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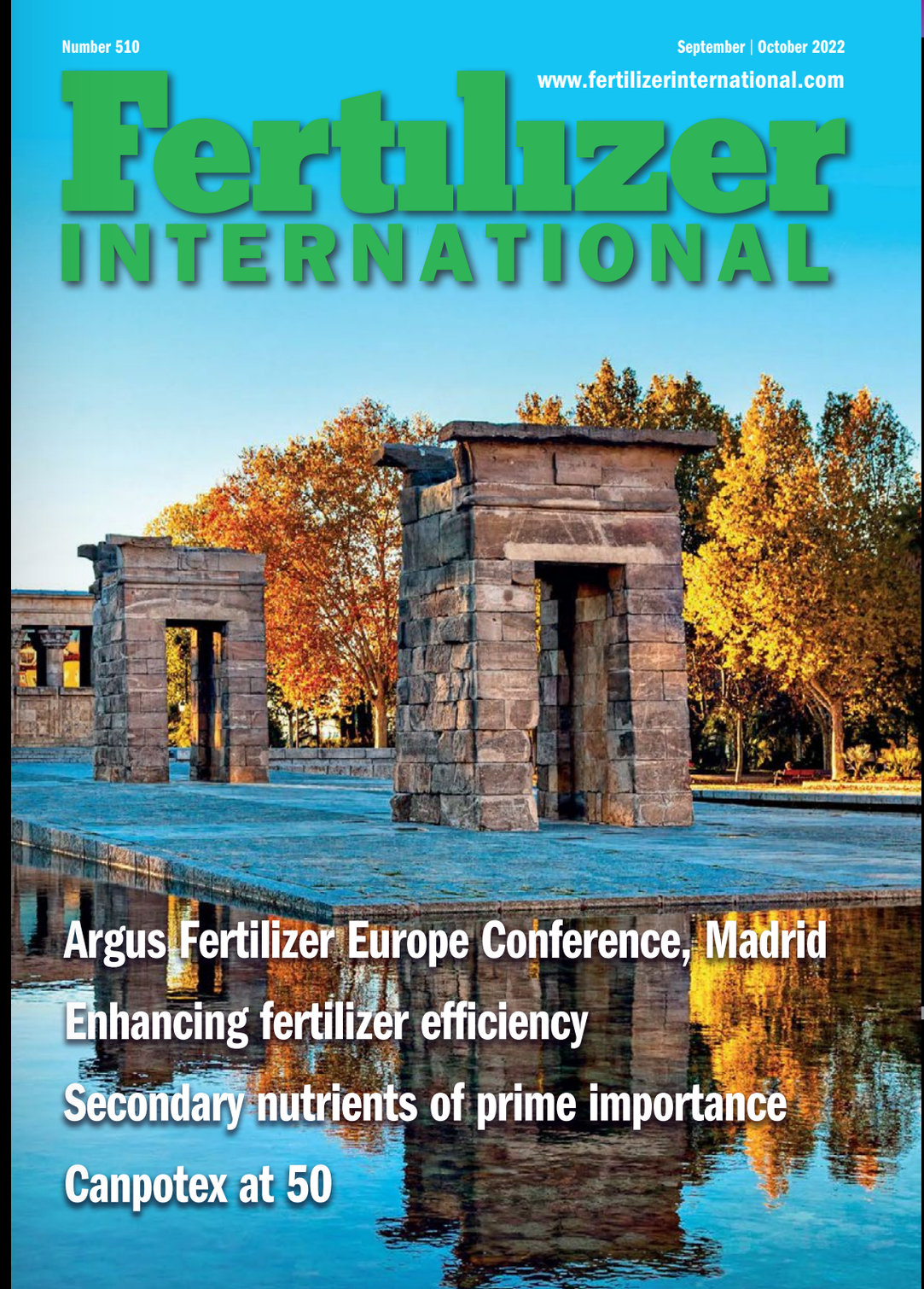

Argus Fertilizer Europe Conference, Madrid

Enhancing fertilizer efficiency

Secondary nutrients of prime importance

Canpotex at 50

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17

Balanced crop nutrition

28

Canpotex at 50

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NUMBER 510 SEPTEMBER | OCTOBER 2022

CONTENTS

PHOSPHATES AND POTASH INSIGHT

REGULARS

FERTILIZER INTERNATIONAL
ISSUE 510
SEPTEMBER/OCTOBER 2022

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The Atlantic just widened

> **"Significant increases in fertilizer selling prices and increased international demand have seen substantial increases in North American producer earnings and cash flows."**

The high-price environment for fertilizers and other commodities, including natural gas, is having very different consequences globally.

Europe is on the front line when it comes to the fallout from the Russia-Ukraine conflict, particularly the Kremlin's use of its natural gas production might as a political and economic weapon.

The phrase 'winter is coming' is definitely concentrating minds on this side of the Atlantic. Ominously, as August ended, fertilizer producers across Europe responded to record gas costs by shutting down ammonia plants across the continent in preparation for months of potential gas scarcity.

At least fifty percent of the continent's ammonia production capacity had been shuttered by the end of August, a situation which CRU described as extraordinary.

Norway's Yara International, for example, curtailed annual production capacity across its European production sites by the equivalent of 3.1 million tonnes for ammonia and by 4.0 million tonnes for finished fertilizers. Production at BASF, Grupa Azoty, Fertiberia and many others has also been negatively affected (see p8).

Yet on the other side of the Atlantic, in the US and Canada, the state of the market looks distinctly different and much more positive. For a start, the region's fertilizer producers, being able to access vast domestic natural gas reserves, are more able to insulate themselves from Russia's hoarding of gas and so limit their feedstock costs.

Earlier this year, Moody's was expecting a substantial earnings and cash flow boost for North American fertilizer producers in 2022.

"Many North American commodity producers will benefit, particularly fertilizer companies, because their raw material and energy costs remain relatively low," Moody's forecast in March, adding: "We expect significant increases in fertilizer selling prices and increased international demand as a result of the dramatic reduction in Russian and Belarusian exports. This will substantially increase North American producers' earnings and cash flows."

This has turned out to be remarkably prophetic, as the publication of first-half results this August has revealed.

Canadian fertilizer giant Nutrien, for example, delivered record first-half earnings in 2022. These increased by a staggering $4.6 billion to $7.6 billion (adjusted EBITDA), a year-on-year rise of more than 150 percent. To put these figures in perspective, Nutrien's January-June 2022 earnings eclipsed its total earnings for the whole of 2021 ($7.1 billion).

What makes Nutrien's 2022 first-half earnings even more remarkable is the fact that last year's financial results were themselves unprecedented and record breaking, with 2021 annual earnings up by more than 90 percent on the previous year (*Fertilizer International* 508, p13).

Nutrien's exceptional financial health has allowed the company to accelerate a range of growth-boosting projects. The company also expects to return around six billion dollars to shareholders this year.

The performance of Florida-headquartered The Mosaic Company has been similarly robust. The world's leading combined potash and phosphate producer reported first-half 2022 earnings of more than $3.4 billion (adjusted EBITDA) in August, up from $1.4 billion in January-June 2021.

Leading North American nitrogen producer CF Industries, meanwhile, also delivered buoyant first-half earnings of $3.6 billion (adjusted EBITDA). CF's January-June results, similar to Nutrien, exceeded its total 2021 annual earnings of $2.7 billion.

What makes Illinois-headquartered CF Industries different, though, is that it bridges the Atlantic divide through its ownership of two British fertilizer production sites operated by subsidiary CF Fertilisers UK. The company announced plans to close one of these production sites – at Ince, Cheshire – in June (*Fertilizer International* 509, p8). The ammonia plant at its other UK site in Billingham, Teesside will also temporarily close this autumn after a doubling in gas costs made production uneconomic.

This gives the company a unique perspective. "We continue to believe it will take several years to replenish global grains stocks, underscoring the critical role CF Industries plays supplying nutrients to farmers around the world during a period when marginal producers in Europe and Asia face production curtailments due to historically high natural gas prices," CF's president and CEO, Tony Will, said in August.

What is clear is that, with ammonia production being taken offline in Europe, major producers on the other side of the Atlantic (and elsewhere) will need to redouble efforts to supply fertilizers to the world's farmers and secure the global harvest. Fortunately, they are in an exceptionally strong financial position to do so. ■

S. Inglethorpe

Simon Inglethorpe, Editor

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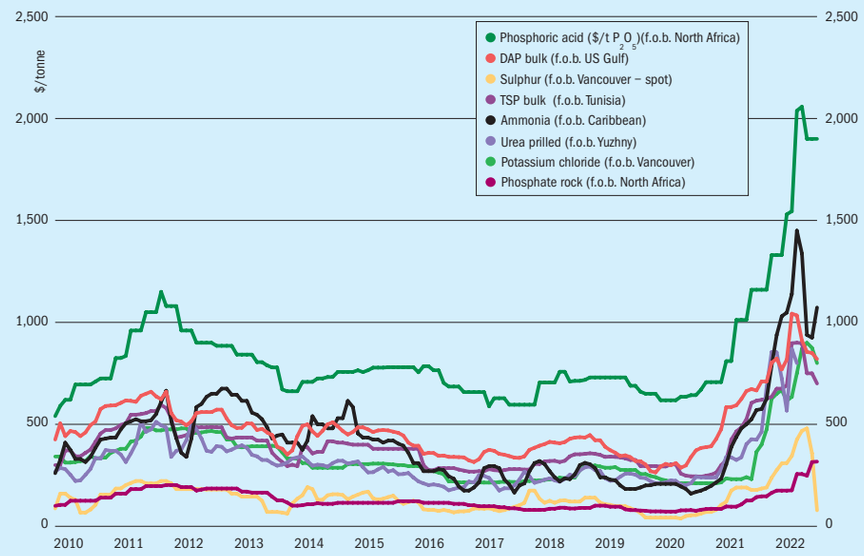
Market Insight

Historical price trends $/tonne



Source: BCInsight

Market Insight courtesy of Argus Media

PRICE TRENDS

Urea: Amid thin demand in key regions, most markets saw consecutive weekly price falls in mid-August. Middle East prices dropped sharply as producers cut prices to clear remaining August and early September cargoes – with three trades confirmed at $550-556/t f.o.b. Similar mid-August price levels were seen in southeast Asia with deals at $540-557/t f.o.b. Brunei and Indonesia.

Some pockets of activity bucked the softening trend. Prices for granular urea delivered to Myanmar, for example, rose by around $30/t, while Iran's f.o.b. prices – in a series of deals at $500/t f.o.b. – climbed by $20/t from last business. The market remains soft overall, however, with low demand in Europe, Brazil, the US and southeast Asia.

Key market drivers: Europe's natural gas crisis has seen feedstock costs for LNG-dependent nitrogen plants pushed to new highs in mid-August, prompting fresh speculation about more European plant shutdowns.

Ammonia: The recent narrow range of prices reflects a market where increasing global supply options are being counter-balanced by the European gas crisis. The greater supply options for September, by creating competition for sellers trying to place cargoes into Europe, are now putting a slight downward pressure on spot prices.

Where possible, European buyers are covering their positions far in advance, while other large buying-regions previously dependent on Black Sea exports appear to be covered with new supply contracts. There is a growing disconnect between Asian markets and those in the west, with buyers in the east looking to distance themselves from Europe's inflated pricing. Although supply is outstripping demand for now, baseline cost estimates for European production are currently above $2,500/t. Yet global supply options continue to provide cargoes at around half this cost. Therefore, at this cost level, it remains uncertain whether European producers can continue with their current production strategies into the four-quarter.

Key market drivers: OCP has bought its first cargoes from the 1,000 t/day Salalah ammonia plant, which will load its first commercial exports this month. OCP has bought 15,000 tonnes from Oman's OQ Trading for loading in late-August, with another 25,000 tonnes for September-loading on an f.o.b. basis. In Europe, the month-ahead Dutch TTF contract for gas recently closed at a new high of more than $70/mn Btu.

Phosphates: Globally, prices continued to edge downwards in mid-August, with both a seasonal and a price-related dearth of demand affecting sentiment in all markets. Buyers are either waiting for further price falls, not committing to quantities, or buying the bare minimum. India was the exception, although its DAP import prices still eroded. Several new DAP sales to India totalled 160,000 tonnes for August- and September-loading. Prices nevertheless softened to $880-895/t cfr, down $10/t at the low end. Further sales will be required ahead of peak rabi demand.

Market price summary $/tonne – End August 2022

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	1,050-1,095	560-600	f.o.b. E. Europe 260-350	f.o.b. US Gulf	803-834	-	-
f.o.b. Yuzhny	Port closed	Port closed	-	f.o.b. N. Africa	850-875	650-750	1,800-1,950
f.o.b. Middle East	915-1,030	570-680**	-	cfr India	890-920	-	1,715*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	715-800	-	cfr US Gulf	150-225	f.o.b. Vancouver	60-95	-
f.o.b. Middle East	750-850	-	-	-	f.o.b. Arab Gulf	70-100	-
f.o.b. Western Europe	-	1,000-1,168	-	-	cfr N. Africa	95-125	-
f.o.b. Baltic	750-830	-	-	-	cfr India	100-130+	-

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.*

Chinese DAP prices softened on a sale to the Philippines at $900/t cfr, eroding netbacks to $860-865/t f.o.b. – down from $865-900/t f.o.b. earlier in August. Brazil's MAP market has remained inactive, causing prices there to slide once again.

Key market drivers: Europe's natural-gas supply crunch is set to hit the ammonia supply chain. Sulphur prices, meanwhile, remained broadly stable after their drop of almost $300/t last month.

Potash: Bearish sentiment and weak demand in key markets continues to exert a downwards pressure on prices. Granular MOP markets are particularly weak, with prices in Brazil sliding further in mid-August to $850-900/t cfr, down from $880-920/t cfr earlier in the month. The granular MOP price in Thailand/Vietnam, meanwhile, dropped to $900-950/t cfr. Standard MOP prices in southeast Asia are also under pressure amid lacklustre demand. In contrast, a lack of Russian and Belarusian product in Europe is helping to support current price levels in the region.

Key market drivers: Negotiations for fourth-quarter sales to southeast Asia are likely to begin next month, and should provide more clarity on pricing in the region. Discussions with European buyers on fourth-quarter sales of standard MOP will also start in September. The presence of Belarusian product in southeast Asia is growing, with another cargo of Belarusian granular MOP reported to be arriving in Thailand in August/September.

NPKs: There was widespread quietness across the global market in mid-August. The few prices changes that did occur mostly moved in a downwards direction. In Africa, offers against Malawian tenders remain under evaluation. Participants are also awaiting news of awards following the Zambian government's request for more than 100,000 tonnes of 10-20-10+S.

Key market drivers: Gas prices in Europe have risen to fresh highs well above the previous peak in early March. The earlier spike was dramatic and followed by steep price decreases, whereas the current climb has been far more gradual. Although Thailand's high-season demand has picked up, floods in the country's north and limits on farmers' purchasing power have kept domestic fertilizer demand below that of previous years.

Sulphur: The sulphur market has begun to stabilise following the large descent in prices from the highs of June and July. The large price drop has sparked some buying interest, despite concerns over phosphate market demand, with large-scale buyers purchasing product at the new lower numbers. Speculative firmer price numbers were circulating in mid-August as a result of renewed confidence among smaller traders. There is some expectation of limited price firming, due to reduced supply from the FSU, and the gap between sulphur pricing and phosphate pricing. This has led some product holders to hold off from lower-priced sales for now. Certainly, buyer confidence is returning, although any bounce-back in prices may not be substantial or sustained if phosphate market weakness persists.

Key market drivers: Bids for the Qatar spot sales tender ranging from mid-$70s to mid-$90s/t f.o.b. The Iran tender is also attracting bids in the low-mid-$70s/t f.o.b.

OUTLOOK

Urea: Supply-side fundamentals remain extremely supportive, despite the current period of demand-driven weakness. Another rally is considered likely, as importers in most markets are behind on purchases and waiting for the market to stabilise before firming up commitments.

Ammonia: The market finds itself in a period of poor liquidity, and is exposed to further fourth-quarter uncertainty because of the European energy crisis.

Phosphates: Sentiment in most markets is weak. Brazilian MAP import demand is absent, as the country's warehouses are already filled ahead of upcoming safra season applications. The return to the market of importers in India and Pakistan next month could stabilise DAP prices, given the significant tonnages needed by both these markets. Support for Nola barge prices is also expected from a pick up in US buying.

Potash: Expectations of continued low liquidity for the next month will keep prices steady to soft. High inventories will hamper demand in key markets and place pressure on suppliers.

NPKs: A further softening in the phosphates and potash markets will prevent NPK prices from rising. But high energy costs, and low production levels in Europe and China, should ensure that any price decreases, if forthcoming, are not dramatic.

Sulphur: Current lower pricing levels are expected to translate into reduced product availability from FSU supply sources. However, any loss of supply is expected to be exceeded by a fall in sulphur demand, as fertilizer end-users curb their output in an attempt to support the phosphate market price. These market dynamics are expected to limit any price recovery in the near-term. Large phosphate producers have curbed their operating rates and production in recent weeks – a situation that is likely to continue in the short term. ■

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EUROPE

Ammonia plants shutdown across Europe

A record rise in gas prices at the end of August triggered a spate of ammonia production curtailments across Europe. These included major shutdown announcements from CF Fertilisers UK, Grupa Azoty, Yara International and others.

"We have now confirmed that 50 percent of total European ammonia capacity (excluding Ukraine) is shuttered or curtailed, up from 26 percent the week prior," CRU reported on 25 August.

CF Fertilisers UK is temporarily halting ammonia production at its Billingham complex on Teesside. The company, a subsidiary of US-headquartered CF Industries, will continue to produce ammonium nitrate (AN) and nitric acid at the site using imported ammonia instead.

