosphorus is then either converted into different allotropes (e.g., red phosphorus) or used in downstream chemicals production.

The thermal route, while significantly more costly than the wet route, has the distinct advantage of being a much simpler and easily replicable way of obtaining high-purity phosphoric acid. Simply reacting elemental phosphorus with water will yield phosphoric acid of naturally high purity. This avoids the need for licensed and patent-protected purification steps associated with the wet process route, as discussed above.

Clearly, the different classifications for industrial and food phosphates – whether based on end-use, process or chemical composition – are interlinked and overlap. Certain phosphate compounds can be produced via the wet or thermal process routes and sold in more than one market segment.

Rather than getting bogged down in the minutiae of classification, this article instead focusses on three key market topics: product certification, the switchover from the thermal to the wet process route, and demand trends for food-grade and industrial-grade phosphates.

Product certification

End users will generally demand certification as a guarantee of product quality and purity. This is a highly important consideration in the industrial and food phosphates market. It is also a determinant of the industry's structure – as, implicitly, certification carries high costs which can act to exclude new players wishing to enter the market. Trading blocs and individual nations, and even regional administrations within countries, can impose their own quality requirements and checks with different degrees of stringency. To access these markets, at least one participant (often the industrial and food phosphate producer, but possibly importers and distributors too) needs to prove that defined standards are being met – an exercise which requires dedication and commitment to passing testing and quality inspections.

While these impositions and their costs can be worthwhile when gaining access to larger markets, they can be too burdensome for smaller players accessing smaller markets – irrespective of whether their food and industrial phosphate products meet the required specifications or not. In effect, certification requirements, by reducing competition, offer large-scale chemical distributors significant advantages, particularly at times of oversupply. This can provide the big, established producers with a strong, almost unopposed position in key markets. New producers, in contrast, are likely to struggle to find market opportunities, unless distributors need to replace one of their suppliers and can assist in obtaining the required certifications.

Similar barriers to entry apply to so-called 'formulation producers' – companies which sell tailored blends of ingredients that include phosphate salts to specific customers. This generally favours stable, long-term relationships with proven 'legacy' suppliers, as the risks involved in switching to a new supplier need to be carefully judged.

The switchover to the wet process route

Despite the barriers faced by new entrants, market change is happening. This is shown by the shift from the thermal process route to the wet route, a trend that is particularly evident in mainland China. The Chinese market has long been notable for the presence of numerous phosphorus furnaces and standalone thermal acid producers. Nevertheless, the market has changed considerably since the mid-2010s, a period which saw major Chinese phosphate players switch to the wet process. GPC (formerly Wengfu), for example, was able to successfully replicate and install Bateman's purification technology, while YTH formed a partnership with Israel's ICL. Hubei Xingfa, although originally focussed on the thermal route, has also diversified its product offering.

These ground-breaking developments have allowed China's domestic phosphate industry to access integrated purification technology – overcoming licensing issues and paving the way for widespread installation. GPC, for example, has installed purification lines at all its phosphate units. This has enabled the company to easily displace sales of higher-cost thermal phosphoric acid and emerge as a true market leader in an already oversupplied market.

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Market trends

This leads on to the major high-level trends affecting the demand for food and industrial phosphates. As explained, the increased availability of purified phosphoric acid via the wet route is already weighing on the thermal phosphorus industry. Market sentiment is even more bearish given the continuing downwards trend in the pesticides market, a key industrial end use. In this market segment, the combination of improved formulations, precision application methods and stricter regulations are significantly reducing the general demand for organophosphates.

The mood in the food-grade phosphate industry, in contrast, has been much more positive and – to date – has more than compensated for the simultaneous reduction in pesticides sector demand. Indeed, food-grade salts used to extend the shelf life of dairy and meat products are enjoying particularly strong momentum due to their direct and positive impacts on food storage and availability.

Process routes and process flexibility also play a significant role in the diverging fortunes of these two end-markets. While the production of organophosphates requires elemental phosphorus generated by the thermal route, the production of food phosphates can in most cases switch between thermal and wet phosphoric acid processes.

Clearly, the thermal route continues to face ever-growing challenges, even at a time when overall global demand for industrial and food phosphates is growing firmly. For phosphorus – in keeping with its nickname the 'devil's element' – the devil is truly in the detail.

The industry's future

While the three preceding sections have covered key factors governing the industry today, two additional topics – carbon emissions and lithium batteries – are likely to shape the industry in future.

Attentive readers will have noticed the four-letter word 'coal' in our description of the thermal route. That's because elemental phosphorus manufacture currently consumes this solid fossil fuel as a reducing agent. The resulting high carbon footprint leaves the thermal route particularly exposed to emissions tariffs and similar policies such as carbon taxes.

The decarbonisation of phosphorus production is, surprsingly, a rarely discussed theme, given that the steel industry has already made significant progress in the use of hydrogen as a reducing agent. The author would therefore like to encourage a broader debate about how to make phosphorus more environmentally friendly. After all, if 'green steel' is a possibility then 'green phosphorus' should surely become a viable future option too.

A more widely discussed and less niche topic is the batteries market. The electrification of the world's vehicle fleet is without question a global trend. It is even taking place in countries (e.g. mainland China and, to an extent, the United States) where transport emissions are not being prioritised as much as the carbon reduction targets being set for electricity and heat generation.

> **As much as the phosphate world may want to get involved in the LFP 'revolution', there is an argument that LFP will largely remain a lithium success story.**

Electric vehicles require a battery to work. In turn, a battery needs an anode, a cathode, and an electrolyte to function. Fortunately, our friend phosphorus has a role to play in all three of these components. For example:

- Black and red phosphorus are being actively studied as a potential basis for anodes
- Lithium hexafluorophosphate is already a commercially available electrolyte
- Crucially, lithium iron phosphate (LFP) has become one of the hottest talking points in the cathode world – ever since Tesla announced it will use it as the option of choice in its Shanghai mega-factory.

LFP is not a new material. It has been produced for decades and is commonly found in batteries for portable electronic devices such as smartphones and tablets. LFP-based batteries, while offering somewhat lower performance compared to nickel-manganese-cobalt (NMC) batteries – in terms of charge duration and total battery life – are considerably cheaper to produce, and therefore find a natural market in lower-value products.

Why then the excitement about LFPs for higher-value markets such as electric vehicles? The answer is 'scalability'. The overall size of the world's car fleet is of such magnitude that the total demand volumes for battery raw materials will increase significantly, even assuming cautious electric vehicle penetration rates.

When it comes to scalability and supply security, cobalt required in NMC batteries has come under particular scrutiny, due to the concentration of mining in the Democratic Republic of the Congo and the consequent risk of supply interruptions. In contrast, phosphorus resources are comparatively diversified and more widely available than cobalt, despite their concentration in a limited number of countries such as Morocco and China.

Growing excitement about the LFP market and its potential is such that its difficult to find a phosphate player that does not mention LFP batteries in its long-term strategic plans. From established producers to junior projects, it seems that everyone wants to ride the LFP wave. Fertecon does, however, issue a 'health warning' for LFP on both the demand and supply side.

Yes, LFP demand is set to increase at a faster rate than many other industrial end-uses for phosphates. Yet capacity developments are already outpacing our demand projections. Between 2020 and 2025, capacity for LFP in mainland China alone is expected to grow more than ten-fold to 4.5 million t/a. That far exceeds what is arguably an optimistic demand expectation of less than two million t/a by 2025. Elsewhere, increasing concerns over the supply security of critical raw materials has led to further capacity additions being actively discussed in regions such as Europe and North America.

On the supply side, our advice is not to put too much emphasis on the phosphorus component of LFP. One tonne of LFP consists of about 0.05 tonnes of Li, 0.35 tonnes of Fe and 0.20 tonnes of P. While there is four times more P present in LFP than Li in volume terms, it is actually their relative price that largely determines the economic dividend. Elemental phosphorus is rarely priced above $3,000/t, for example, while one single tonne of lithium carbonate (containing 18% Li) was recently traded on the Chinese market at above $75,000/t.

Therefore, as much as the phosphate world may want to get involved in the LFP 'revolution', there is an argument that LFP will largely remain a lithium success story. Concentrating on more conventional industrial-grade and food-grade phosphate markets, while perhaps not as exciting, is likely to be a safer bet in our view. ■

Happy 70th Birthday ERCOSPLAN!

PHOTO: ERCOSPLAN

The ERCOSPLAN Group of Companies held an international potash symposium on 6-8 October 2022 at the Messe Erfurt Congress Centre in Erfurt, the capital of the German state of Thuringia. The overall theme of this year's event was: the exploration, extraction and processing of mineral salts – as well as the creation and use of underground cavities in the saline host rock.

ERCOSPLAN's renowned potash mining and technology events, being held every five years, have become an industry tradition. This year's symposium marked two celebrations – ERCOSPLAN's 70th anniversary as an Erfurt-based business and its 30th anniversary as a worldwide potash engineering company.