It has yet to decide when Billingham's temporary shutdown will start.

"At current natural gas and carbon prices, CF Fertilisers UK's ammonia production is uneconomical, with marginal costs above £2,000 per tonne and global ammonia prices at about half that level. The current cost of natural gas at NBP* is more than twice as high as it was one year ago, with the NBP forward strip suggesting that this price will continue to rise in the months ahead," CF Fertilisers UK said in a statement. (*NBP is the wholesale trading point for UK natural gas.)

However, the company said it still "expects to fulfil all ammonia and nitric acid contracts and all orders of AN contracted for delivery in the coming months" by switching to imported ammonia.

The ammonia production halt at Billingham follows the announced closure by CF of its Ince, Cheshire fertilizer production complex in June, ending more than 55 years of production at the site (*Fertilizer International* 509, p8).

Ammonia production at Billingham and Ince was halted on 15th September last year due to high natural gas prices, although the Billingham plant restarted a few weeks later after the UK government stepped in to cover costs (*Fertilizer International* 505, p8).

The cash support offered by the British government last year was designed to ensure continuing CO_2 supply to UK industry, particularly the food and beverage sector. The UK relies on Billingham for the CO_2 generated as a by-product of ammonia production. CF says it has notified its CO_2 contract customers about the latest production halt at the site.

The 24th August announcement by CF Fertilisers UK came the day after Poland's Grupa Azoty halted nitrogen fertilizer production at Tarnow, Poland, and also reduced production at its Pulawy site. In total, the company has the capacity to produce 524,000 tonnes of ammonia, 375,000 tonnes of urea and one million tonnes of NPKs annually.

The decision was prompted by record natural gas prices. Azoty estimates that its natural gas costs have leapt from €72 per megawatt hour (MWh) on 22nd February to €276/MWh on 22nd August.

Yara International also reacted to these record high gas prices by announcing further production curtailments on 25th August. These will reduce its total European ammonia output to around 35 percent of capacity.

The decision means that Yara has now curtailed its annual capacity by the equivalent of 3.1 million tonnes for ammonia and 4.0 million tonnes for fertilizers (1.8 million tonnes urea, 1.9 million tonnes nitrates and 0.3 million tonnes NPK) across its European production sites.

"Yara will where possible use its global sourcing and production system to optimize operations and meet customer demand, including continued nitrate production using imported ammonia when feasible. Yara will continue to monitor the situation and adapt to market conditions going forward," the company said in a statement.

BASF also cut ammonia production in Germany over the summer in reaction to high gas prices.

"We are reducing production at facilities that require large amounts of natural gas, such as ammonia plants," BASF's CEO Martin Brudermueller said in an earnings call of 27th July. "We are monitoring developments very closely, particularly at our largest site in Ludwigshafen, where we use considerable amounts of gas."

BASF said falling gas supplies from Russia were behind its decision. Ammonia production is particularly vulnerable, being responsible for one quarter of its overall natural gas consumption. The company said it would fill some of its ammonia supply shortfall with purchases from external suppliers but warned that farmers would still face higher fertilizer costs next year.

"[A cut in ammonia production] would put additional pressure on an already extremely tight market. Russia is a major exporter of ammonia and fertilisers. Exports from Russia are currently in sharp decline. A reduction in gas supplies in Germany would further exacerbate the shortage of fertilisers worldwide, reduce food production and lead to further price increases for basic foodstuffs," a BASF spokesperson said.

As of 23rd August, ICIS was reporting widespread disruption to ammonia and nitrogen fertilizer production across Europe linked to soaring wholesale gas prices. Partial or full shutdowns or reduced production rates were reported at the following sites:

- Yara Sluiskil and OCI, the Netherlands
- CF Fertilisers Ince, UK
- BASF Ludwigshafen and SKW, Germany
- Fertiberia Huelva, Spain
- Yara Ferrara, Italy
- Petrokemija, Croatia
- Azomures, Romania
- Grupa Azoty Tarnow and Pulawy, Poland
- Achema, Lithuania.

"At least 50% of European ammonia capacity has been curtailed. The reality is likely higher than this. The repercussions could be extraordinary and expand well beyond agriculture and fertilizers," Chris Lawson, CRU's head of fertilizers, said on 27th August.

Additional to the above list, CRU is also reporting that Anvil has ceased production in Poland and that Duslo in Slovakia is also facing downtime.

AFRICA

Stamicarbon wins first African urea project license

Stamicarbon has been selected as the licensor for an unnamed 4,000 t/d capacity urea project in sub-Saharan Africa, its first license in the region.

The company, part of Maire Tecnimont Group, will deliver the process design package for the front-end engineering design of a urea melt and granulation plant. The urea melt plant (with pool reactor) will incorporate Stamicarbon's LAUNCH FINISH™ MP Flash design. This improves operational energy efficiency by significantly reducing steam consumption. The new plant will also use Stamicarbon's LAUNCH FINISH™ Fluid bed Granulation design and include an acidic scrubbing system to remove emissions. The entire synthesis section of the new plant will be in Safurex®.

The overall design, by minimising the number of equipment items, will reduce the urea plant's footprint and its capital cost. Less equipment also translates into lower maintenance costs and operational cost savings. The plant is also designed to deliver high on-stream times and high-quality products with low formaldehyde consumption and low dust and ammonia emissions.

Pejman Djavdan, Stamicarbon's CEO, said: ''We are proud to be part of this remarkable project. It is a genuinely solid project with an innovative concept that is bound to add value to the community and the region at large. With this project, Stamicarbon has increased its footprint in Sub-Saharan Africa and positioned itself as the world leader in cutting-edge technology and solutions relevant to the fertilizer industry."

AUSTRALIA

Carbon-free production breakthrough

A team of scientists at Melbourne's Monash University have reported a breakthrough in the electrolytic conversion of nitrogen into ammonia.

The scientists say they can now convert nitrogen from air into ammonia using renewable electricity at an unprecedented rate due to the complete selectivity of the conversion reaction. This should pave the way for sustainable ammonia generation at industrial scale in future, they suggest, and also enable carbon-free fertilizer production.

Lead scientist Dr Hoang-Long Du, and team leaders Dr Alexandr Simonov and Professor Doug MacFarlane, have developed a unique electrolyte that supports the nitrogen-to-ammonia conversion reaction by producing a high-performance layer on the operating electrode.

Their findings have just been published in the journal *Nature*.

Dr Simonov said the process for carbon-free fertilizer production via renewable energy had been known for some time – but was not very selective. "Typically, a significant portion, sometimes as large as half of the electricity was used in making other unwanted compounds, making the process impractical," he said. "Our new discovery shows how ammonia can be made with complete selectivity."

Professor MacFarlane, said that reaching 100 percent selectivity for ammonia was a vital step in making the process industrially practical. "This discovery builds on years of work in our group understanding the fundamental chemistry underpinning the process," he said.

Dr Du said another important feature of the new electrolyte was its high process stability. "Since the electricity is exclusively used for

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the nitrogen to ammonia reaction, no degradation processes can occur and the process can operate stably on a long timescale," he said.

Jupiter Ionics, a Monash University spin off company, is scaling up the newly discovered process. The company is planning to install the technology on farms, or in regional centres, to produce fertilizers locally using on-site renewable energy. It hopes to have the first prototype devices working on a farm in Victoria next year, according to the Jupiter's CEO Dr Charlie Day.

"This new research is opening up a novel pathway to ammonia production, over a century after Haber and Bosch first developed their eponymous process," Dr Day said. "Importantly, it will enable production at a range of scales and in a range of settings, all powered by increasingly abundant and cheap renewable energy."

Jupiter Ionics is receiving funding for the scale-up project from the Australian federal government's CRC Program along with support from partners Fortescue Future Industries, WesCEF and SJDC Produce Ltd.

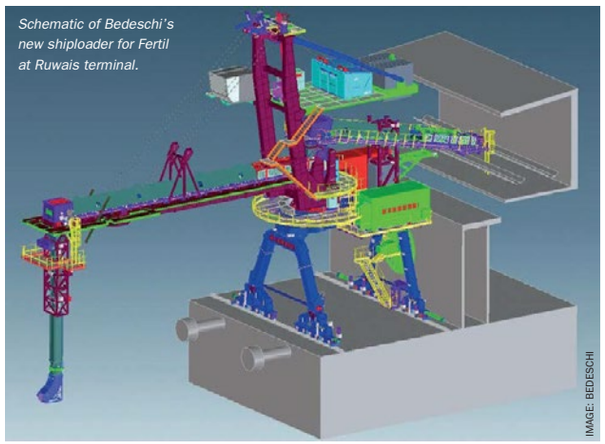
UAE

New Ruwais shiploader for Fertil

Bedeschi is supplying a new 1,200 t/h capacity shiploader for Fertil's Ruwais terminal in Abu Dhabi. The tailor-made 'luffing and slewing' type shiploader will be delivered on site fully constructed.

The new machine will replace the existing shiploader used for fertilizer and granular urea loading operations at the terminal. It runs on rails and uses a towed tripper to divert product from a wharf gallery conveyor onto the transfer belt that, in turn, supplies the loading boom belt.

Installation of the new shiploader will not disrupt Fertil's operations at Ruwais, according to Bedeschi.



Schematic of Bedeschi's new shiploader for Fertil at Ruwais terminal.

IMAGE: BEDESCHI

SAUDI ARABIA

World's first blue hydrogen and blue ammonia certification

In a world first, Saudi Aramco and state fertilizer producer Sabic Agri-Nutrients (AN) have been awarded independent certificates of accreditation for blue hydrogen and blue ammonia production at Jubail in Saudi Arabia.

The landmark certificates were awarded to the two companies by TUV Rheinland, a German-based independent testing, inspection and certification agency. The certification covered 37,800 tonnes of blue ammonia produced by Sabic AN and 8,075 tonnes of blue hydrogen produced by Sasref, a refinery wholly owned by Saudi Aramco.

To receive blue certification, verification is needed that the carbon dioxide generated by ammonia and hydrogen production is being captured and used downstream.

"Sabic recognises that hydrogen will play an essential role in decarbonisation and it is part of Sabic's overall road map toward carbon neutrality by 2050, with a 20% reduction target in carbon emissions by 2030," said Fahad Al Sherehy, Sabic's vice president of energy efficiency and carbon management. The new initiatives will also support Saudi Arabia's goal to become carbon neutral by 2050, he said.

Oil and gas giant Aramco recently announced plans to produce up to 11 million tonnes per annum of blue ammonia by 2030. This ambitious target represents around 50 percent of the current global merchant ammonia market, according to analysts Profercy.

BRAZIL

Unigel invests $120 million in green ammonia project

Unigel has announced Brazil's first industrial-scale green hydrogen production project.

The company, Brazil's largest nitrogen fertilizer manufacturer, will initially invest $120 million installing three standard thyssenkrupp nucera 20 megawatt (MW) electrolysers at its Camaçari industrial complex in Bahia as part of the project's first phase.

The new 60 MW plant will have production capacity for 10,000 t/a of green hydrogen and 60,000 t/a of green ammonia. Around three quarters of the plant's energy requirements will come from renewable sources.

Unigel will use the green ammonia generated to manufacture fertilizers and acrylics. The new plant will also supply green hydrogen to industrial customers to help steel makers and oil refiners decarbonise their production chains.

The ultimate aim, in the project's second phase, is to quadruple electrolyser capacity to produce around 40,000 t/a of green hydrogen.

"Throughout our nearly 60-year history, we have always been attentive to technological innovations and have invested to meet industrial and agribusiness demands. With this project, Unigel takes the first step towards the decarbonization of several sectors, contributing substantially to combating climate change on the planet," said Henri Slezynger, Unigel's founder and chairman.

Dr Werner Ponikwar, CEO of thyssenkrupp nucera, welcomed this first-of-its-kind project: "As Brazil is one of the world-leading countries in terms of installed renewable energy, we are pleased to enter this partnership to make green hydrogen an affordable energy vector already today. Only through large-scale production with robust, reliable and cost-effective technologies at competitive renewable power prices will green hydrogen become market-ready with widespread use."

Nutrien buys ag retailer Casa do Adubo

Canadian fertilizer giant Nutrien Ltd has entered into an agreement to acquire the Brazilian fertilizer retailer and distributor Casa do Adubo S.A.

The purchase includes 39 retail locations, under the brand Casa do Adubo, and 10 distribution centres, under the brand Agro-distribuidor Casal. These sites are widely distributed throughout Brazil, supplying the states of Acre, Bahia, Espírito Santo, Maranhão, Mato Grosso, Minas Gerais, Pará, Rio de Janeiro, Rondônia, São Paulo and Tocantins.

The acquisition of Casa do Adubo is part of Nutrien's retail growth strategy for Brazil and is expected to generate additional yearly sales of approximately $400 million. This should increase Nutrien's total annual sales in Latin America, through its Nutrien Ag Solutions retail arm, to around $2.2 billion.

"The acquisition expands our footprint in Brazil from five states to 13 and supports growers in a key region of the world that will increasingly be relied on to sustainably increase crop production and feed a growing population, especially with the current global food insecurity challenges," said Ken Seitz, Nutrien's president and CEO. "We expect that integrating Casa do Adubo will further enhance our ability to provide whole-acre solutions for all customers in the region while delivering quality earnings in this large and growing market."

"We appreciate the reputation Casa do Adubo has earned for delivering strong financial performance, attracting top talent and offering quality products and services," said André Dias, Nutrien's regional leader in Latin America. "With the acquisition, we will strengthen our existing presence and expand to serve additional growers with innovative solutions that help sustainably feed the world."

Once complete, the acquisition will increase Nutrien's Latin American presence to 180 commercial units, including customer-facing retail branches and 'experience centres', five industrial plants and four fertilizer blenders.

The transaction does, however, still require the approval of CADE, Brazil's Administrative Council for Economic Defense.

MOROCCO

Green ammonia pilot plant for Jorf Lasfar

Plans to construct a green ammonia pilot plant at OCP Group's massive Jorf Lasfar phosphate complex were agreed in mid-July.

The agreement, between Morocco's Mohammed VI Polytechnic University (UM6P) and Dutch company Proton Ventures, covers the construction of a four tonnes per day capacity green ammonia unit. The front end will incorporate a PEM electrolyser and an alkaline electrolyser for green hydrogen production. These will both have a capacity of two megawatts.

The latest agreement follows an earlier contract for the turnkey construction of the pilot plant signed in November 2021 by UM6P, OCP Group and the Institute Research Energy Solar et Energy Nouvelles (IRESEN) as part of the 'Green H2A' initiative.

The pilot plant will be operated in preparation for larger industrial projects. The unit will be equipped with an emulator that can simulate the different electrical load profiles, with varying amounts of photovoltaic and wind energy, of sites in Morocco and other global locations. The knowledge and know-how gained from these pilot tests will be used in a larger scale exploitation phase

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scheduled to begin in the first-quarter of 2024.

Paul Baan, CEO of Proton Ventures, said: "It is an important step to design and build this green ammonia plant in order to bring the energy transition to reality! We are looking forward to work with UM6P, OCP and IRESEN and all subcontractors to deliver a successful project."

"Through this agreement, the UM6P confirms its desire to make green hydrogen an industrial reality in Morocco," said Mohammed Bousseta, a director at UM6P.

"Through this installation, the partners of the 'Green H2A' platform, which are OCP, UM6P and IRESEN, …can shed light on larger-scale projects that are currently being developed by several international players in our territory and internationally," said Samir Rachidi, scientific director and acting general Manager of IRESEN.

ISRAEL

ICL and PlantArcBio develop novel biostimulant

Fertilizer producer ICL and biotech company PlantArcBio have developed a novel biostimulant.

The new product uses RNAi technology to maximise the natural yield-increasing mechanisms of plants. It has been shown to successfully improve crop yields while having a minimal impact on the environment.

The biostimulant has significantly increased seed weight per hectare for canola crops in early-stage field trials. ICL and PlantArcBio are planning larger-scale field trials for later this year. These will test the new biostimulant technology using both commercial sprayers and standard farming practices. Greenhouse trials for soybeans and rice are already in progress, with early results showing good potential.

ICL and PlantArcBio have already filed a joint patent for the biostimulant covering its application on multiple crops.

"The use of novel biostimulants based on RNAi technology helps promote sustainability, by reducing the use of chemicals in agriculture," said Hadar Sutovsky, ICL's VP for external innovation and the general manager of ICL Planet. "[it] does its work, then rapidly disappears from both the plants and the environment, lasting no more than a few days, as it is highly biodegradable and also leaves no residual footprint."

"The positive canola field trial results constitute another milestone in strengthening PlantArcBio's capabilities in the development of RNAi-based products," said Dror Shalitin, the founder and CEO of PlantArcBio. "ICL, a market leader in crop nutrition products, is a great strategic partner for us to commercialize this sustainable technology worldwide."

The value of the global biostimulants market was estimated at $3.2 billion in 2021, and is projected to grow at 12 percent per annum to reach $5.6 billion by 2026, according to ReportLinker.com.

SPAIN

Fertiberia acquires biotech firm Trichodex

Spain's Grupo Fertiberia has acquired Trichodex, a biotechnology company located in Seville.

Founded in 1991, Trichodex manufacturers products based on patented biological processes. These improve crop protection and boost profitability by using microorganisms to produce 'bioactive' compounds. The company currently markets its biotech products in a dozen countries in Europe and Latin America.

The purchase of Trichodex is part of Fertiberia's strategy to offer high added-value biofertilizers and biostimulants as part its product portfolio.

"The combination of Trichodex biotechnology with the development of innovative products from Grupo Fertiberia will provide farmers with cutting-edge sustainable tools to improve their crops," said Javier Goñi, president of Grupo Fertiberia.

ETHIOPIA

Yara sells stake in Dallol SOP project

Yara is selling its longstanding ownership stake in the Dallol SOP project in Ethiopia to XLR Enterprises Limited via a share purchase agreement.

Yara had previously been the majority shareholder in the sulphate of potash mining project in Ethiopia's Afar region, with XLR Enterprises Limited and Liberty Metals and Mining Holdings being the other partners. The project has been on hold since 2019.

"The divestment supports Yara's transformation by reallocating capital and risk appetite towards its strategic focus areas. Yara's full legal ownership interest in the project together with all economic rights and all obligations and liabilities attaching or relating thereto will be transferred to XLR Enterprises at closing," Yara said in a statement.

Costs associated with the Dallol project and its sell-off will not affect Yara's 2022 financial results, as the company had previously declared an associated $232 million impairment loss in the fourth-quarter of 2021.

Yara announced the Dallol divestment in July. The transaction is conditional on local regulatory approval and customary closing conditions.

BELGIUM

SQM launches Ultrasol®ine K Plus

SQM launched Ultrasol®ine K Plus, a new potassium nitrate product that incorporates iodine, on the European market in mid-July.

Ultrasol®ine K Plus is designed for fertigated crops. It allows growers to apply iodine as a plant micronutrient in a form that is guaranteed to be safe and at an effective science-based dose. The new speciality fertilizer combines iodine with two essential plant macronutrients – potassium and nitrate nitrogen.

Its European launch follows several years of scientific investigation and grower trials (*Fertilizer International* 509, p18). These have revealed that iodine deficiency in plants is associated with yield losses, similar to the deficiency effects observed with other plant nutrients.

SQM is recommending that iodine should now be supplied to crops at the right dosage for optimal crop production. The Chilean-based company says that co-application of iodine with potassium nitrate makes it easy for the grower to maintain an effective and safe concentration of iodine in the root zone. As a result, Ultrasol®ine K Plus can prevent iodine deficiency in crops without the risk of excessive iodine application.

The product has already been extensively tested globally and is backed by more than 100 well-documented crop trials with growers. Results have confirmed that iodine can deliver distinct benefits, including improvements in:

- Root growth
- Above-ground plant growth
- Photosynthesis
- Nitrogen metabolism
- Tolerance to abiotic stress
- Flowering and fruit quality with less fruit rot and better shelf life. ■

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People

Nutrien appointed **Ken Seitz** as president and CEO on 8th August. He has been the company's interim CEO since January. Mr Seitz also joined Nutrien's board of directors from this date. His appointment as CEO followed an extensive seven-month global search for internal and external candidates led by the board and supported by a world-class executive recruitment firm.

Mr Seitz brings more than 25 years of global management experience to the role. He has worked across more than 60 countries and possesses deep agriculture and mining sector experience. Under Ken's interim leadership, Nutrien has achieved record results, delivered bold actions in response to agricultural market changes, and brought together key parties to help navigate the unprecedented global food security challenge. He has also furthered Nutrien's sustainability strategy.

Russ Girling, Nutrien's chair, said: "Nutrien's record performance and disciplined execution of strategy during some of the most turbulent times we have seen globally underscore the strength of Ken Seitz's leadership. As the company's president and CEO, Mr Seitz will continue to drive positive outcomes for all of our stakeholders as we strive to safely and sustainably feed the world."

Girling added: "Mr Seitz strongly aligned to our comprehensive leadership needs given his extensive international experience in our industries, passionate connection to our purpose, efficacy in driving our stated strategy and personal commitment to employee safety and an inclusive workplace. Additionally, Mr Seitz demonstrated proven performance in an interim role this year receiving an extensive range of positive feedback from our stakeholders. The board has every confidence Mr Seitz is the right leader to drive our strategy forward."

In reply, Ken Seitz said: "I look forward to continuing the important work of safely and sustainably feeding a growing world with the executive leadership team, our employees globally and support of the board of directors. Growing up on a dairy farm in Saskatchewan, I am honored and humbled to work alongside growers during these challenging times today and going forward. Nutrien is extremely well positioned to help meet the global goals of food security and climate action, partnering across the food system. Our purpose is to feed the future, and I am invigorated by the noble pursuit to help solve these critical world needs."

H.J. Baker's chief operating officer (COO) **Luis Masroua** has become president of the company.

"Luis has been a great asset to H.J. Baker since joining us," said CEO Christopher Smith. "I know that with his years of international business experience he will be an excellent leader for the company moving forward."

Masroua has been responsible for many significant changes since joining H.J. Baker as COO in May 2018. These include the sale of the company's Brazilian animal health and nutrition business and the purchase of Oxbow Sulphur in 2019.

"It is a great honor to be named President of H.J. Baker," Masroua said. "This is a historic company. I aim to continue its legacy of excellence for our customers and suppliers, as well as our many excellent employees."

Masroua joined H.J. Baker after working for Cargill for two decades. At Cargill, his roles included managing director of Cargill Animal Nutrition in Russia and managing director of Agribrands Purina in Venezuela and Peru. Luis holds an MBA from the Weatherhead School of Management and a master's degree from the Thunderbird American Graduate School of International Management.

Compass Minerals has appointed **Melissa Miller** to the company's board of directors. She brings to the board more than 20 years of extensive leadership experience in human resources (HR) management. Ms Miller will serve on the company's Environmental, Health, Safety and Sustainability Committee and its Nominating/Corporate Governance Committee. Her appointment expands the board of directors of Compass Minerals to 10 members.

"At Compass Minerals, we recognize that a skilled and engaged workforce is essential to driving value creation," said Joe Reece, the company's non-executive chairman. "We are excited about the experience and unique perspective Melissa will bring to our board in helping us continue to develop and empower our employees for success while also attracting new and diverse talent."

Ms Miller currently serves as executive VP and chief HR officer at Arconic Corporation, a leading manufacturer of aluminium sheet, plate, extrusions and architectural products. From 2005, she held several HR leadership roles with the predecessor companies Arconic, Inc and Alcoa, prior to Arconic Corporation's launch in 2020. Melissa holds a BSc in psychology from Pennsylvania State University.

Calendar 2022/2023

SEPTEMBER

12-13
TFI World Fertilizer Conference,
DALLAS, Texas
Contact: Valerie Sutton
Tel: +1 202 962 0490
Email: vsutton@tfi.org

28-29
12th GPCA Agri-nutrients Conference,
DUBAI, UAE
Contact: Samereen Bukhari,
Conference Producer
Tel: +971 4 451 0666 ext. 127
Email: samereen@gpca.org.ae

OCTOBER

5-7
IFA Asia Pacific Crossroads,
SINGAPORE
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

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

31-2 NOVEMBER
IFA Strategic Forum,
WASHINGTON DC, USA
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

JANUARY 2023

30-1 FEBRUARY
CRU Argus Fertilizer Latino Americano
2023, RIO DE JANEIRO, Brazil
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FERTILIZER INTERNATIONAL
ISSUE 510
SEPTEMBER/OCTOBER 2022

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The Argus Fertilizer Europe Conference returns as an in-person event at the Hotel RIU Plaza España, Madrid, Spain, 17-19 October 2022.

After a period of uncertainty and a pause on live events, Argus Fertilizer Europe is making a welcome return to Madrid this October.

Now in its 34th year, the conference typically attracts 600+ attendees, across 300+ companies from 50+ countries, making it one of Europe's largest fertilizer trading events, and guarantees access to new customers and suppliers, as well as existing contacts.

The conference programme lets you join the debate on critical issues facing the European fertilizer industry.

In this event preview, we look at what's new for 2022.

Site visit to Fertiberia's Puertollano plant

This year's event features a special opportunity for a select group of attendees to visit Fertiberia's new green ammonia plant in Puertollano. The visit to Puertollano will take place on 17th October and will last all day, with a special networking dinner planned post-visit.

Multiple networking opportunities

Argus Fertilizer Europe is renowned as the place where senior representatives from across the European fertilizer supply chain, including producers, trading firms and distributors, gather to network. There will also be multiple opportunities throughout the event to create connections within formal and informal settings.

The conference floorplan this year features specific networking zones. These offer plenty of areas to host client meetings and will provide a range of different amenities (food, drink, charging points etc). Complimentary meeting tables will also be available in the exhibition area on a first-come, first-served basis. Please visit the website to view the networking zone map.

The event's networking app, featuring the full attendee list, will launch a month before the conference – allowing participants to set up their profiles and start planning their schedules. Within the app, attendees will be able to message one another and set up meetings with potential suppliers, clients and new business partners ahead of the conference.

Revamped Fertilizer Fast Track

New to the market? Need a refresher on market essentials? Then gain access to exclusive online resources covering the basics of the fertilizer market before the conference – so you can make the most of your time during the event.

Roundtables

On the first day of the conference, get a head start on networking with like-minded individuals – on the topics that matter most to you – by participating in the roundtables hosted in the exhibition area. Topics include: Does environmental sustainability ensure economic sustainability?; Alternate sourcing of fertilizers: a deep dive into Asian markets; Growing business between the Americas and Europe; How are traders reacting to fertilizer supply shocks?

Exhibition area

Discover the latest products dedicated to the European Fertilizer market. Hear the latest on innovations from EMT, Koppern, Agripower, Saviolife, Evergrow, Fertiberia, ANWIL, Heorgra Fertilizantes, Eirich, DCX, Cotecna, AGI and many more.

Main conference stream

Gain key insights into the most important challenges facing the fertilizer sector. With topics ranging from rising shipping costs to geopolitics, hear from the senior executives of influential fertilizer companies on subjects such as green hydrogen and ammonia, food security and EU regulation.

The event's highly informative 'Europe markets digest' presentations will provide attendees with the opportunity to hear from leading Argus experts. This session will provide an overview of the key market developments within the industry, as well as an analysis of macroeconomic and geopolitical events, and how these are influencing and shaping the fertilizer raw material and finished product markets.

The wide range of companies presenting at this year's event include Fertiberia, Haifa, Anglo American, Triferto, Agrifirm, Nitricity, Fertilizers Europe, ANFFE, SkyFusion, Groupe Eyssautier-Verlingue, ADM Investor Services, Sulphur Mills, ORO Agri, RWZ and others.

Specialty fertilizer stream

This year, to keep you up to date with changes in the specialty fertilizer market, this stream will provide attendees with in-depth analysis and updates on biostimulants, foliar fertilizers, micronutrients and certification. You'll also be the first to know about new specialty products and projects that are hitting the market.

There will be an opportunity to hear from Fertiberia, Agripower, Haifa, Fitosoil, International Fertiliser Society, Agripower, KAELTIA, Rhenus, Vlaeynatie and others.

Join the European fertilizer community in Madrid

Maximise this opportunity to meet with senior decision-makers across the European bulk and specialty fertilizer supply chain all under one roof. Secure your place ahead of the conference to ensure early access to the event app and to start planning your schedule.

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

Successfully enhancing fertilizer efficiency

Producing efficient fertilizers that deliver nutrients directly to crops in exactly the right amounts has clear economic and environmental benefits. Recent advances in controlled-release and stabilised fertilizer technology are highlighted.

THYSSENKRUPP

Urea product innovations

Bernd Peuckmann and Rolf Weiss of thyssenkrupp Fertilizer Technology (tKFT) and Yevgeny Makhynya, Marc Wieschalla and Tobias Birwe of thyssenkrupp Industrial Solutions (tkIS)

Several innovations developed by thyssenkrupp can add value to urea and other fertilizer types and improve their efficiency.

Introduction

Increasingly, the fertilizer industry needs to meet new, more stringent environmental obligations and respond to calls from society for greater sustainability. In Europe, these demands are exemplified by the EU's Green Deal – although similar pressures apply in other regions.

Industry decarbonisation is also being promoted by subsidies on new technologies and through policies which tax carbon emissions or carbon-based products. For these reasons also, the fertilizer sector must reduce its carbon emissions and enhance both production and product efficiency.

These changes, although challenging, also open up new opportunities. For example, fertilizer producers can create more value from their existing assets via small revamps that increase production capacity and/or improve process efficiency and reduce emissions. At the same time, the diversification of product portfolios is of growing importance as a way of achieving higher margins and better nutrient use efficiency.

To prepare the fertilizer industry for these future needs, thyssenkrupp Fertilizer Technology (tkFT) and thyssenkrupp Industrial Solutions (tkIS) have developed the following options that add value to urea and other fertilizer products:

- Controlled-release fertilizers and fertilizers stabilised using inhibitor treatment technology – to meet upcoming European and worldwide demand for products with better nitrogen use efficiency
- Urea enriched with elemental sulphur to close the global sulphur gap.

Controlled-release fertilizers (CRFs)

The conventional application of commodity fertilizers to crops typically results in big nutrient losses. These can reach 70 percent or more for some nitrogen fertilizers such as urea. Such losses are directly responsible for the nitrate pollution of groundwater and soils in countries where intensive agriculture and fertilization is practiced, such as those in Western Europe.

Consequently, legislators in some regions have reacted by introducing restrictions that limit both the amount of applied fertilizers and the number of applications allowed during the growing period. Additionally, the use of so-called stabilised fertilizers (SFs) is also being mandated to cut nutrient losses. From 2020, for instance, only stabilised urea can be applied by farmers in the European Union[1] and Germany[2].

Having recognised this trend, thyssenkrupp Industrial Solutions, as a leading EPC contractor for ammonia and urea plants, has been working to develop SFs and controlled-release fertilizers (CRFs) together with their associated production processes. One successful outcome has been the development of innovative polymer coated urea (PCU) products (*Fertilizer International* 503, p26). These special types of CRF use biologically degradable polymers such as polylactic acid (PLA) to coat urea granules (Figure 1).

These polymers decompose in soil without producing environmentally harmful substances and can be produced from renewable resources. This ensures that the whole production and crop application process is sustainable.

These types of CRFs make nutrients available over the entire growing period. They are also more efficient as they supply

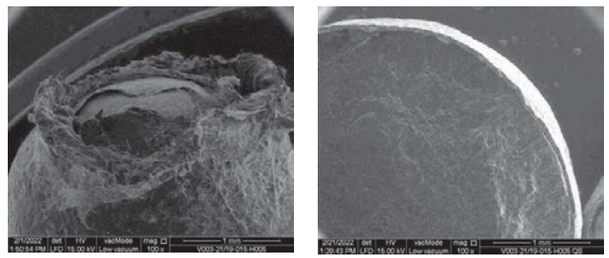

Fig. 1: Electron microscope images of a PLA-coated fertilizer granule.

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nutrients in the exact quantities required by crops. This provides the option to:

- Either increase crop yields by up to 10 percent for the same amount of fertilizer
- Apply less fertilizer to achieve the same yield
- Or potentially combine these two positive effects.

The production of CRFs can be integrated within an existing ammonia-urea production complex, or set up as a standalone plant, and can be realised for a wide range of production capacities. The same coating technology can also be successfully applied to other fertilizer types, including potash-, phosphate- and sulphur-containing fertilizers, to minimise nutrient losses and increase their nutrient use efficiency.

Innovative inhibitor treatment technology (ITT)

Regulators around the world have recognised the problem of ammonia volatilisation from surface-applied urea. The result has been an increasing number of regulations governing the application of urea to soils.

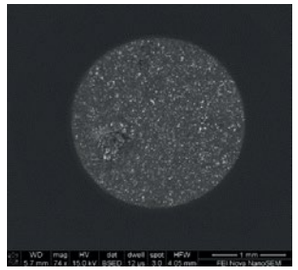
The treatment of urea granules with urease inhibitors is one answer to this problem. This reduces ammonia emissions, improves nitrogen use efficiency and increases crop yields. The use of urease inhibitors also provides farmers with more freedom in their fertilizer application strategy.

Inhibitors need to be present when urea is applied to the soil. The easiest way to achieve this is by incorporating the inhibitor within urea granules during their production (*Fertilizer International* 503, p26).

Thyssenkrupp's new inhibitor treatment technology (ITT) provides a highly efficient way to treat granular urea with a urease inhibitor at large scale in the quantities required globally. ITT is flexible too – being offered as a plant add-on for both existing and new UFT® fluid bed granulation plants. This saves on cost and space since no additional coating equipment is needed. Furthermore, ITT is not labour intensive and allows additional surface treatments further down the value chain (e.g., for micronutrients).

To successfully apply a urease inhibitor there is a need to ensure that the formulation and the granulation technology are completely compatible and correctly match one another. BASF and thyssenkrupp Fertilizer Technology (tkFT) ensured this by cooperating closely together on a new ITT project. This enabled the two project partners to successfully develop an application-specific version of BASF's proprietary Limus® urease inhibitor for use in the UFT® fluid bed urea granulation process. No additional investment by operators is necessary beyond a simple dosing system.

ITT has been thoroughly tested and validated at pilot plant scale. It was also recently verified for the first time at a full-scale industrial UFT® fluid bed urea granulation plant. The technology is now on track to become fully commercialised, once the results of inhibited urea production at industrial scale have been summarised and product stability has been proven.



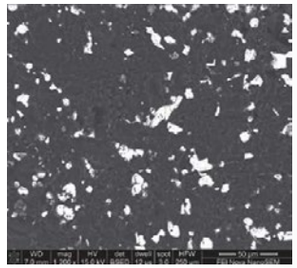


Fig. 2: Cross-section of a Urea-ES® (40-0-0-13S) granule.

Urea with elemental sulphur (Urea-ES®)

The global sulphur nutrient shortage remains a problem, despite measures taken by the fertilizer industry to address this. Indeed, the sulphur containing products currently available on the market are not sufficient to close the ever-growing sulphur deficit in soils. In 2015, this sulphur deficit was estimated to be approximately 10 million tonnes globally, according to The Sulphur Institute (TSI). As a result, the continuing lack of soil sulphur availability is reducing crop production in many areas.