Sustainable and socially responsible

This year's event provided a platform for promoting economically and ecologically sustainable potash fertilizer production. It also explored how underground cavities in saline host rocks at potash mines could be created and used for purposes such as backfilling, hazardous waste storage and as potential radioactive waste repositories.

The symposium generated an enthusiastic national and international response. Participants agreed about the importance of having a practical, sustainable and socially responsible potash mining industry globally – one that strikes the right balance between economics and ecology.

More than 250 delegates from 21 countries and six continents attended this year's event in Erfurt. These included engineering professionals and high-level delegates from the mining and fertilizer industry, environmental authorities, as well as private and institutional investors.

There was regret that so few Russian and Belarusian potash industry delegates were able to attend this year. However, the reasons for this are even more regrettable – the war in the Ukraine and the inevitable sanctions against both countries.

Much more positively, the symposium was again held with the full support and endorsement of **Bodo Ramelow**, Thuringia's prime minister. The promotion of the potash industry in his state and throughout Germany – and the safeguarding of jobs – remain matters close to his heart. This was something he reiterated in his plenary message to delegates (see photo above).

A full conference programme

The symposium included:

- A packed programme of 35 presentations in three plenary and six parallel sessions
- An exhibition with more than 30 posters
- Two full-day excursions to the Werra and the South Harz potash districts.
- Presentations covered diverse topics such as geological deposits, mining and processing technology, environmental protection during potash production, and the decommissioning of mines and the restoration of natural habitats.

First plenary session

This session was devoted to potash mining in Thuringia and Germany. **Martin Ebeling** (pictured), manager of the Werra potash plant operated by K+S Minerals and

PHOTO: ERCOSPLAN

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PHOTO: ERCOSPLAN

Delegates visit the underground potash mine in Sondershausen.

Agriculture GmbH, opened the session. This plant is responsible for more than 40 percent of the final products manufactured by K+S Group.

Martin outlined the future of Werra's production all the way through to the year 2060, when – from today's perspective – its potash deposits will be exhausted. Numerous technical challenges will have to be mastered in the coming decades, in his view. The secondary mining of the most valuable parts of the deposit, for example, has already begun and will need to be continued. The use of fossil fuels in potash fertilizer production will also need to phased out by 2045. This transition which will require further reductions in energy consumption, expansion in the use of renewables, waste heat utilisation and the adoption of green hydrogen. Looking ahead, water protection, land use and – for at least the next two decades – fossil fuel use will all contribute significantly to the future costs of the Werra Plant.

DEUSA International GmbH operates a potash solution mine and processing plant in Bleicherode, Thuringia. This extracts and processes carnallitite via hot leaching. CEO **Peter Davids** reported on the company's progress in becoming a climate neutral and sustainable mining operation. Nevertheless, the solution mining of carnallitite and the use of thermal processes to recover technical brines still poses challenges, he explained, due to current high gas prices.

Positive potash exploration results obtained by South Harz Potash Limited in 2022 were presented by **Ian Farmer**, the company's acting executive chairman. He went on to explain the prospects for the resumption of potash production in the South Harz potash district of northern Thuringia.

Second plenary session

The second plenary session investigated the global availability of raw materials in the new geopolitical environment brought about by the Russia-Ukraine conflict. This highlighted the need for a renaissance in the production and supply of raw materials within Europe, and also examined the existing legal hurdles in both the European Union and in Germany that are preventing this currently.

There is an indispensable need for a secure and sustainable supply of mineral raw materials and energy, said **Volker Steinbach**, vice president of the Bundesanstalt für Geowissenschaften und Rohstoffe im GEOZENTRUM HANNOVER. In the current market situation, this was vital for securing the future of Germany as a business location, explained Volker, as high (as well as volatile) raw material prices and supply bottlenecks are currently a burden on German companies. In the future, restoring German and European value chains will be necessary to successfully transform the market, he suggested, a process that has already begun. This transformation will require the strengthening of domestic mining and metallurgy sites, the diversification of raw materials supply, and participation in international mining projects. This will be the only way to ensure that sustainable extraction, processing and ultimately recycling of raw materials are possible, Volker concluded.

The presentation by **Lutz Katschmann**, head of the geology and mining department at the Thüringer Landesamtes für Umwelt, Bergbau und Naturschutz, explained the complexities of current and future raw material extraction in Thuringia.

Fritz von Hammerstein, partner and lawyer at CMS Hasche Sigle, spoke about current mining laws and planning procedures. He then presented proposals for accelerating the approvals process. These should be highly pragmatic and reduce the documentation required by the regulatory authorities. Any workable remedies, suggested Fritz, would also need to apply to both European and national legislation.


PHOTO: ERCOSPLAN

The managing directors of ERCOSPLAN – Henry Rauche (left) and Thomas Kiessling (right).

Six parallel sessions

The six parallel sessions covered current potash projects and innovative potash methods, processes and systems. The sessions covered:

- Conventional and solution mining, the processing of potash ores and product beneficiation
- Underground storage of industrial and hazardous waste and potential nuclear waste repositories, as well as special mining projects in saline host rocks
- The closure and safeguarding of potash and rock salt mines and the restoration of natural habitats at former production sites
- Environmental protection and sustainability in potash fertilizer production

These discussions were organised to reflect ERCOSPLAN's main business activities. From a fertilizer industry point of view, the following highlights are of interest:

Jochen Greinacher, the CEO of Redpath Deilmann GmbH, presented new information on innovations in mechanical and conventional shaft sinking, He illustrated this using the example of the shaft sinking for the greenfield Slavkali project which was completed last year in Nezhinsk in Belarus. The construction of two eight metre wide and 700 and 750 metre deep shafts was completed in just 29 months from the start of site set-up. Following the very successful use of shaft boring roadheader (SBR) machines in this project, Redpath Deilmann and Herrenknecht AG decided to develop a similar SBR for harder rock formations with strengths between 100-250 MPa. The prototype will be available in 2023.

Matt Simpson, the CEO of Brazil Potash Corp, provided an update on the company's Autazes potash project located in Brazil's Amazon region. This greenfield project combines strong competitive advantages with high sustainability objectives. Matt highlighted the importance of domestic Brazil potash for overall global food security, given the world's reliance on Brazil as a production powerhouse for agricultural commodities and foodstuffs.

The presentation by **Achim Strauss** and **Stéphane Rigny**, the CEO and executive chairman, respectively, of Kanga Potash, covered the latest developments at the Kanga carnallite solution mining project in the Republic of Congo. They emphasised the importance of site selection for determining project economics.

Jens Hanisch, a consultant at FAM/BEUMER Group, and **Kai Ulrich**, the technical manager of the Moscow office of FAMAKO Anlagenexport GmbH, shared their experience of using wet hammer mills for crushing crude salt. They reported on the potential efficiency improvements delivered by this new mechanical development.

Case studies on the optimisation of evaporation and crystallisation plants were presented by **Sebastian Ebner**, project engineer at Ebner GmbH & Co KG. These were illustrated by recently implemented projects and those currently planned by the company.

Fabian Horbert introduced delegates to Köppern's GranuGrinder machine. Fabian, the head of the engineering department at Köppern Aufbereitungstechnik GmbH & Co KG, highlighted how improving the design of established grinding technology can help conquer new applications.

Suitable processing methods for the poly-mineral potash deposits found in Ukraine's sub-Carpathian region were described by **Ivan Kostiv**, a mineral salts specialist at the country's State Scientific Research and Project Planning Institute for Basic Chemistry (NIOCHEM).

Dennis Heiss, sales director, potash, salt & building materials, Rhewum GmbH, analysed global potash demand growth. He explained how – from the point of view of a plant manufacturer – the optimisation of the screening and sorting process steps can improve potash production efficiency and therefore help to avert imminent food crises by improving fertilizer supply.

Final plenary

The final plenary session was concluded by ERCOSPLAN's **Thomas Kiessling** and **Henry Rauche**. Their presentation offered an outlook on potash engineering 'Made in Erfurt' and its future prospects.

The 2022 international potash symposium was a well-attended and thoroughly successful event. ERCOSPLAN received very positive feedback from delegates and is looking look forward to organising the next 75th/35th anniversary event. Please save a date in your diary for 2027!

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Potash project listing 2022

Fertilizer International presents a global round-up of current potash projects.