Yet using a readily-available and commonly-applied fertilizer as a carrier product could offer a holistic answer to the global sulphur shortage. Urea is an ideal and obvious sulphur nutrient carrier, in our view, due to its large-scale availability, distribution and use globally.

Elemental sulphur needs to be oxidised into sulphate form to make it available to crops. To improve the oxidation rate – and therefore plant-availability – the surface area of elemental sulphur particles must be significantly increased, e.g., by micronisation. This enables soil bacteria to quickly oxidise sulphur in a shorter time.

Shell and thyssenkrupp Fertilizer Technology (tkFT) have jointly developed a continuous Urea-ES® fluid bed granulation process for the production of sulphur-enhanced urea granules (*Fertilizer International* 492, p44; *Fertilizer International* 507, p38). This integrated process combines Shell's Urea-ES® technology with tkFT's UFT® fluid bed granulation technology. In this innovative process, micron-sized particles of elemental sulphur (ES) are incorporated into urea and homogeneously distributed (Figure 2) via a sulphur dispersion unit.

The availability profile for micronised elemental sulphur (Figure 3) provides in-season sulphur supply while limiting nutrient losses. This ensures that sulphur is available as a nutrient to crops throughout their entire growth cycle.

Shell's Urea-ES® process produces micronised sulphur particles with an average particle size of less than 25 microns. This emulsion is stabilised with the help of an additional Shell additive (ThioAdd®) before being granulated in the UFT® fluid bed granulation plant to obtain the final product (Figure 4).

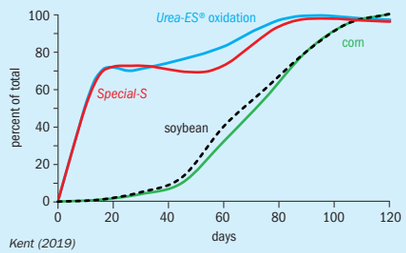
In this process, expensive urea solution is partially substituted with less expensive elemental sulphur, thereby reducing the overall cost for the producer. The sulphur-containing products obtained are also known to sell at a premium in various markets such as in North and South America and Europe.

Nutrient content can also be improved by combining urea with elemental sulphur. Urea-ES® with a formulation of 40-0-0-13S, for example, contains 53 percent nutrients – compared to standard urea (46-0-0) which contains 46 percent nutrients. Another Urea-ES® formulation (35-0-0-24S) has an even higher nutrient density of 59 percent. Consequently, Urea-ES® products have the potential to reduce the CO_2 impacts of fertilizer distribution, as their higher nutrient density makes transportation and handling more cost efficient.

The higher agronomic effectiveness of Urea-ES® fertilizer has also been demonstrated in the many agronomic trials conducted worldwide since 2014. Crop trial results show an equivalent and/or improved performance compared to existing nitrogen and sulphur fertilization practice.

Importantly, Urea-ES® provides an all-in-one source of nitrogen and sulphur and does not need to be blended, unlike other sulphur-containing nitrogen products. Additionally, it is fully compatible with urease inhibitors, whose use is increasing in more and more markets. Urease inhibitors are not degraded by elemental sulphur, as happens with the addition of ammonium sulphate, for example. In summary, Urea-ES® technology has the potential to add significant value for fertilizer producers and ultimately for growers at farm level[3]. ■

Fig. 3: **Sulphur oxidation vs crop sulphur needs over time**



Kent (2019)

PHOTO: THYSSENKRUPP FERTILIZER TECHNOLOGY (TKFT)

Fig. 4: Urea-ES® product manufactured at tkFT's pilot plant, Leuna, Germany.

References

1. Europäische Kommission, 2020. *Kommission begrüßt Abstimmung im Bundesrat zur Düngeverordnung.* [Commission welcomes vote in Bundesrat on fertilizer ordinance]. Europäische Kommission Presseartikel 27 März 2020, Vertretung in Deutschland.
2. Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. *Official Journal*, L375, p 1-8.
3. Kent, M. 2019. Enhancing urea with sulphur. *Fertilizer International* 492, p44.

SMART FERTILIZERS

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STAMICARBON

Smart fertilizers for broad-acre crops

Oluwaseun Omomowo, Public Relations Officer

Fig. 1: **UN sustainable development goals**

IMAGE: UNITED NATIONS

The global challenge

Global food production will undoubtedly need to expand in future to meet the rising demands of a growing population. Equally, affordable food will need to become available to all, if humanity is ever going to eradicate hunger. To deliver these goals sustainably, a careful watch on the environmental impact of farming will also be necessary.

The United Nations has incorporated these aims in Sustainable Development Goal #2: End Hunger, Achieve Food Security and Improved Nutrition and Promote Sustainable Agriculture (Figure 1). The FAO has estimated that an increase in crop production of more than 45 percent will be required by 2050.

Fertilizers are set to play an increasing role in the growth of food production. In particular, the usage of urea, as the dominant nitrogen fertilizer, will need to be critically monitored. Although the application of urea remains essential if crop yields are to increase, its nutrient use efficiency is low. The lost nitrogen is volatilized into air as ammonia and N_2O, or lost to surface and groundwater as nitrates. These losses have adverse environmental effects, ranging from air pollution and fine dust to elevated levels of nitrates in drinking water and the eutrophication of surface waters.

Use of smart fertilizers

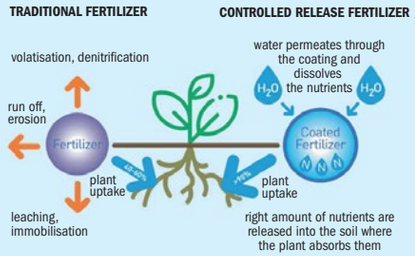
Fertilizers are traditionally applied a few times during the season to ensure that plant nutrient needs are continuously met throughout the growing cycle. It is common practice in Europe nowadays to apply fertilizers in three split applications: the first application fulfils between 40-50 percent of total crop demand, the second applied several weeks later meets 20-30 percent of demand, while a third and final application, several weeks before harvest, boosts the nutritional value of the crop. However, the need to make sufficient levels available throughout the growing cycle can mean nutrients are quickly lost to the environment, as farmers tend to oversupply these to maximise their yields. The loss of oversupplied nutrients between applications often results in poor overall nutrient use efficiency.

A smart fertilizer, in contrast, behaves very differently. It should be able to unlock and release nutrients to match the nutrient demands of the crop. In this way, nutrient release is attuned to the needs of the crop, creating a perfect balance between nutrient supply and plant uptake, so preventing losses of nutrients to the environment. Ideally, optimal nutrient use efficiency can be achieved by adjusting the release curve of the fertilizer so it corresponds exactly with the nutrient demand curve of the crop.

Polymer coated controlled-release urea

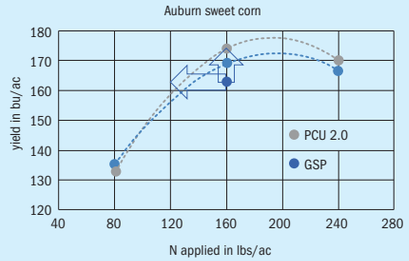
Controlled-release urea can be regarded as a true 'smart fertilizer'. It is produced by encasing the urea granule within a polymer coating. This acts like a membrane, sealing the urea from the surrounding soil environment. Over time, urea's hygroscopic nature naturally attracts and draws in water (rain, moisture) through the membrane, where it dissolves part of the urea. A driving force then develops due to the high nitrogen concentration inside the membrane relative to the low concentration outside. As a consequence, nitrogen dissolved in water permeates outwards through the membrane into the soil, ready

Fig. 2: **Nitrogen uptake**



Source: Stamicarbon

Fig. 3: **Field trials sweet corn**



Source: Stamicarbon

to be absorbed through the root system of the plant in an efficient and controlled manner (Figure 2). As the rate of permeation through the membrane is temperature dependent, and nutrient release also depends on water availability, an almost perfect balance is created between crop needs and fertilizer supply. As a result, losses to the environment, whether to air or water, are prevented and maximum nutrient use efficiency is achieved.

Field trials

Field trials have been conducted with polymer coated controlled-release urea (PCU 2.0). Trials in different cropping systems, such as field corn, sweet corn and potatoes, have shown that significant increases in nutrient use efficiency are achievable (Figure 3). A single application of controlled-release urea provided 5-10 percent higher yields, against a split application of conventional fertilizers, when applied at the same overall application rate. Alternatively, controlled-release urea provided similar crop yields when applied at 75-85 percent of the total application rate of conventional fertilizers.

A business case analysis showed that the higher yield target allowed for a $150-800/t premium (depending on crop) for controlled-release urea, over regular urea, whereas the lower application target allowed for a $60-110/t premium for controlled-release urea over regular urea. This excludes the additional benefits of single application such as less labour and fuel.

Using controlled-release fertilizers to optimise cropping provides a number of important benefits:

- Negligible ammonia volatilisation losses
- Negligible nitrate leaching losses
- Steady controlled-release of nutrients over the 3-4 month growing season
- Nearly all nutrients are available for the crop
- A single application in spring, with no need for a summer side dress, reduces application costs.

There is also the option to choose between two optimal fertilization strategies:

- Higher yield from a similar application rate (allowing for higher fertilizer cost) or
- Similar yield from a lower application rate (less application of higher cost product).

Partnership development

A novel technology for the production of polymer coated controlled-release fertilizers, registered as PurActive™ Technology, has been developed by US-based Pursell Agri-Tech. This new approach, which combines a novel polymer composition with innovative coating technology, provides an economic solution to smart fertilizer production.

Stamicarbon, the leading urea technology licensor, has acquired a 20 percent stake in Pursell Agri-Tech. The mutually beneficial collaboration joins up Stamicarbon's global network and technological capability with Pursell Agri-Tech's leading expertise in coated fertilizers. This will enable both companies to pursue promising controlled-release fertilizer market opportunities worldwide. Stamicarbon's technology package called Controlled-Release Fertilizer Design™ is being offered to the market as a full 'Lump Sum Turn Key' project option.

Modular plant design

At the heart of the Controlled-Release Fertilizer Design™ package is a modular coating plant. It has a relatively low investment cost and a compact design, making it possible to erect such plants close to existing logistics facilities near end-user markets.

The first commercial Controlled-Release Fertilizer Design™ reference plant, operating on a 24 hours, 5 days a week regime, is running in Sylacauga, Alabama, in the US. It has a capacity to produce up to 100,000 t/a of controlled-release fertilizer and is being operated by our partner Pursell Agri-Tech.

Feeding the future

Previously, a technology capable of economically producing smart fertilizers for broad acre agriculture has simply not been available. This has now changed with the introduction of Stamicarbon's Controlled-Release Fertilizer Design™. This provides fertilizer producers and distributors with the ability to supply a range of new products to the market that provide optimised fertilization. There is also the flexibility to achieve this in one of two ways: by increasing yields, or by reducing fertilizers inputs. At the same time, the wider application of controlled-release fertilizers reduces the negative pressure on the environment associated with the loss of nutrients to air and water. This latest innovation from Stamicarbon demonstrates how the fertilizer industry can take positive action to support United Nations Sustainable Development Goal #2: End Hunger, Achieve Food Security and Improved Nutrition and Promote Sustainable Agriculture. ■

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PHOTO: KAS

KOCH AGRONOMIC SERVICES

Leading the way on nitrogen stabilisers

Greg Hunter (left), VP of Global Sales at Koch Agronomic Services (KAS), discusses market developments in an exclusive interview with *Fertilizer International*.

Market growth

The enhanced efficiency fertilizer (EEF) segment of the global fertilizer industry was valued at $4.7 billion in 2018 by Rams & Co – with global consumptionfor the year estimated at 15.7 million tonnes, up from 14.4 million tonnes in 2016. Segment growth was driven by the rising popularity of stabilised nitrogen fertilizers (SNFs), particularly urea stabilised with urease inhibitors.

Consumption of SNFs was estimated at 10.7 million tonnes in 2018 – divided between 8.2 million tonnes for urease inhibited (UI) and 2.6 million tonnes for nitrification inhibited (NI) products. Looking ahead, the consumption of SNFs is expected to accelerate at 10-12 percent p.a., according to Rams & Co, with the size of the SNF segment potentially reaching 30.5 million tonnes by 2028.

Yet, apart from the Rams & Co assessment, hard and fast facts on the stabilised fertilizer market are difficult to come by.

Do you have any comments on the market for stabilised nitrogen fertilizers (SNFs) since this assessment was published – and are you seeing distinctly different growth patterns between North America and other regions?

We are seeing continued growth of the segment across the globe, but specifically in North America and Europe as growers are looking to optimise inputs and capitalise on commodity prices. The uncertainty around the changing regulatory landscape in Europe and Canada is making it difficult to know how it will affect demand in the future. In general, growers are becoming more attuned to the risk of nitrogen loss and seeking solutions to protect their nitrogen inputs.

High and volatile prices

We've seen both highly volatile and record fertilizer prices this year due to the supply fears associated with the Russia-Ukraine conflict. Is this market development – and the high price environment in general since the global economic recovery from Covid pandemic – sparking greater interest in fertilizer efficiency and stabilised products?

Koch Agronomic Services (KAS) is a long-term focused business, which helps us to navigate any day-to-day volatility seen in the global industry. We believe in the value proposition of our product and our ability to meet our customers' demands going into season. KAS anticipates continued strong demand and a need for nitrogen stabilisers as we go into the next growing season, especially as growers focus on their macro inputs. We expect an increase not only in the use of stabilisers in the industry, but also the knowledge around products and sources in the market.

New products

KAS has been a pioneer in the stabilised fertilizer market and continues to innovate. The landmark launch of CENTURO® stabiliser in 2018, the company's next-generation nitrification inhibitor for use with anhydrous ammonia and urea ammonium nitrate (UAN), was followed by the launch of ANVOL® stabiliser in 2019. This nitrogen stabiliser combines NBPT, the urease inhibitor found in AGROTAIN® stabiliser, with Duromide to deliver longest-lasting protection against ammonia volatilisation compared to NBPT alone.

How has the market responded to the introduction of new nitrogen stabilisers such as CENTURO® and ANVOL® – and have they acted as a spur to adoption and a boost to growth?

For years, growers have worked to fine-tune and optimise their NPK inputs. They adopted good management practices such as employing the 4R Nutrient Stewardship framework when thinking through these applications. Part of that has been utilising our CENTURO® and ANVOL® nitrogen stabilisers to get the most out of their fertilizer investment.

Nitrogen stabilisers allow growers to optimise their nitrogen rate. A theme found in KAS's third-party research is the higher the nitrogen application rate, the higher the loss a grower can experience as a percentage of the nitrogen applied. Simply put, applying pounds of unprotected nitrogen can translate to additional losses which can mean reduced return on investment.

Nitrogen stabilisers, such as CENTURO and ANVOL, are tools to enable growers to have the confidence of applying nitrogen at the right rate, which is in line with the 4R Nutrient Stewardship framework. There are several factors that are setting up to make these technologies even more critical to a grower's operation, and we anticipate continued growth in these stabiliser practices.

An expanding portfolio

Following on from this, will innovation and new products remain an important priority for KAS, as it seeks to grow the market and overcome remaining market barriers?

KAS is committed to adding value for our current and future customers. As a leader in plant nutrients, we continue to build strong relationships with our customers and work to provide solutions that are aligned with their growth strategies.

We are always looking to expand KAS's role from nitrogen management into nutrient management leadership by building a portfolio of plant nutrition products that work to improve the efficiency, uptake and utilisation of nutrients, adding value to farmers and global food production.

The acquisition of the Compass Minerals micronutrient assets in May 2021 has made KAS an even more robust crop nutrition solutions provider across the world. The goal over the last year was to smoothly transition the WOLF TRAX™ DDP® micronutrients and PROTIVATE™ (formerly ROCKET SEEDS®) nutritional seed enhancer products into the KAS portfolio.

That product portfolio furthers KAS's commitment to help farmers around the world improve nutrient efficiency, utilisation, and uptake. These efforts match with KAS's vision of becoming a leader as a nutrient efficiency solutions provider.

Educating the market

The market nowadays is as much about providing services to farmers as it is about supplying products. Indeed, they are increasingly being integrated as part of a single, seamless package. Does market education remain important and, if so, what's the best way to communicate the agronomic, environmental and economic benefits of stabilised fertilizers – and are their particular key messages that growers respond to?

There is still a large opportunity to continue to educate on the value enhancers and additives in a nutrient management plan, especially against the backdrop of today's input and commodity prices. There are many misconceptions when it comes to nitrogen loss or how certain nutrients work within a cropping system. KAS is working with our customers and providing educational materials that can be found on our website (KochAgronomicServices.com) to better understand how our solutions can assist in overcoming limiting factors when it comes to nutrient management plans.

Improving nutrient use efficiency

Will stabilised fertilizers, in your view, have an important role to play in delivering the necessary NUE improvements required over future decades?

Nitrogen stabilisers protect against losses due to unpredictable weather conditions and other nitrogen loss factors. These solutions also allow a grower to get the most out of their nitrogen investment and optimise nutrient use efficiency (NUE). As growers become more attuned to their inputs and maximise their yields, we anticipate continued growth for these technologies. ■

New additions to the KAS product portfolio

WOLF TRAX DDP micronutrients are specially formulated to simplify nutrient management, boost crop performance and maximise the fertilizer investment made by farmers. WOLF TRAX is uniquely designed to coat onto dry fertilizer blends by incorporating patented EvenCoat® Technology. WOLF TRAX delivers high nutrient availability through better distribution in the field in comparison to traditional granular micronutrients. As a result, growers have confidence that their crops are receiving the right amount of micronutrients close to growing roots – improving micronutrient use efficiency, addressing deficiencies and promoting crop performance.