Plant/project	Type	Company	EPC/EPCM contractor(s)	Equipment/technology	Location	Product	Capacity '000 t	Status	Start-up date
AUSTRALIA									
Beyondie	G, LBE	Kalium Lakes	DRA Global	Ebner/K-UTEC/Köppern	Western Australia	SOP	90	C	2022
Lake Wells	G, LBE	Australian Potash			Western Australia	SOP	170	FS	2023/24
Lake Mackay	G, LBE	Agrimin			Western Australia	SOP	450	FS	N/A
Lake Way	G, LBE	Salt Lakes Potash			Western Australia	SOP	245	FS, P	In receivership
BELARUS									
Petrikov	G, CM	Belaruskali			Gomel	MOP	1,500	UC	2021
Nezhinsky GOK	G, CM	Slavkaliy	China State Engineering Corp/ Deilmann-Haniel	Herrenknecht SBR system	Lyuban	MOP	2,000	UC	2024
Soligorsk II+III	B, CM	Belaruskali			Soligorsk	MOP	1,000	UC	2021
BRAZIL									
Autazes		Brazil Potash	CITIC Construction			MOP	2,400	FS	N/A
Cerrado Verde	G, CM	Verde AgriTech			Minas Gerais	SG	2,400	UC	2022
CANADA									
Jansen	G, CM	BHP	DMC Mining	Herrenknecht SBR system	Saskatchewan	MOP	4,350	UC	2027
Esterhazy K3	B, CM	Mosaic	Hatch/AMC	DCM Group	Saskatchewan	MOP	1,800	UC	2024
Bethune	G*, SM	K+S Canada			Saskatchewan	MOP	200	UC	2022
Bethune	G*, SM	K+S Canada			Saskatchewan	MOP	400	UC	2022/26
Milestone	G, SM	Western Potash	Artisan Consulting/AKITA Drilling		Saskatchewan	MOP	146	UC	2023
Tugaske	G, SM	Gensource/Helm	Kamalyte Resources/GSFC		Saskatchewan	MOP	250	FS, P	N/A
Wynyard	G, SM	Amec FW (Wood)			Saskatchewan	MOP	625	FS, P	N/A
CHINA									
Ge'ermu	G, LBE	Zangge Potash			Golmud, Qinghai Province	MOP	200	UC	2022
Eritrea									
Colluli	G, CM	Colluli Mining Share Company (CMSC)	DRA Global		Danakil Depression	SOP	472	FS, P	N/A
ETHIOPIA									
Dallol	G, SM	Liberty Metals & Mining/ XLR Capital	SNC-Lavalin		Afar	SOP	600	FS, P	On hold
Danakil Potash	G, SM	Circum Minerals			Danakil	MOP/SOP	2,000/750	FS, P	On hold
ISRAEL									
Dead Sea Works	B, LBE	ICL			Dead Sea	MOP	200	UC	2022
JORDAN									
Safi	B, LBE	Arab Potash Co			Dead Sea	MOP	200	UC	2022
LAOS									
Ganmeng	G, CM	Lao Kaiyaun			Ganmeng	MOP	500	UC	2023
Ganmeng	G, CM	Sino-Agri			Ganmeng	MOP	800	C	2021
MOROCCO									
Khemisset	G, CM	Emmerson			Khemisset	MOP	810	FS	N/A
PERU									
SalSud	G, LBE	Salmuras Sudamericanas			Sechura desert	SOP	100	P	On hold
RUSSIA									
Solikamsk III	B, CM	Uralkali			Perm	MOP	500	UC	2022
Ust Yayvinsky	G, CM	Uralkali			Perm	MOP	2,000	UC	2023
Solikamsk II	B, CM	Uralkali			Perm	MOP	900	UC	2024
Talitsky	G, CM	Acron (Verkhnekamsk Potash Company)			Perm	MOP	2,000	UC	2025
Usolskiy II	G*, CM	Eurochem			Perm	MOP	1,500	UC	2026
SPAIN									
Muga	G, CM	Highfield Resources			Navarra & Aragón	MOP	500	FS, P	2024
UK									
Woodmsith Mine	G, CM	Anglo American	DMC Mining/STRABAG AG/ Worley	Herrenknecht SBR system	North Yorkshire	Polyhalite	10,000	UC	Under review
USA									
Sevier Playa	G, LBE	Peak Minerals (EMR Capital)			Utah	SOP	215	FS, P	N/A

NOTES:
- Greenfield projects (G): generally, these must have reached the detailed/bankable feasibility study (FS) stage for inclusion.
- Brownfield expansions (B): capacity indicates incremental additions, not total capacity.

PROJECT TYPE:
G Greenfield
G* Greenfield ramp-up/expansion
B Brownfield expansion
CM Conventional mine
SM Solution mine
LBE Lake brine extraction

PRODUCT:
MOP Muriate of potash, KCl
SOP Sulphate of potash, K_2SO_4
SG Super Greensand, glauconite

START-UP DATE:
N/A Not available or provided

PROJECT STAGE:
FS Feasibility study
P Permitted
UC Under construction
C Completed/commissioned

PEAK MINERALS

Sevier Playa SOP project, Millard County, Utah

Peak Minerals Inc. (Peak) is developing the Sevier Playa sulphate of potash (SOP) project in Millard County, Utah.

The 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. Peak's two-phase, 25-year mine plan for Sevier Playa will utilise just 53 percent of the underlying recoverable indicated SOP resources.

Sevier Playa is the only fully permitted, brine-sourced SOP project under development in North America. The project is well positioned to become the region's lowest cost SOP producer – with a position in the bottom of the second quartile of the global industry's cost curve. Its Utah location is also well situated to serve the large domestic US market as well as growing markets in Mexico and South America, according to Peak.

Private equity firm EMR Capital acquired 100 percent ownership of Sevier Playa in October 2020, having been an investor since 2015. More than $100m has already been invested in this 'shovel ready' project over the past decade.

Sevier Playa will use a proven, brine-based solar evaporation method. This offers cost advantages over other SOP production methods, such as those based on the secondary Mannheim process, suggests Peak. Extracting SOP using solar energy also helps to minimise the project's environmental footprint while at the same time producing a natural, organic-certified product.

Sevier Playa has probable SOP reserves of 3.4 million tons and in-situ measured and indicated resources of more than 38 million tons. The plan is to extract economically valuable brines from the playa via trenches. These provide uniform grades and flow rates and are more efficient than wells – although well extraction could provide an opportunity to extract brine from deeper layers of the playa in the future.

The extracted brine will be fed via a network of canals to pre-concentration ponds where halite is precipitated. The pre-concentrated brine will then be channelled to production ponds where valuable solid mineral salts are precipitated. These salts will be transported to the nearby processing plant by truck.

PHOTO: PEAK MINERALS

Trenching machine, Sevier Playa, Millard County, Utah.

Table 1: **Sevier Playa project economics: September 2022 feasibility study update**

	Phase 1	Phase 1 + 2
Capex	$345m[1]	$672m[1]
Nameplate production capacity	215,000 t/a	474,000 t/a
Initial life of mine (LOM)	25 years	25 years
LOM average all-in operating costs[2]	$256/ton	$303/ton
Run-rate EBITDA[3]	$121m	$234m
Post-tax net present value (NPV, 8%)	$361m	$642m

Notes:
1. *Includes SOP Capex only.*
2. *Includes $MgCl_2$ by-product credits, assuming a market price of $72/t for liquid and $408/t for solid, less assumed selling costs of 10%.*
3. *Assumes a LOM average granular SOP price (2022 real terms) of $803/t (Phase 1 only) and $808/t (Phase 1+2).*

Source: Peak Minerals

At the processing facility, the solid minerals will be crushed, turned into a slurry and pumped through a flotation circuit. This simple process circuit purifies the SOP product and crystalises it into its final form while rejecting waste materials.

Peak identified the following opportunities to optimise the project during its recent feasibility study update (Table 1):

- **Phased development reduces project risk.** The 215,000 t/a capacity Phase 1 production focuses on the southern playa, later expanding to 474,000 t/a capacity in Phase 2 which includes northern playa. This phased approach reduces operational risks and improves project flexibility.
- **Capex optimisation.** This includes measures to optimise trench profiles, on-playa brine infrastructure, production pond placement and powerline routing. It also reduces evaporation pond sizes, and recommends the outsourcing of harvesting/hauling and using a third-party built and owned rail transload facility. The cost estimate for the Rocky Mountain Power interconnection has also been updated.
- **Process improvements.** Adopting a back-mix process would maximise reacted MOP production and sulphate

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recovery while lowering costs. There is also potential to optimise the leach unit operation. The use of wet harvesting also lowers costs, improves recovery, and removes the need for costly and logistically challenging berm raises.

The Phase 1 mine plan for Sevier Playa concentrates on the southern part of the playa only and captures around 27 percent of the total recoverable resource. Peak is targeting a production start date of 2027 for this initial phase.

Next steps for the Sevier Playa project include completion of front-end engineering and design (FEED), securing project funding and awarding the contract for the playa/ponds. Funding arrangements have already commenced to raise around $25 million in new funding to complete the FEED and support the construction financing process in 2023. The pursuit of an additional financing partner is also underway. A project finance adviser, meanwhile, has been appointed to examine debt funding alternatives.

Peak Minerals is aiming to finalise all studies, FEED and project financing within the next 12 months – so it is in a position to commence construction towards the end of next year. ■

EBNER

Ebner: evaporation and crystallisation specialist

Germany's Ebner GmbH & Co KG is a family-owned specialist designer and manufacturer of evaporation and crystallisation plants. The company develops tailor-made plants completely in-house, from the customer's first enquiry to final delivery, having expertise that encompasses plant design, fabrication, erection, and start-up.

Ebner is an established global player. To date, the company has successfully constructed 600 new evaporation and crystallisation plants and optimised more than 200 other plants worldwide.