PROTIVATE nutritional seed enhancer provides young crops with the critical nutrients needed for optimal establishment. By applying proprietary blends of nutrients directly to the seed, PROTIVATE is specifically tailored to provide early season nutrition. This maximises emergence and resilience for a variety of crops, from corn and soybean to cotton, wheat, canola, alfalfa and more. The PROTIVATE portfolio features three formulations and application methods that match with the available equipment used by growers or retailers. PROTIVATE also boasts an additional operational advantage by functioning as a talc replacement, working as a seed-drying source even in high humidity conditions. By encouraging better seed singulation, this helps to avoid costly skips and doubles during planting. ■

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New biodegradable CRF coating technology

ICL has developed a new generation of rapid biodegradable coatings for its controlled-release fertilizer (CRF) portfolio. The new coating technology reduces the environmental footprint of CRFs and will help farmers meet the requirements of Europe's Green Deal. This patented innovation, named eqo.x, coats nitrogen fertilizers for field grown crops. Eqo.x has already been fully tested in the field – and shows excellent results in terms of production, nutrient use efficiency, volatilisation and leaching reduction. **Ronald Clemens**, ICL Global Marketing & Portfolio Manager CRF, explains the benefits.

CRFs rise to the sustainability challenge

One of the main challenges facing today's farmers is the changing regulations governing fertilizer inputs. For example, Europe's Green Deal, which includes the Farm-to-Fork strategy, aims to minimise the environmental footprint of agriculture. The reduction of fertilizer losses by at least 50 percent by 2030 is an important pillar of this strategy.

Controlled-release fertilizers (CRFs) can play a key role in meeting these Green Deal requirements. They increase nutrient use efficiency (NUE) – by maintaining or increasing yields while lowering the fertilizer input – reduce nutrient losses, and often only require one application for the entire season.

ICL has been testing CRFs in the field for decades, proving how they can reduce fertilizer inputs, while maintaining yields, and at the same time reduce nitrogen losses, ammonia volatilisation, and nitrous oxide (N_2O) emissions.

Biodegradable technology for sustainable farming

To meet the future requirements of the new EU Fertilising Products Regulation (2019/1009), ICL has been (and still is) developing sustainable innovations for its CRFs. The company has just launched its new generation of rapid biodegradable coatings: eqo.x. This biodegradable release technology has been thoroughly field tested – showing the same or better production results with consistent and fully predictable release patterns.

Ronald Clemens says: "Sustainability and high nutrient use efficiency are ICL's focal points in respect of its specialty fertilizers to the agriculture markets. With this innovation we create a sustainable solution from various angles, delivering a solution towards the Farm-to-Fork strategy in Europe, and making it possible for farmers to reduce fertilizer rates without losses in yield. In that respect, this innovation is ahead of the present regulations and ready for future standards coming."

ICL's R&D department in the Netherlands is renowned for its coating expertise. The department's expert team of coating specialists, drawn from various industries, have managed to 'crack the code' by creating the first of a new generation of rapid biodegradable coatings. These will help create more sustainable farming systems, as Ronald Clemens explains: "We have been working on the topic of faster biodegrading coatings, combined with maximum field performance, for the last 15 years. For controlled-release nitrogen fertilizers for soil grown crops, we are ready now. The eqo.x release technology is protected by patent and ICL is investing in a new production line in the Netherlands."

Coating technologies over the years

ICL's Osmocote pioneered the CRF market, having been introduced more than 50 years ago as the first polymer coated fertilizers on the US market. These NPK granules, encapsulated with an organic resin coating, ensured that one nutrient application to crops was enough for a prolonged period of time.

Osmocote's market introduction marked the start of a whole new principle in fertilizer application. In the decades that followed, new generations of fertilizer coatings were developed. These helped match nutrient release much more closely to plant demands, without any peaks or dips in the nutrient supply to crops. E-Max release technology is the current polymer coating that ICL incorporates in its CRF products for the agricultural market.

ICL's newest biodegradable coating, eqo.x, is set to be one of the most important innovations and technological launches since the first CRFs were introduced on the market. It is expected, once again, to shape the future of fertilization.

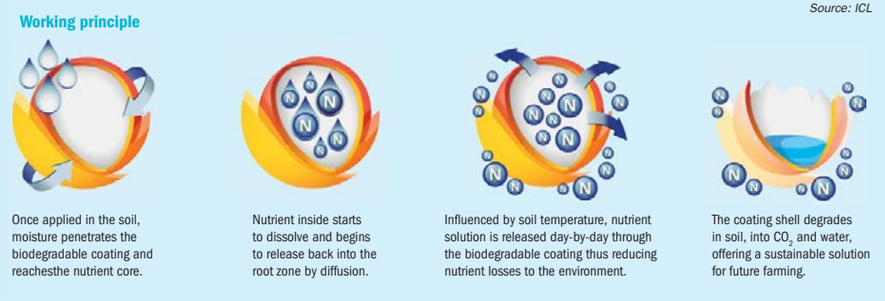
"We see this as a huge step forward in the use of enhanced efficiency fertilizers for the agricultural market," comments Ronald Clemens. "The biodegradable release technology will be able to reduce all kinds of nutrient losses, and combines this with all the known advantages of CRFs, like the possibility to reduce application frequency and rates."

Consistent and predictable nutrient release

One of the key characteristics of high quality CRFs is that farmers can always rely on their performance. A consistent and predictable nutrient release pattern is essential to match the plant's demands – and the performance of each bag of fertilizer product should always meet these expectations.

Eqo.x technology shows the same high performance and reliability as currently used technologies (Figure 1). Ronald

Fig. 1: **The working of eqo.x technology is similar to existing coating technologies**



Clemens explains how the new biodegradable coating functions:

"The coating works similar to our existing coatings. The soil temperature is affecting the speed of release in a similar way as the E-Max coating is doing. That makes it easy for the farmer to use the products, as both the application as well as the performance will not change. The new technology includes an improvement in release patterns, making the CRFs with eqo.x technology even more reliable and predictable than before. And after the longevity ends, the coating shells will degrade even faster to CO_2 and water, leaving no trace behind."

Reducing nutrient losses to the environment

The amount of nutrient loss and how it occurs (volatilisation, leaching or denitrification) depends on the type of fertilizer, the soil to which the fertilizer is added and the weather conditions. The challenge is to maximise the nitrogen (N) efficiency of fertilizers and minimise the risk of environmentally-problematic N losses (Figure 2). The use of enhanced efficiency fertilizers (EEFs) such as CRFs offers one successful route to minimise the risk of losses.

Based on the latest trial results, nitrogen losses from conventional urea can be as high as 40-50 percent of total applied N. CRFs, in contrast, limit these losses substantially, being able to reduce both nitrogen losses and improve NUE, in comparison to conventional urea.

Results of the NMI lab trial

The environmental impacts of CRFs with eqo.x technology were evaluated by NMI (Nutrient Management Institute B.V.) in a recent lab trial. The institute measured nitrogen losses by leaching, volatilisation and denitrification, and compared these results to conventional fertilizers.

In the NMI experiment with red beet, a CRF with eqo.x technology was compared to conventional urea applied at the same time and the same rate. Results are shown graphically in Figures 3-9.

In the NMI trial, the CRF reduced N leaching by 54-61 percent (Figure 3) and reduced NH_3 volatilization by up to 54 percent (Figure 4), versus conventional urea. The N_2O losses were also significantly higher for conventional urea in the first 30-40 days, whereas the CRF reduced N_2O emissions by 11 percent overall (Figure 5).

Some 40-50 percent of N applied was lost to the environment using conventional urea (Figure 6). The CRF, in comparison, limited these losses to only 16 percent (Figure 7). Encouragingly, N uptake also increased and, in general, the experiment

Fig. 2: **Most of the nutrient losses occur via NH3 volatilisation, NO_3 leaching and denitrification (N_2, N_2O)**

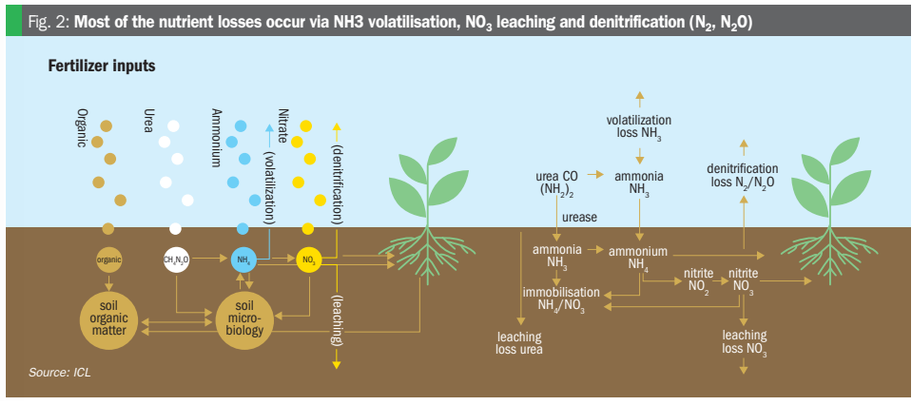


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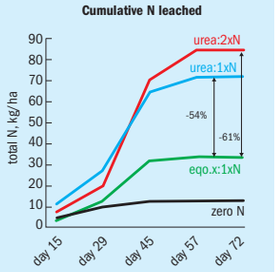
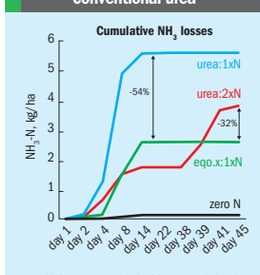
Fig. 3: **Nitrogen lost due to leaching, eqo.x vs. conventional urea**



Using urea coated with eqo.x technology, total N lost by leaching was reduced by between 54-61 percent after 72 days, compared to conventional urea.

Source: NMI/ICL

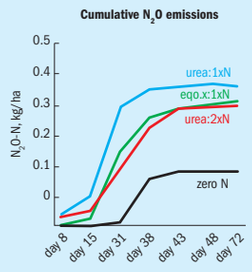
Fig. 4: **Nitrogen lost due to NH_3 volatilisation, eqo.x vs. conventional urea**



Using urea coated with eqo.x technology, N losses from NH_3 volatilisation were reduced by 54 percent after 14 days, compared to conventional urea applied at the same time and rate (blue). When compared to a split application of urea, a reduction in N losses of 32 percent was achieved after 45 days (red).

Source: NMI/ICL

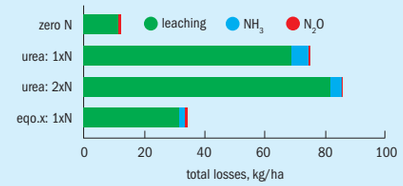
Fig. 5: **Nitrous oxide losses, eqo.x vs. conventional urea**



Using urea coated with eqo.x technology, N_2O losses were reduced by 11 percent after 72 days, compared to conventional urea applied at the same rate.

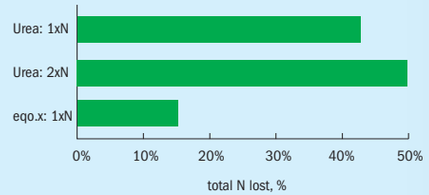
Source: NMI/ICL

Fig. 6: **Approximatively 40-50% of applied N is lost to the environment using conventional urea**



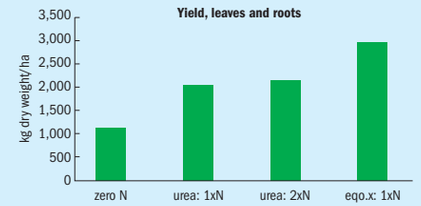
Source: NMI/ICL

Fig. 7: **Eqo.x coated urea limits N losses to only 16 percent of total applied N**



Source: NMI/ICL

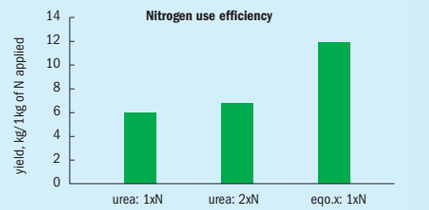
Fig. 8: **CRFs with eqo.x increased nutrient use efficiency (NUE)* by 83 percent in comparison to conventional urea**



**Nitrogen Use Efficiency, calculated as Agronomy Efficiency = (Y–YO)/F*
Y = Yield of harvested portion of crop when the said nutrient is applied,
YO = Yield of harvested portion of crop when the said nutrient is not applied,
F = Application rate of said nutrient.

Source: NMI/ICL

Fig. 9: **Eqo.x coated urea delivered significant yield increases compared to conventional urea***



**By limiting nitrogen losses, more nitrogen was made available for plant uptake. The plants therefore produced more when the CRF was applied at the same nitrogen application rate per hectare.*

Source: NMI/ICL

demonstrated an 83 percent NUE increase (Figure 8).

Importantly, the CRF with eqo.x technology is capable of achieving higher or similar crop yields with less fertilizer. Trial results with the CRF showed a significant yield increase of 37 percent, versus conventional urea, at the same N application rate per hectare (Figure 9).

"These results confirm our thoughts that with CRFs we are able to improve nutrient use efficiency by reducing fertilizer rates, and at the same time lower nutrient losses, without farmers losing their yields," comments Ronald Clemens.

Increased nutrient use efficiency with eqo.x

Wide ranging trials with eqo.x technology have all shown an increase in NUE (e.g., Figure 8). This is to be expected with a CRF, says Ronald Clemens: "The technology contributes to reducing nutrient losses and improved nutrient use efficiency. It will help farmers to maximise their yields. Official trials were done with trial institutes and universities from North to South Europe, in various conditions. We have tested in crops like potatoes, but also in very hot conditions in rice cultures where the product is fully under water. We have tested the release specifications in the lab under various temperature regimes, in water and in soil as well as under practical circumstances. In all those conditions the nutrient use efficiency was significantly increased, giving better results than growers practices in terms of yield, number of applications or application rates."

What's next

From 2023 onwards, ICL will start to gradually deliver eqo.x technology to the market in its Agrocote and Agromaster formulations. In the meantime, the company's R&D team is continuously working on new solutions.

"We are extremely happy with this innovation, being available already now so that we are prepared towards the future," sums up Ronald Clemens. "The next step is that more of our coating technologies will move to a faster degradability." ■

The benefits of CRFs

- Controlled-release fertilizers (CRFs) are a precision nutrition technology that release nutrients over a longer period of time through a special coating. This resulting nutrient release pattern closely matches the needs of crops throughout the growing season.
- CRFs play a key role in modern agriculture by improving yields, reducing nutrient losses, and minimising fertilizer application rates.
- CRFs have environmental benefits in comparison to conventional fertilizers, as their use allows growers to cultivate high-quality plants efficiently with a significant reduction in nutrient leaching to both soil and groundwater.
- As such, CRFs are part of the solution in helping meet the future target to reduce nutrient losses in EU agriculture by 50 percent, as set out in the Farm-to-Fork Strategy, the Zero Pollution Action Plan, and EU Soil Strategy for 2030. ■

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Calcium and magnesium: secondary nutrients of prime importance

The drive for ever higher crop yields is shifting the focus onto secondary nutrients such as calcium and magnesium. In this article, we look at the role of magnesium and calcium in crop nutrition and the main fertilizer product options.

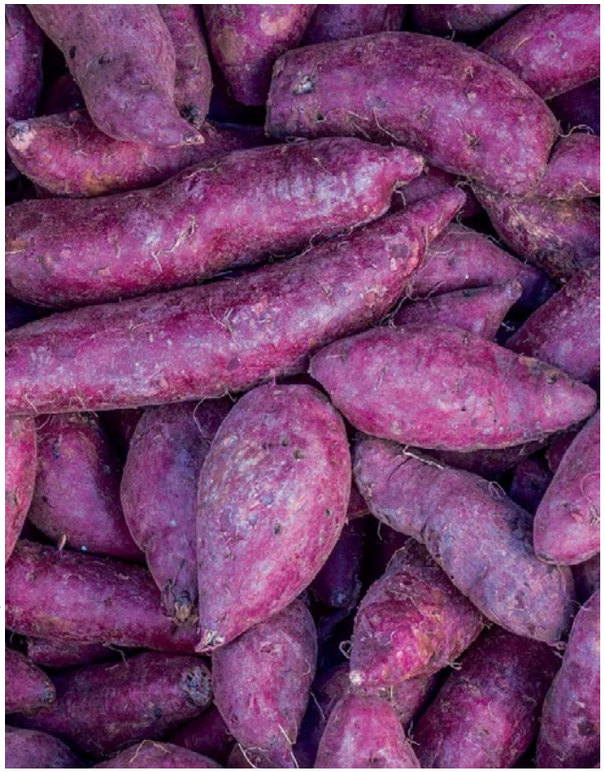


PHOTO: RUNGSURIYA CHAREESRI/SHUTTERSTOCK.COM

The quality and yield of crops such as potatoes benefit from the supply of secondary nutrients calcium and magnesium.

Although calcium and magnesium, alongside sulphur, are classed as secondary nutrients, they are as important for balanced crop nutrition as any of the other 14 essential plant nutrients. The calcium requirement of some crops can even exceed that of the primary nutrient phosphorus.

Yet the most commonly applied commodity fertilizers – urea, DAP/MAP (diammonium phosphate/monoammonium phosphate) and MOP (muriate of potash) – notably lack the presence calcium and magnesium. The resulting crop deficiencies can be yield limiting.

Other fertilizers such as polyhalite can supply all three secondary nutrients – Ca, Mg and S – in a plant available form.

As well as being necessary for balanced fertilization, calcium can improve the storage properties and shelf life of produce, while magnesium is vital for photosynthesis.

Calcium – the strength nutrient

Calcium (Ca) is generally needed in moderate amounts by plants, being typically present in growing shoots at between 0.1 to 5 percent dry weight[1].

Described by some as "the premier of the soil's nutrient elements," Ca is necessary in plants for protein production, cellular growth and improves disease resistance by protecting against microbial pathogens such as fungi and bacteria. Specifically, Ca maintains the stability and rigidity of plant cell walls and is essential for root growth and function[2].

According to The Mosaic Company: "Calcium is a low-key essential nutrient that carries a heavy load in plant growth. Too often, it takes a backseat as soil fertility programmes developed for many high-yield and high-quality crops. Peanut and tomato growers are probably exceptions in their emphasis on good calcium nutrition."

High Ca demanding crops include alfalfa, almonds, apples, peanuts, potatoes and tomatoes. Canola is also reported to have around twice the Ca demand of wheat. Typical Ca removal rates by crops range from around 1.1 kg/ha for barley and wheat (2.7 t/ha yield) to 125 kg/ha for alfalfa (9.8 t/ha yield).

Increasing the calcium concentration in onions, apples, pears and potatoes has been shown to improve[2]:

- Crop quality
- Resistance to disease and environmental stress
- Storage of produce.

Yara International suggests that calcium fertilizers such as calcium nitrate can improve plant health and deliver more valuable crops and produce by:

- **Extending shelf-life and preserving quality.** Fruit and vegetables stay fresher looking for longer, resulting in high quality produce with the potential for higher prices.
- **Strengthening cell walls.** Calcium binds cells together and plays an important role in the cell structure.
- **Increasing stress resistance.** A good supply of calcium helps crops tolerate a wide range of stresses making them less susceptible to disease and minimising physiological disorders.

Some of the main crop benefits of Ca are shown in Figure 1.

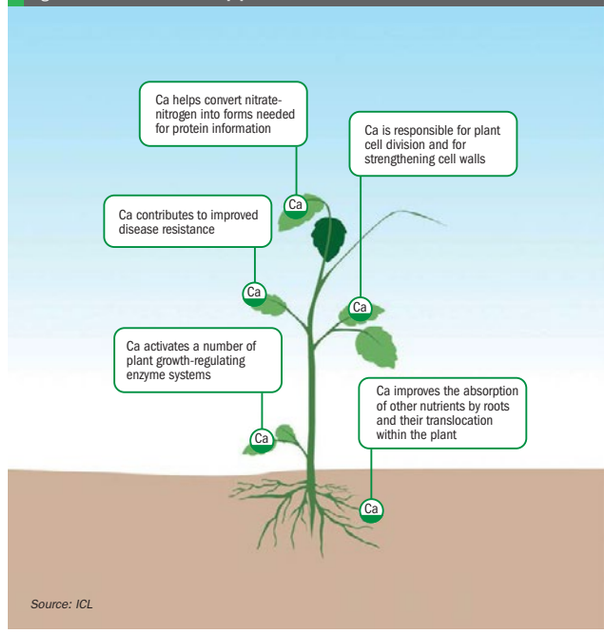
The Ca content of non-calcareous, temperate soils normally ranges from 0.7-1.5 percent, while highly weathered tropical soils typically have a much lower Ca content (0.1- 0.3 percent). Calcareous soils, in contrast, can contain as much as 25 percent calcium.

The concentration of Ca in soils and its availability to crops is influenced by pH, cation exchange capacity (CEC) and soil type. In general, Ca deficiency is more likely in crops grown on sandy soils with a low CEC[2].

Costly Ca-deficiency disorders in fruit and vegetables include:

- 'Tipburn' and 'brown heart' in leafy vegetables
- 'Black heart' in celery
- 'Blossom end rot' in watermelon, pepper and tomato fruit
- 'Bitter pit' in apples
- 'Empty pod' in peanut
- Cracked skin in tomato, cherry and apple fruit.

Fig. 1: **Role of calcium in crop production**



Source: ICL

Fertilizing with calcium

Common calcium sources are shown in Table 1. These include relatively insoluble liming materials, such as calcitic limestone, used to correct acid soil pH – generally known as aglime (agricultural lime). Most acidic soils which have been treated with aglime will have an adequate plant-available supply of Ca. Gypsum is also commonly applied as a soil amendment in countries such as Brazil to improve the chemical and physical properties of tropical soils.

Soluble Ca fertilizers such as calcium nitrate are applied at specific growth stages in high-value tree and vegetable crops to boost calcium uptake[2]. These can be soil-applied as a dry fertilizer or applied via fertigation in water-soluble or

Table 1: **Common calcium sources**

Product	Ca content, %
Calcitic limestone ($CaCO_3$)	32
Gypsum ($CaSO_4 \cdot 2H_2O$)	22
Triple Superphosphate ($Ca(H_2PO_4)_2.H_2O$)	15
Calcium nitrate ($Ca(NO_3)_2$)	19
Calcium ammonium nitrate solution	8
Calcium chelates	2-5
Calcium Thiosulfate (CaS_2O_3)	6
Calcium Chloride ($CaCl_2$)	36

Source: TFI

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fluid form. Periodic foliar applications of soluble Ca fertilizers during the growing season are also common for fruits and vegetables to correct deficiencies and improve crop quality.

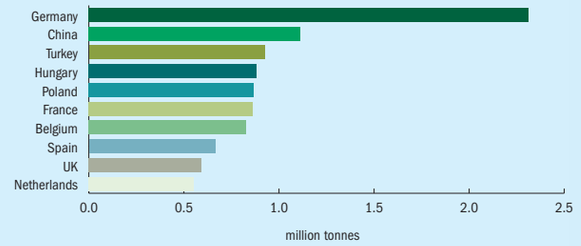
Some popular calcium fertilizers and their properties are highlighted below.

Calcium ammonium nitrate (CAN)

The delivery of nitrogen in nitrate form can deliver superior yields and quality in arable, fruit and vegetable crops. Because of this, the popularity of nitrate fertilizers – including calcium ammonium nitrate (CAN) and calcium nitrate (CN) – continues to grow.

Global CAN production reached 15.9 million tonnes in 2019. Distinct regional markets for nitrates reflect both grower preferences and regulations. In Europe, for example, restrictions on the sale of straight AN – due to its potential for misuse – has created a sizeable market for CAN. Consequently, EU countries together with Turkey are now responsible for more than half of global CAN consumption (Figure 2) (*Fertilizer International* 503, p28).

Fig. 2: **Apparent consumption of CAN for the ten leading consuming countries, 2019**



Source: IFA

Calcium nitrate

Agricultural calcium nitrate (CN, 15.5-0-0+26.3CaO) products are typically manufactured from nitric acid and calcium carbonate (limestone). They are available as both liquid fertilizers [45% $Ca(NO_3)_2$] and in solid crystalline form [$Ca(NO_3)_2.4H_2O$]. Global output is estimated at around 2.3-2.5 million tonnes p.a. (*Fertilizer International* 503, p28).

Yara through its YaraLiva range is the largest CN producer globally. The company's market-leading products include soil-applied YaraLiva TROPICOTE and the water-soluble greenhouse-grade YaraLiva CALCINIT.

CN is widely used in fertigation and hydroponic systems. Soil-applied products, meanwhile, due to their calcium content, can improve the texture of clayey soils, improve soil water retention and soil oxygenation, and help release exchangeable nutrients held by the soil.

Standard CN is relatively impure, containing around seven percent of total nitrogen in ammonium form. This level of ammonium, linked to the presence of ammonium nitrate, can be deleterious to the yield and quality of fertigated greenhouse crops. Uralchem and Prayon have both responded to this perceived problem by bringing high-purity anhydrous CN products (17-0-0+33CaO) to market.

Belgium's **Prayon** added Calcium Nitrate EXTRA to its Hortipray® range at the end of 2016. This highly-concentrated, water-soluble product boosts calcium content from 25 percent to 33 percent (CaO), compared to standard calcium nitrate. It also guarantees that at least 17 percent nitrogen content is available as nitrate.

Calcium carbonate – combatting soil acidity

Globally, acid soils with a pH below 5.5 occupy about 30 percent of the land surface and are estimated to reduce crop productivity by around 40-50 percent. Traditionally, liming has been the most common method for neutralising widespread soil acidity and keeping soil pH within a range that is favourable for crop production. This typically involves the addition of calcium- and magnesium-rich materials to soils such as chalk, limestone, burnt lime or hydrated lime. It is common for farmers to apply large quantities of limestone (aglime) to their land every 5-10 years – with the general aim of improving soil productivity.

Omya recently launched the soil amendment product Calciprill®. This high-quality form of natural calcium carbonate is designed for precise correction of soil acidity. Calciprill consists of micronised ultrafine particles (0.7-100 µm) that have been granulated into 2-6 mm diameter prills for easy application. Calciprill's purity means its neutralising value is equal to or better than traditional aglime.

Calciprill granules can be applied in precision agriculture with standard fertilizer spreaders before, during or after planting, at times when the change in pH most benefits crop growth. Once in the soil, the granules disintegrate easily, increasing pH where it is needed, especially in the crop root zone.

By correcting soil pH, Calciprill improves the plant availability of soil nutrients. It also provides crops with essential calcium throughout their growth cycle, enhancing crop health and quality, suggests Omya (*Fertilizer International* 509, p22).

Calcium thiosulphate

Tessenderlo Kerley International markets the calcium thiosulphate fertilizer CaTs® as a versatile source of liquid calcium and sulphur. This clear liquid fertilizer contains six percent calcium and 10 percent sulphur. It is offered as a chloride- and nitrate-free liquid calcium source for fertigation, foliar spaying and direct application to soil.

As well as supplying two key nutrients, calcium thiosulphate also behaves as an activator – improving overall fertilizer efficiency by enhancing the uptake of other nutrients. In addition, it functions as a soil conditioner and amendment, helping to reduce the harmful effects of sodium on soils, for example.

Normal soils are well structured and contain aggregates able to resist erosion. The pore spaces between these aggregates hold water, as well as providing it with a pathway to drain, and offer a good medium for healthy crop roots. Such soils are described as 'flocculated'. The aggregates in soils containing too much sodium, in contrast, are unstable and separate to become 'dispersed'. The resulting poor structure of these degraded 'sodic' soils make it more difficult for plants to root and for water to penetrate.

Conventional Ca sources such as limestone or gypsum can be used as soil conditioners to treat sodic soils. They function by displacing sodium with calcium, although their effectiveness is hindered by their limited solubility. Calcium thiosulphate, in contrast, being a liquid product, is more effective at displacing sodium, because its calcium ions can quickly enter the soil solution.

Applying calcium thiosulphate to sodic soils helps to reduce crusting problems, improves water infiltration, and leaches out sodium, according to Tessenderlo. The thiosulfate present in products like CaTs® can also liberate additional calcium from any aglime present. These valuable properties suggests that calcium thiosulphate has a role to play in regenerating degraded soils by helping to improve soil health and structure.

Table 2: **Magnesium fertilizers: selected mineral/chemical sources**

Mineral Solubility	Chemical formula	Mg content %	Mg content g/L
Soluble sources:			
Magnesium chloride	$MgCl_2$	25	560
Kieserite	$MgSO_4.H_2O$	17	360
Langbeinite	$2MgSO_4.K_2SO_4$	11	240
Magnesium nitrate	$Mg(NO_3)_2.6H_2O$	9	1,250
Magnesium sulphate (Epsom salt)	$MgSO_4.7H_2O$	9	357
Semi-soluble sources:			
Magnesium oxide	MgO	56	-
Magnesium hydroxide	$Mg(OH)_2$	40	-
Dolomite	$CaMg(CO_3)_2$	20	-
Hydrated dolomite	$MgO.CaO/MgO.Ca(OH)_2$	18-20	-
Struvite	$MgNH_4PO_4.6H_2O$	10	-

Source: Mikkelsen (2010)

Magnesium – essential for plant growth

Magnesium (Mg) is an essential, if frequently overlooked, plant nutrient. It is instrumental in many plant functions, being present in vegetative dry matter at between 0.2-0.4 percent concentration. The element is a key component of chlorophyll, with each molecule containing 6.7 percent magnesium. It is therefore vital for photosynthesis, as well as playing an important role in the synthesis of starches, sugars, amino acids, proteins, vitamins and oils (*Fertilizer International* 502, p34).

Mg increases plant productivity by boosting photosynthesis, mobilising carbohydrates, promoting the uptake of other nutrients including phosphorus (P), and functioning as an enzyme activator. Additionally, it acts as a P carrier in plants and regulates cellular respiration. Mg also helps create strong root systems, and increases resistance to pests, fungal attack and disease in leaves, seeds and fruit. Overall, Mg creates stronger, healthier and nutrient-rich crops with increased yields (*Fertilizer International* 455, p19).

According to a recent review of the role of magnesium fertilizers, an optimal supply of Mg improves the stress tolerance of crops and increases the yield and quality of harvested products[3].

Mg is an activator for many critical enzymes. Without sufficient Mg, photosynthesis and enzyme activity within the plant decreases and chlorophyll begins to degrade in the older leaves of plants. This causes the main symptom of Mg deficiency, chlorosis – shown by yellowing between leaf veins which remain green (*Fertilizer International* 455, p19).

Magnesium deficiency occurs most frequently in low pH, sandy soils where Mg can be easily leached away. Soil testing to identify potential deficiencies is therefore recommended. Mg assimilation by plants is also depressed in the presence of high levels of soil aluminium (Al^{3+}) which have a detrimental effect on root growth. Excess potassium (K) can also negatively affect Mg availability.

Magnesium fertilizers and crop requirements

A number of different Mg fertilizer options are available to meet crop demands (Table 2). These are typically divided into semi-soluble and soluble sources. For semi-soluble Mg fertilizers, particle size largely determines their dissolution rate in soils.

Magnesium removal by crops depends on soil Mg supply, growing conditions, crop type and target yields. At the top end, high-yielding sugarbeet and forage crops can remove Mg at rates of 90 kg/ha and 56 kg/ha, respectively. In general, cereal crops remove smaller amounts of Mg at harvest compared with root crops and many fruit crops[4].

While Mg is essential for all plants, the following crops are said to be especially responsive to Mg fertilization: alfalfa, blueberry, beet, broccoli, cabbage, cauliflower, celery, clover, conifers, corn, cotton, cucumber, eggplant, lettuce, onion, pepper, potatoes, pumpkin, spinach, squash, tobacco, tomato, and watermelon. Applying Mg fertilizers to grassland, wheat and potatoes has also been shown to be beneficial[3] (*Fertilizer International* 502, p34).

Mg fertilizer applications are necessary to ensure balanced nutrient supply to both pasture and animals. The removal of soil Mg without sufficient resupply generally causes significant falls in available Mg in grassland soils.

Mg is important for both the quality and yield of wheat and other cereals. Carbohydrate translocation and therefore optimal grain filling is supported by available Mg. Thousand-grain weight, one of the most important wheat-grain quality parameters, is generally negatively affected in Mg-deficient soils. Processing properties, such as milling behaviour during flour production, are also known to be directly related to plant Mg content.

Mg is known to be a key determinant of potato quality and yield. It has a direct effect, for example, on starch content and therefore the 'mealiness grade' of cooking potatoes. Tuber firmness is a major quality parameter – because it prevents bruising and various forms of discolouration during harvest, transport and storage – and is improved by Mg supply. Mg is also thought to decrease the incidence of black spot and prevent the discolouration of pulp during potato processing.

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Potassium magnesium sulphate (SOPM)

Potassium magnesium sulphate ($K_2Mg_2(SO_4)_3$, SOPM, 11% Mg) is manufactured by extracting and processing naturally-occurring deposits of the mineral langbeinite. SOPM is valued as a fertilizer for its magnesium and sulphur content, as well as being a chloride-free source of potassium.

SOPM has been mined in the United States for over 70 years from what The Mosaic Company calls "the world's largest and purest deposits of langbeinite ore" at Carlsbad, New Mexico. Two producers, **Mosaic** and **Intrepid Potash**, mine and manufacture SOPM at Carlsbad and market this under the brand names *K-Mag*® and *Trio*®, respectively. Mosaic produces around 600,000-700,000 tonnes of *K-Mag*® annually from around 3.0-3.4 million tonnes of mined ore, while Intrepid produced 228,000 tonnes of finished product in 2019 from 935,000 of mined ore.

Magnesium nitrate

Magnesium nitrate ($Mg(NO_3)_2.6H_2O$, 9% Mg) is widely used in the horticultural sector to supply water-soluble Mg alongside nitrogen (N).

Commercial grades are typically manmade products synthesised by reacting nitric acid with magnesium metal or magnesium oxide. Magnesium hydroxide and AN also react to form magnesium nitrate, releasing ammonia as a by-product (*Fertilizer International* 455, p19).

Haifa Chemicals of Israel supplies water-soluble magnesium nitrate (11-0-0+16MgO) under the Magnisal™ brandname. The product is marketed at a range of crops, including barley, citrus, cucumber, deciduous fruit trees, grapes, mango, olive, potato, tomato and winter wheat.

ICL offers the fully water-soluble magnesium nitrate product Select Magnific (11-0-0+15.5MgO). This crystalline fertilizer, provided in whitish flakes, is designed for fertigation and foliar use, and is recommended for field crops, orchards, flower crops, as well crops grown under protection in polytunnels or greenhouses.

Magnesium chloride

Magnesium chloride ($MgCl_2$, 25% Mg) is sold as both a water-soluble and liquid fertilizer.