The company has extensive experience in the design and manufacture of evaporators and crystallisers for the potash industry. These are suitable for a range of fertilizer salts including potassium chloride (KCl), widely known as MOP (muriate of potash), and potassium sulphate (K_2SO_4) referred to in the industry as SOP (sulphate of potash). The plant production capacities for these salts can vary from a few kg/h to more than 200,000 kg/h.

In addition to offering basic engineering services, Ebner says it is the only worldwide plant manufacturer with in-house capabilities for the following spectrum of project activities:

- Different process route studies
- Experimental trials to validate test data using remote pilot plants or mobile pilot plants located on-site
- Final plant design and selection of suitable subcontractors
- Static and strength computations for components
- Complete engineering for measurement and control technology
- 3D planning of the entire plant with consideration of assembly/maintenance concepts
- Fabrication of apparatus and piping in its own in-house workshop
- Assembly of the complete plant as a turnkey project, if requested
- Commissioning of the plant including performance testing
- After-sales services such as annual optimisation via a remote connection to the customer's programmable logic controller (PLC)

Ebner designed, manufactured and erected this evaporation and crystallisation plant for K+S.

In offering these services, Ebner can draw on decades of experience and data collection. The company also benefits from experienced and flexible personnel with efficient plant handling expertise. These staff can also advise customers on change-management, if necessary. Ebner has more than 100 employees – many of whom have been with the company for decades.

These strengths enabled Ebner to deliver Belaruskali's last large-scale MOP plant with a production capacity of 190 t/h. This successfully entered full operation after only five days of commissioning.

This is just one of numerous plants Ebner has executed for many leading potash producers such as K+S Mineral and Agriculture GmbH. The company was involved in one of K+S's largest single investments in Europe. Ebner designed, supplied and installed for K+S a 180 t/h capacity evaporation plant that crystallises several individual salts.

Ebner is currently preparing a major 30 t/h capacity MOP project in Saskatchewan, Canada. Project engineering has already been completed with Ebner selected as the plant equipment supplier. This plant will operate with a new type of solution mining process and, unusually, the entire complex will operate without above ground evaporation ponds and salt tailings.

Ebner, as well as installing new plants, also undertakes plant conversions and retrofits. There is increasing demand for projects which upgrade and replace process technology and reduce energy consumption. This trend is linked to rising energy costs and, consequently, retrofitting is proving to be an increasingly important part of Ebner's work portfolio. ■

KALIUM LAKES

Beyondie SOP project, Pilbara, Western Australia

Kalium Lakes Limited (KLL) confirmed that the Beyondie project produced its first batch of SOP in early October 2021 during commissioning. This makes KLL Australia's first SOP producer, the company said in an Australian stock exchange (ASX) release. The company later passed another critical milestone in 2022 with its first commercial sale of SOP in July.

The 90,000-tonne capacity SOP project is located in the remote Pilbara region of Western Australia, about 1,400 kilometres north of Perth. The project includes the construction of trenches, pumping stations, ponds, a processing plant, gas power station, airstrip, access road and an 80-kilometre gas pipeline.

The SOP product obtained will be trucked by road from Beyondie to Perth. On arrival, it will either be collected by local domestic customers, or shipped by sea to the east coast of Australia and New Zealand. The company plans to ship excess product to South East Asian markets.

The AUD 280 million project reached financial close at the end of 2019. Project financing included:

- AUD 102 million of senior debt funding from KfW IPEX-Bank, with approximately half of this amount supported by a guarantee from Euler Hermes, the German government's export credit agency
- AUD 74 million loan package from the Northern Australia Infrastructure Facility (NAIF).

The company subsequently raised an additional AUD 50 million in capital at the end of 2021 to expand Beyondie's production output to 120,000 t/a.

KLL has a 10-year take-or-pay offtake agreement with German potash producer K+S for 120,000 t/a of the project's production volume. This will allow K+S – already the world's largest SOP producer outside China – to deliver SOP from Beyondie to supply its existing market share in Australia, New Zealand and South East Asia.

Production expertise, equipment and technology for the project is being provided by Germany's Ebner, K-UTEC and Köppern (*Fertilizer International* 501, p52).

The project has experienced commissioning and start-up delays in the last 12 months. The SOP purification plant was idled at the start of 2022, pending the harvesting of more high-grade potassium salts from evaporation ponds and to allow plant rectification work to take place. Commissioning of the purification plant subsequently resumed in mid-April.

The SOP plant was due to fully re-start in June 2022, following validation of the process design, with commercial SOP sales being targeted from July onwards.

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Construction at the Beyondie SOP project in Pilbara, Western Australia, early 2021.

Kalium reported that around 1,000 tonnes of commercially saleable SOP had been produced by the end of June. The inaugural commercial SOP sale to Western Australian fertilizer manufacturer and distributor CSBP Fertilisers was subsequently made on 31st July, under its offtake agreement with K+S.

Commenting on this, Len Jubber, Kalium's CEO, said: "A critical milestone came with the first commercial sale of SOP in July 2022. This heralded the start of the era of domestic SOP production in Australia for distribution to the Australian and international agricultural markets."

The purification plant was shutdown again in August, to allow further equipment testing, but resumed operations in mid-September. Following these commissioning delays, Kalium successfully raised AUD 34 million to provide additional working capital and for debt restructuring.

Kalium Lakes now expects the Beyondie project to be operating at an SOP production capacity of around 80,000 t/a by the first-quarter of 2023, with this ramping up to a production target of 120,000 t/a by the third-quarter of 2024. ■

KÖPPERN

Köppern: the compaction-granulation experts

Köppern, a family-run business founded in Hattingen, Germany, has been manufacturing briquetting, compaction and comminution machinery since 1898. The company has been supplying compaction and granulation equipment and plants to the fertilizer industry for more than 70 years. Its sales include several hundred roller presses in over 60 countries.

Granular potash is produced almost exclusively by a compaction-granulation process. Fine-grained potash feed is generally compacted on roller presses to produce flakes with a density close to that (>95%) of natural potash. These flakes are then crushed and screened to produce a closely-sized (often 2-4 mm) granular product.

> **"Granular potash is produced almost exclusively by a compaction-granulation process."**

PHOTO: KÖPPERN

Köppern roller press.

Three key components

A typical compaction-granulation plant for MOP (muriate of potash) consists of three key components – roller presses (compactors), crushers and screens – configured in closed-circuit. The feed is firstly compacted at an elevated temperature. Köppern typically installs compactors with a 1,150 mm diameter and 1,000 mm working width. Multiple compactors are often installed within one potash plant. These presses have a maximum flake throughput of approximately 140 t/h and a gross granular potash capacity of 40-50 t/h. After compaction, impact and roller mills, working in a closed-loop cycle with multi-deck screens, crush the flakes into granulate with an approximate density of 1.9-1.95 g/cm^3.

Since the 1990s, the preferred flake capacity of potash compactors has increased to 110-130 t/h. The majority of new compactor investments made by potash producers in recent years have been in designs of at least 100 t/h flake.

Design innovation

Köppern has introduced a number of innovations and design changes to ensure compactors of this size are safe, reliable to operate and deliver excellent flake quality. This has involved the modification of various sub-assemblies, including the frame, feeder, roll design, roll drive and the hydraulic systems.

Vibrations are a particular operational problem when de-aerating and compacting potash – as they can result in severe juddering that damages equipment. The risk of this can be reduced by lowering roll speed and/or feed rate. However, changing the compactor drive design to increase mechanical stiffness is a preferable way of solving this problem at source. This approach also maintains throughput, and is therefore less of a compromise for customers.

For many years, Köppern has stiffened the drive train of large roller presses by manufacturing these with planetary gear reducers mounted directly onto the roll shafts. The company delivered its first large potash compactor (130 t/h) with this drive technology to Germany in 1998. Since then, compactors with this drive design have been widely-adopted worldwide. For example, Köppern's fertilizer compaction customers in Brazil, Canada, China, Croatia. Hungary, Jordan, Italy, Russia, Serbia and Spain have either modified or ordered new roller presses fitted with this type of main drive.

All large potash compactors supplied by Köppern since the early 1990s have also been supplied with a hinged frame. This allows quick access to rollers for assembly or maintenance. Rollers can be picked up easily without dismantling any part of the frame or feeder.

The feeder is an important component of the compactor. It needs to transport large volumes of material, de-aerate this effectively and distribute it evenly over the entire working width of the roller. The ability to independently adjust screw speeds also prevents misalignment by controlling the gap between rollers. Meeting these requirements prompted Köppern to develop a special double-screw feeder design. This design was first introduced into the potash industry in the mid-1990s in roller press upgrades in Germany and Belarus. The newly developed double-screw feeder was subsequently supplied to K+S in Germany and further clients in Canada, Chile and Belarus.

It is also economically advantageous to provide the roller body with exchangeable tyres, as this allows refurbishment of the tyre profile after wear.

Most of the above improvements and new design features, developed by Köppern over the years, can be found in many compactors used today by the global potash industry. ■

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