ICL operates the world's largest magnesium chloride production plant at its Dead Sea Works (DSW) complex in Israel. **Compass Minerals** is the only US producer of naturally occurring magnesium chloride, harvesting this from the Great Salt Lake in Utah. The company markets this as an early-stage plant nutrient for wheat crops. It is also sold in North America as stand-alone de-icer or de-icing additive, and as a dedusting/stabilising agent for gravel roads.

Kieserite and Epsom salt

Germany's **K+S** is the leading international producer of magnesium fertilizers derived from naturally occurring kieserite ($MgSO_4.H_2O$, 17% Mg) and Epsom salt ($MgSO_4.7H_2O$, 9% Mg) (*Fertilizer International* 502, p34).

According to the company, magnesium is an undervalued yet irreplaceable macronutrient for crop production due to its many beneficial effects on plant growth, yield and quality. Mg is an essential crop nutrient, according to K+S, due to its roles in root growth, and carbohydrate production and transport, all of which influence the uptake of nutrients from the soil. Agronomic evidence collated by K+S also suggests that Mg is an especially valuable plant nutrient under climate change conditions– when plants are subjected to drought, strong radiation and heat stress.

The basic Mg and S needs of crops can be covered by soil fertilizers such as ESTA® Kieserit, Korn- Kali® or Patentkali®, according to K+S. Additionally, crops can be supported during different growth stages by applying a foliar fertilizer such as of EPSO Top®. This contains Mg and S in combination with micronutrients such as manganese, zinc or boron. Early applications of EPSO Top® promote root growth, while applications during later growth stages support the transport of assimilates from the leaves to grain, roots or tubers.

Sinomagchem (Yingkou Magnesite Chemical Ind Group Co Ltd) is based in Dashiqiao – the so-called 'magnesite metropolis' – in China's Liaoning Province. It extracts magnesite from Dashiqiao's large-scale deposits to manufacture up to 500,000 t/a of magnesium sulphate and 200,000 t/a of magnesium oxide.

The company is China's largest manufacturer and exporter of chemically-produced magnesium sulphate fertilizers. Its product range includes fertilizer-grade:

- Magnesium sulphate (kieserite)
- Magnesium oxide
- Boron-and zinc-enriched magnesium fertilizers (Mg plus B, Mg plus Zn).

Polyhalite

Unlike the other Ca and Mg sources highlighted in this article, the natural mineral polyhalite ($K_2Ca_2Mg(SO_4)_4.2H_2O$) combines all three secondary nutrients (Ca, Mg and S) in a single fertilizer.

ICL, for example, manufactures the established and popular FertilizerpluS product range using polyhalite extracted from its Boulby mine in the UK. **Anglo American** is also investing heavily in the nearby under-development Woodsmith Mine near Whitby on England's North Sea coast. This massive deep mine project will extract the company's polyhalite product POLY4 from the same UK mineral deposit (see accompanying article on p33).

ICL recently expanded its FertilizerpluS product portfolio by adding two new product lines – ICL NPKpluS and Polysulphate Premium (*Fertilizer International* 509, p22).

NPKpluS is a new NPK line developed in response to rising demand for magnesium and calcium and the increasing importance of sulphur as a nutrient. The product's nutrient composition – with three soluble sulphates of magnesium, potassium, and calcium – guarantees more complete and efficient crop fertilization and improves yields compared to traditional fertilizer practices, according to ICL.

NPKpluS is produced by ICL at plants in China (prilling) and Ludwigshafen, Germany (blending) and is available in a variety of formulations. Blends can incorporate zinc and/or boron, for example, if required.

Polysulphate Premium contains uniform, robust spherical granules formed by granulating powdered polyhalite. These have an attractive appearance and blend easily with other granulated fertilizers. The smooth surface of granules protects against abrasion, humidity and damage, while their spherical shape guarantees a steady flow and a consistent broad spread during field application. ■

References

1. White, P. & Broadley, M., 2003. Calcium in Plants. *Ann Bot*, 92(4), 487-511.
2. Flis, S., 2019. Calcium: Improved plant health and nutrition through 4R management. *Crops & Soils*, 52(4), 28-30.
3. Senbayram, M. et al., 2015. Role of magnesium fertilizers in agriculture: plant-soil continuum. *Crop & Pasture Science*, 66, 1219-1229.
4. Mikkelsen, R., 2010. Soil and Fertilizer Magnesium. *Better Crops*, 94(2), 26-28.

Fuelling balanced crop nutrition with POLY4

The fertilizer price and supply chain shocks caused by the war in Ukraine have supercharged the debate about the shift to more sustainable and efficient crop nutrition – with farmers and governments urgently looking for different approaches to maximise crop productivity.

Anglo American's Scott Yarwood (right) discusses POLY4 cereal trial results with an EU farmer.

The almost threefold rise in average fertilizer prices since mid-2021 was singled out by Qu Dongyu, director-general of the UN Food and Agriculture Organization, at a meeting of the G20 in July. He highlighted the risks to global food production from fertilizer supply shortfalls in the upcoming planting season. Qu made it clear that now, more than ever, farmers need to produce more from less by making better and more efficient use of fertilizers.

Throughout the agricultural industry, such high-level concerns have brought about a renewed focus on maximising nutrient use efficiency – whether through the adoption of alternative practices, technologies or products.

Back to basics to move ahead

"If we want to take efficient and sustainable crop nutrition seriously, we really need to go back to first principles," says Ross Mitchell, head of agronomy at Anglo American's Crop Nutrients business. "Liebig's law says the availability of the most abundant nutrient in the soil is only as good as the availability of the least abundant nutrient in the soil."

"Nitrogen, phosphorus and potassium will always be the powerhouses. But if you neglect the other nutrients, such as magnesium and calcium, not only can you inhibit your yield, you can also create long-term problems for the health and productivity of your soil."

While Mg and Ca are not required in as large amounts as N, P and K – or even sulphur – for most plants, they still need to be available in sufficient quantities to improve and strengthen crop health and support crop quality. Magnesium is crucial for chlorophyll production and therefore photosynthesis, whereas calcium is the building block of all plant cell structures.

Anglo American's polyhalite based product POLY4 product will be a significant new source of both these nutrients, with upwards of 10 million tonnes of polyhalite expected to be extracted annually from the company's under-development Woodsmith mine in the north of England.

"POLY4's sustained nutrient release profile will enable farmers to fill in those nutrient dips where supply doesn't traditionally meet plant demand," says Ross. "Those incremental improvements lead to big improvements in the ability of the plant to uptake other nutrients, such as nitrogen and phosphorous, just as Liebig's law dictates. Overall, you are getting healthier, higher quality and greater yield of crops through improved nutrient use efficiency."

Anglo American is investing heavily in creating a solid bank of evidence on the agronomic performance of POLY4 and its crop and soil benefits. With over 2,000 trials under its belt, including more than 1,150 commercial on-farm demonstrations, the company now has a robust vision for this polyhalite product and the opportunities its offers.

The value of magnesium and calcium

Magnesium plays a crucial role in crop development throughout all stages of the growth cycle. As an essential building block of chlorophyll, it is required by all crops to help generate energy from sunlight during photosynthesis. A consistent supply of magnesium also helps plants take up and use other nutrients. Plants deficient in magnesium, in contrast, produce less chlorophyll and are less able to transport carbohydrates.

Ensuring magnesium is readily available can therefore improve crop quality and make fertilizer applications more efficient. This is

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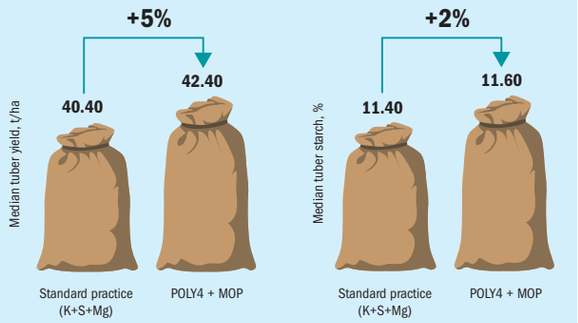
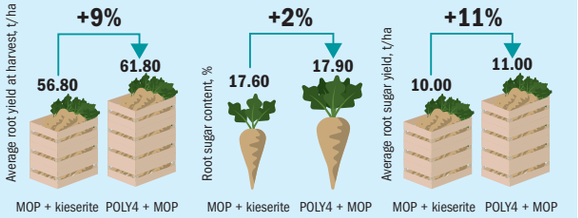
Fig. 1: **POLY4 potato trial in Germany**



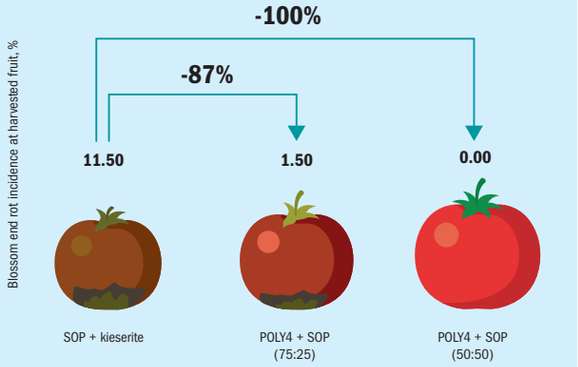
Source: Anglo American Crop Nutrients

Fig. 2: **POLY4 sugar beet trial in Poland**



Source: Anglo American Crop Nutrients

Fig. 3: **POLY4 tomato trial in Italy**



Source: Anglo American Crop Nutrients

particularly important for high-value crops such as potatoes or tomatoes, for example, where having healthy looking and marketable produce is vital if growers are to achieve a good price for these 'cash crops'.

Potato is known to be a magnesium hungry crop that can benefit from the application of POLY4. In recent German trials, POLY4 treatments outperformed standard fertilization practice for potatoes (K+S+Mg) by delivering yield gains of up to five percent (Figure 1). By providing nutrients in low chloride form, POLY4, as well as increasing yield, improved potato starch content by two percent. These potato trials were carried out across six German regions on different soil types, ranging from loamy sand to a silty clay with low potassium content.

POLY4 has also demonstrated yield and sugar content improvements with sugar beet. Trials in Poland assessed crop nutrition plans that incorporated POLY4 versus standard fertilizer practice for sugar beet with MOP (muriate of potash, KCl) and kieserite ($MgSO_4 \cdot H_2O$). The trials were carried out on two sites, one a silty loam and the other a loamy sand soil. POLY4 treatments performed well, delivering an average nine percent yield advantage for sugar beet at harvest (Figure 2). The sugar content of these harvested roots also improved by two percent.

Both these examples show the direct link between more balanced nutrient supply and both crop yield and crop quality improvements. The end result being a higher market value for harvested produce and therefore larger incomes for the farmer.

Calcium is another nutrient that plays an important role in balanced crop nutrition. In the tropical soils of Brazil, for instance, calcium is often used to strengthen and improve soil structure and to displace aluminium. Importantly, calcium also helps plants to resist disease, regulate water retention and strengthen their cell structure. These benefits in turn improve the post-harvest shelf life and storage ability of crops, factors which are vital in fresh produce markets.

POLY4 is granular with sustained release properties. This makes calcium available to the plant for a prolonged period, compared to conventional calcium sources such as lime or gypsum, which bind more easily to soil particles or leach through the soil profile. Furthermore, the calcium in POLY4 helps to increase the tensile strength of soil and its resistance to compaction. Improving tensile strength, by preventing soil movement and erosion, helps to minimise nutrient losses, while greater resistance to compaction, by maintaining a porous soil structure, helps improve drainage and prevent runoff.

What's more, trials have shown how POLY4's calcium content can help a plant's disease resistance. A recent tomato trial in Italy, for example, demonstrated POLY4's effectiveness at preventing calcium-deficiency disorders. The incidence of blossom end rot in tomato was markedly reduced in treatments with POLY4 versus treatments with SOP (sulphate of potash, K_2SO_4) and kieserite (Figure 3).

In future trials, Anglo American's agronomic team is planning to investigate POLY4's effectiveness against other calcium deficiency disorders, such as bitter pit in apples or pod rot in peanuts. The calcium needs of peanuts are especially high, as the fruit develops by absorbing nutrients directly from the soil instead of transport via the roots.

Maximising nutrient use efficiency

POLY4 is a natural product offering a well-balanced supply of nutrients. These are completely plant available and not in competition with each other, as can happen with other compounds. POLY4 also spreads more evenly during application, making it easier for farmers to achieve a uniform nutrient distribution across the field.

"POLY4 is like an insurance product for farmers in tropical conditions," says Lino Furia, Anglo American's regional agronomy manager for Latin America.

"More balanced nutrients and uptake means better quality, healthier plants able to thrive in a wide variety of agroecological conditions and extreme weather situations," explains Lino. "This is especially important for perennial crops like citrus or coffee, which require careful management and protection to produce a consistent high-quality crop – you cannot rectify mistakes later."

Coffee, for example, requires good magnesium availability during blossoming, its point of peak demand, to ensure the fruit ripens consistently. Lack of magnesium can also lead to leaf sunburn and reduced fruit formation and uniformity. Yet local farmers, because they typically focus on N, P and K applications, often disregard secondary nutrients.

"Having a good process is crucial for coffee growers to achieve the consistency that buyers demand," says Lino. "If you can supply a good balance of nutrients that are always available to the crop, particularly at peak demand, you will have a healthier plant that produces better fruit."

He continues: "This is a far more sustainable approach, both environmentally and economically, than using a specialist product, like a foliar spray, to rectify a problem caused earlier in the growing process.

"It's like running a car – if you only use low octane fuel and do not service it frequently, eventually you will hit trouble. By supplying balanced crop nutrition, including magnesium and calcium, POLY4 will provide a solution for farmers to maximise the health and productivity of their crops consistently, whenever and wherever they need it."

Challenging preconceptions

The concept that more balanced fertilizer practice leads to improved yields is not new. In the past, though, a farmer's ability to achieve this was mainly dependent on product affordability and availability. Secondary nutrient and micronutrient products were not widely available and were usually only used by large-scale farmers on high value crops. Anglo American is seeking to turn these assumptions on their head.

"We're challenging preconceptions of traditional fertilizer industry thinking, indeed of what a fertilizer really is," says Dr Alexander Schmitt, Chief Marketing Officer of Anglo American's Crop Nutrients business.

"The current market for secondary nutrients is not a reflection of need, it is merely a reflection of the industry's production capacity and old 20th century commoditised structures. But every plant needs just enough of these nutrients to maximise its health and vitality, and therefore the efficiency of the farm.

"POLY4 is a way of ensuring that you are maximizing your crops' chances of success and with the tonnages we plan to produce, we will be able to provide that security to many more farmers than the present market caters for.

"We know that there is an expanding market for low chloride potassium and sulphur, and favourable trends for more sustainable, low emission products that protect and enhance the soil. Add to that the fact that it is easy to spread and blend, is suitable for organic farming and has a sustained nutrient release profile, and you have a product perfectly positioned to help solve the challenge of achieving more efficient and sustainable fertiliser practices on a large scale.

"We are aiming to reimagine crop nutrition for the 21st century." ■

SECONDARY CROP NUTRIENTS

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IFA 2022 Annual Conference


PHOTO: IFA

Some 1,160 delegates from 475 companies and 76 countries gathered in Vienna, Austria, for the 89th International Fertilizer Association (IFA) Annual Conference, 30 May – 1 June 2022. We report on the main highlights of this three-day flagship event.

Above: Conference welcome reception at the Hofburg palace, Vienna.

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

The theme of this year's conference was 'Navigating Market Risks in Pursuit of Sustainability'. The programme covered systemic challenges and risks facing the fertilizer industry – and highlighted how these could translate into new opportunities and ultimately create value for investors.

Opening address

The conference was opened by IFA's director general **Alzbeta Klein** and **Svein Tore Holsether**, IFA's chair and the president and CEO of Yara International.

"We have plenty of work to do in many parts of the world including in Africa. How to navigate market risks and accelerate the sustainability of our industry is the focus of this gathering. I am confident we can navigate these waters and feed the world sustainably," Alzbeta said in her introductory welcome to delegates.

Globally, food insecurity is double what it was two years ago, with the world's poor being hit by the combined impacts of climate change, the Covid-19 pandemic, conflict in Ukraine and rising living costs. Svein Tore Holsether, while offering a sobering prognosis, provided leadership on how the fertilizer industry should respond to current crisis conditions.

"Some 276 million people were already in severe food insecurity at the start of year, double that of a couple of years ago. Today, 50 million are at the emergency level of hunger. The war in Ukraine is not the only reason, climate is also part of the equation," Holsether said.

He stressed that the choice facing decision-makers is not about solving the food crisis *or* the climate crisis – it's about doing both. One small positive from these looming crises, suggested Holsether, was that the rest of the world was starting to recognise the importance of fertilizers – both what they are and what they do.

This was shown by the focus on the global food system at this year's World Economic Forum in Davos, for example. "Half of the world's population gets food because of fertilizers," Holsether said.

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Svein Tore ended on a positive note by offering up prescriptions to address short- and medium-term food system challenges. The answer to the dire short-term situation, he suggested, was to shore up the World Food Programme and make this a priority, alongside the creation of safe corridors to get cereals out of Ukraine – something that was subsequently delivered over the summer in a deal between Russia and Ukraine brokered by the UN and Turkey. Making sure trade flows freely was the key to avoid famine, in his view. That included avoiding restrictions on exports and getting fertilizers to farmers.

Navigating risks in pursuit of sustainability

Shari Friedman, Eurasia Group, took a fresh look at climate action and goals in a well-received keynote address.

Shari Friedman, managing director for climate and sustainability at Eurasia Group, gave the keynote address. She highlighted how interconnected climate action, the energy transition and food security are.

"Fertilizer companies sit at the intersection of several global shifts – energy transitions, food security and the impacts of a changing climate," Friedman said. "They have the opportunity to define their role in solutions that the world is urgently seeking."

In her view, framing the climate debate solely by the question: "Are we going to limit global warming to one point five degrees?" – and then answering it with a binary yes/no was "not helpful". This was because this enormous question has so many factors and sub-factors, some of which are unknowable.

Instead, Shari suggested it was more helpful to identify past and future 'seismic shifts' that will propel us towards meeting the 1.5°C target. The US Securities and Exchange Commission (SEC), for example, is currently mandating climate-related disclosures for business. This decision, Friedman suggested, can be traced all the way back to Bank of England governor Mark Carney's ground-breaking speech on the financial risks of climate change in 2015.

Looking ahead, in the absence of decarbonisation policies, climate litigation was a new development that could force companies to act and spark a future 'seismic shift', in her view.

"We are hurtling down a dangerous path, we have solutions but not a lot of time. It takes political will," said Friedman. "The drumbeat for solutions will continue, with increasing action from consumers, policymakers and other stakeholders."

The keynote address was followed by a roundtable discussion between senior executives.

Incitec Pivot's CEO, **Jeanne Johns** explained how her company had made a massive step change over the last 18 months by setting absolute targets for net zero by 2050 and defining a clear pathway for achieving this.

"Credibility is everything. We took the approach to [firstly] have an ambition for net zero and [next] to build a plan, then we defined the target," said Johns. "Mindset counts [too] – going from seeing obstacles to seeing solutions."

The company's sustainability initiatives included the conversion of the Gibson Island plant in Brisbane to green ammonia.

"Converting a 50-year-old fertilizer plant to green ammonia will be ending one chapter and starting another," said Johns. "Younger and older engineers and other employees are excited about the future – they see the opportunities as well as threats."

Raviv Zoller, ICL's president and CEO explained how "doing the right thing" on sustainability provided a "fabulous opportunity for connecting with employees". He also stressed the need for credibility.

"Everyone loves change as long as it's happening to someone else," Zoller said. "I've learned that the strongest indicator of company success is the employee's belief in the product, what the company stands for and our behaviour – living up to what we say we do."

On sustainability, **Alk Brand**, CEO of avocado producer Westfalia Group, provided an amusing metaphor: "The best way to eat an elephant is piece by piece. Start by changing what's in front of you."

He advised company managers to "focus on targets" by picking obvious challenges that can make a real difference. "In France, we picked one customer, and decided to remove plastic [packaging] from just [this] one customer, which saved 65 tonnes of plastic," Brand said.

Alexander Schmitt, chief marketing officer at Anglo American Crop Nutrients, spoke about the positive lessons he's learned from the mining industry's transition to sustainability. He urged his fertilizer industry peers to be prepared to think differently, challenge the conventions of the past and think outside the box.

'FutureSmart Mining' at the Quellaveco copper mine in Peru exemplifies Anglo American's successful change of thinking on sustainability. This mine is safe, efficient, water-less, 100 percent digital, completely autonomous and powered by renewable energy. It's a cutting edge production model that phosphate and potash miners could learn from.

Schmitt also stressed the importance of communities and partnerships in bringing Anglo's under-construction Woodsmith polyhalite mine project to market in the UK, quoting from 15-year-old Vinisha Umashankar's powerful speech at the 2021 COP26 summit in Glasgow: "We can only move together towards the future. So united we rise and, together, we will definitely succeed".

Medium-term market outlook

Introducing the 2022-26 medium-term outlook, **Laura Cross**, the director of IFA's market intelligence service, spoke about the unprecedented market circumstances currently.

"The situation in the market has never been seen in modern history. We're in a market driven by availability and affordability," Cross said, with the war in Ukraine having had a massive market impact: "As of 24th February, everything changed."

What was unique about the current market was this combination of both an affordability *and* an availability crisis, Cross said:

"As it did in 2008-09, fertilizer affordability will present a challenge in 2022. The difference this year, is that the market is also facing an availability crisis."

These extraordinary circumstances had prompted IFA to develop a completely new market forecasting methodology. This new approach, for example, considers the 'delta' between N, P and K global production (actual output), on the one hand, and production capacity on the other. This gap stands at 66 million tonnes currently. Combined, Russia and Belarus contribute a delta of 43 million tonnes. To put this in perspective, these two countries, at a stroke, easily eclipse the total world delta of 37 million tonnes in 2007.

As well as taking account of availability and constrained supply, the new forecast also provides three scenarios (optimistic, pessimistic, middle ground) based on five criteria:

- Evolution of the Russia-Ukraine conflict
- Sanctions regimes
- Ability of Russia and Belarus to export to 'friendly' countries
- Protectionist fertilizer policies
- Fertilizer affordability.

With fertilizer supplies hemmed in globally, IFA's new forecasting approach also uses supply 'capability' as a measure of what's available on the market, instead of the more usual capacity and capacity expansions. Results suggests that potash capability is most constrained – with potash also the nutrient most skewed to the downside – followed by nitrogen capability and then phosphates capability.

"Nitrogen and potash capability are exposed to downside risks in the coming years, driven by exports [or lack of] from Belarus and Russia and their [level of] trade with so-called 'friendly' and 'unfriendly' countries," said Cross.

Short-term market constraints are expected to affect the three primary nutrients in different ways, with:

- P use dictated by affordability
- K use dictated by availability
- N use dictated by both of the above.

On the demand side, **Armelle Gruère**, IFA's demand program manager, highlighted the significant decrease in fertilizer affordability over the course of 2021 and 2022.

For the 2022 fertilizer year (FY), IFA is forecasting a contraction in global fertilizer demand of between -0.2 percent (optimistic scenario), -3.8 percent (middle ground scenario) and -6.9 percent (pessimistic scenario).

"South Asia and East Asia are forecast to experience the largest fertilizer demand declines in fertilizer year 2022, but Africa could experience the sharpest drop in fertilizer use as a share of total consumption," said Gruère.

Global demand is, however, expected to rebound in FY 2023 by as much as 1.9 percent (optimistic scenario) or as little as 1.2 percent (pessimistic scenario).

Low affordability

A panel discussion revealed the scale of the fertilizer affordability problem in this new supply-constrained world.

Despite the FAO Food Price Index (FFPI) rocketing to all-time highs this spring, agricultural commodity prices, in reals terms, are relatively low and falling, according to **Josef Schimdhuber**, deputy director of the FAO's statistics division. This is explained by factoring in the costs of inputs using The Global Input Price Index (GIPI) – which has risen further and faster than the FFPI – to deflate these prices.

Schimdhuber explained what was needed to bring the market back into equilibrium: "Either costs for inputs, notably

CONFERENCE REPORT

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fertilizer and energy have to fall, or nominal prices for food and consumers need to rise – or a combination of the two."

Fertilizer subsidies, however, risked creating unwelcome and perverse outcomes. "In a supply constrained market, if you subsidise demand, prices increase. It also takes away fertilizers from more productive to less productive farmers. Food production goes down which risks creating a food crisis in Asia," Schimdhuber said.

With not enough fertilizers to go around, this raised a seemingly intractable dilemma of how you guarantee fertilizer supplies to the world's poorest and most in need (but less efficient) farmers, if it diverts fertilizers away from more efficient commercial growers, without this compromising food production and food security.

Stepan Yashin, an associate partner at McKinsey, summarised the impacts of the Russia-Ukraine conflict on global food security. Removing Ukraine from global markets could see an initial 15 million tonne drop in agricultural commodity volumes (mostly wheat, corn, barley and sunflower seeds), a deficit that could rise to 20-41 million tonnes in the medium term.

"Logistics are the source of the greatest constraints in the current situation, in particular Black Sea ports," said Yashin.

The stakes are high, in his view, given that 1.4 billion people live in highly vulnerable countries at risk of food insecurity. This applied particularly to national diets that mainly depend on wheat or maize.

Tom Kehoe, deputy director for agriculture at the Gates Foundation, raised the alarm on fertilizer affordability in parts of Africa. Malawi, for example, is seeing a new level of unaffordability due to a record $1,000 price spread between urea and maize. The previous high was $600.

"Fertilizer price escalation: this is what scares me most in Africa," Kehoe said, telling delegates: "You guys need to step up and make clear fertilizer is a key part of food security – because it is."

Kehoe was also concerned about the breakdown in normal market incentives. The commodity market maxim that "the cure for high prices is high prices" doesn't apply currently in his view. "Farmers don't have the ability to respond to high prices, as supply is constrained. We're in a global auction," he said.

Kehoe said "big bold levers" were needed in the current situation as normal incentives aren't working. He called for the removal of sanctions on fertilizers, as well as removal of biofuel mandates/subsidies as these were diverting potentially life-saving calories away from food production.

Managing supply chain risks

This high-level panel examined the causes of supply chain disruption and how these were best managed.

Corrine Ricard, the president of Mosaic Fertilizantes, highlighted Brazil's 90 percent import dependence for fertilizers and its reliance on a narrow range of ports. The potential loss of Russian and Belarusian fertilizer imports was "just the latest disruption" in her view, adding to previous disruptions from the Covid-19 pandemic, extreme weather and bottlenecks caused by a lack of investment in infrastructure.

She described the new council, formed in response to Brazil's national fertilizer plan, as "a glimmer of hope". This public-private initiative was bringing different ministries and companies together to problem solve on agriculture, infrastructure, energy and mining – its work on port infrastructure and logistics being one example.

"Some solutions involve bigger investment by the industry in infrastructure. We have gotten used to just in time delivery and that's not happening now," said Ricard.

Tip O'Neill, the president of International Raw Materials, said current supply chain problems were a result of "under-investment in not just infrastructure but human capital" too – resulting in the current shortage of train and truck drivers and other supply chain employees.

Diverting fertilizers away from biofuels and removing obstacles to fertilizer trade were also issues in the current crisis, in O'Neill's view: "We need to rethink some of these trade barriers – all governments. How long are we going to grow crops for biofuel?"

Ashish Lakhotia, CEO of Fertilizers & Agri Inputs at ETG Inputs pointed out the almost impossible decisions being faced by fertilizer buyers in Southern and Eastern Africa at a time of highly volatile prices. With minimal stocks on the ground in-country, the dilemma was when "should we buy, should we not buy", Lakhotia said. Unfortunately, this was simply a recipe for indecision and paralysis.

Stephen Edkins, the CEO and Co-Founder of DCX/FertX, agreed with this analysis: "What Ashish describes is true in almost any medium and small nation." He said that, from financing to working capital, almost everybody in the fertilizer trading arena was facing problems.

De-containerisation was also affecting logistics for speciality products such as liquid fertilizers. Edkins said there was "no silver bullet" for such transport woes – except the need for more containers.

Measuring sustainability and decarbonisation progress

Panellists in this session gave their practical takes in response to less-than-ideal market conditions.

Rupert Simons, senior project manager at SYSTEMIQ, outlined major opportunities to reduce the fertilizer industry's downstream 'scope 3' agricultural emissions. Partnerships held the key, in his view.

"It's only with partnerships that go up and down the value chain that we can unlock solutions," he said. That included collaborating with food companies, retailers and farmers. These players could join together to market low-carbon food products, for example.

Simons said that recent price shocks did not reduce the imperative to cut emissions. "Some measures to fight climate change and the cost of living crisis are complementary. We need to do both," he said.

Josie Armstrong, principal consultant at CRU, was also seeing more collaboration, plus greater interest in ESG: "Fertilizer producers are working with farmers to improve their farming methods and reduce their scope 3 emissions. Today, we see clients who previously had no ESG aspect to their business asking us what are the climate risks affecting them."

Robert Vroege, commodities director at ING Bank, spoke about financing fertilizer industry decarbonisation and the shift in production to blue and green ammonia. Making decarbonisation financeable required three things, in his view: legislation, green product premiums and value chain partnerships.

On Green ammonia, Vroege said: "Who's willing to pay [green] premiums. You need to certify that and be able to count on it." He suggested that blue ammonia projects were a more immediate, lower capex decarbonisation option than green ammonia ventures currently. The introduction of the Carbon Border Adjustment Mechanism (CBAM) in Europe also provided an additional incentive for blue ammonia projects, according to Vroege, as it was "a simple calculation that you can bank on".

Gender diversity

The conference's final panel discussion, moderated by Alzbeta Klein, focussed on advancing diversity, especially within leadership teams.

This was actually a bottom line financial imperative for business, according to **Corrine Ricard**, president of Mosaic Fertilizantes. She pointed out that companies with more gender equality and greater ethnic diversity in their top management teams avoided 'groupthink' and therefore performed better with higher financial returns. "There is a global war for talent. Overlooking the fantastic potential of 50 percent of the world's population is just plain foolish," Ricard said.

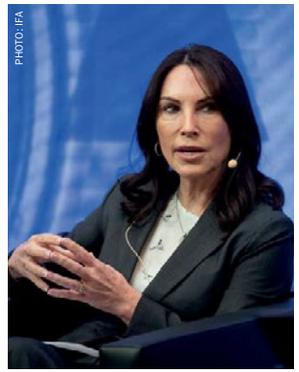
PHOTO: IFA

Corrine Ricard of Mosaic Fertilizantes spoke with passion and insight about advancing diversity in the fertilizer industry.

Maliha Malik, COO of the Food Security and Agriculture Center of Excellence (FACE), Fauji Fertilizer Co (FFC), shared lessons from her professional experience of empowering women in agriculture. "49 percent of the population in Pakistan are women and 60 percent of them are working in agriculture. Access to education and knowledge, global farming practices and individual rights is key to alleviating mismatched skills and the recognition of women in different roles in agriculture," Malik said.

The industry is heading in the right direction in its mission to attract, retain and develop more women in agronomy, suggested **Rejane Souza**, Yara International's VP for crop knowledge and agronomy. She highlighted the importance of mentorship in career progression. "Mentoring is an extremely important part of developing new professionals and training them to succeed in the future," Souza said.

This theme of mentorship was expanded on by **Caroline Quignon**, R&D product specialist, Yara International. She had benefitted professionally from this. "[Yara's] mentorship programme enabled me to recognise bias and discrimination issues, how to face and overcome them – being aware that I'm not the only one stumbling over these topics over and over again is a very useful learning experience," Quignon said.

Recognising and overcoming gender bias was also highlighted by **Jeanne Johns**, Incitec Pivot's managing director and CEO: "There is a lot of unconscious bias about what leadership means, what it looks like, role models, and these soft barriers filter women out. [There's a need to] create a cultural shift that starts at the top and embraces diversity in all senses and kinds – so people really hear every voice around," Johns said. ■

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Wastewater treatment technologies

Effective and efficient wastewater management is a vital task that is being aided by the introduction of new treatment technologies. The recovery of economically-valuable nutrients from wastewaters is another priority.

VEOLIA WATER TECHNOLOGIES

Creating SOP from wastewater

PHOTO: VEOLIA

Veolia's HPD® ECRP™ (Enhanced Chloride Removal Process) system.

As we move to a more circular economy, companies will increasingly be looking to minimise their waste generation by investing in sustainable processes. This will shift the focus onto proven and successful production technologies that offer a triple win – for the bottom line, the environment and society.

SOP for the future

Veolia's HPD® crystallisation technology is capable of manufacturing high-quality water-soluble potassium sulphate (SOP, sulphate of potash, K_2SO_4) using a range of different feedstocks. One innovative production option is to manufacture SOP from the wastewater generated at pulp and paper mills.

In this process, glaserite (a double salt of SOP and sodium sulphate) is initially recovered via a black liquor ash treatment system and then converted into high-quality SOP crystals for fertilizer use. For this and other feedstock options, the crystallisation process holds the key when it comes to controlling the purity and size of the final SOP crystals.

Case study

A pulping production plant in Brazil uses a washing process to increase the purity of the pulp. This generates an organic-rich liquor stream that is recovered for energy production. It is necessary, however, to remove chemicals from this liquor to avoid the undesirable build-up of chloride and potassium during the recovery cycle, as these can create corrosion and boiler fouling if left uncontrolled.

To prevent this fouling and corrosion, 650 t/d of precipitator ash from the boiler is being treated using Veolia's proprietary Enhanced Chloride Removal Process (ECRP™). This crystallisation technology is highly effective at removing undesirable impurities. Valuably, the system is also able to take a previously unwanted waste material and turn it into a useful fertilizer product for growing the next crop of trees for pulp production.

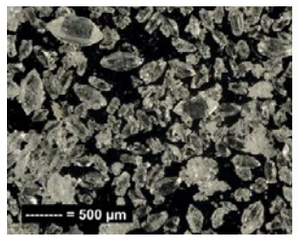
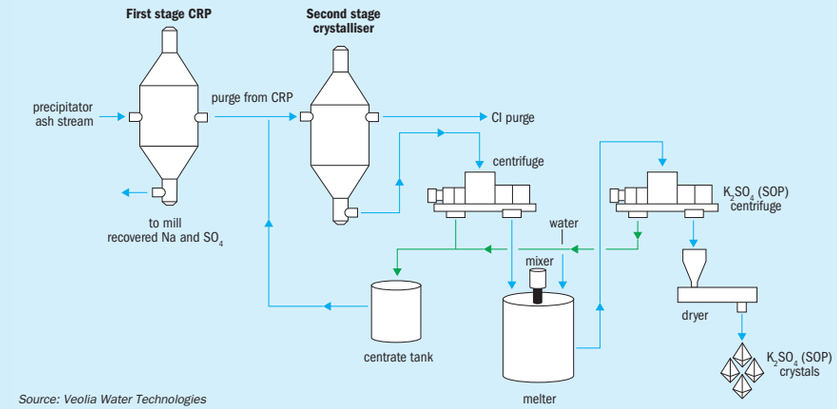


PHOTO: VEOLIA

High-quality SOP crystals manufactured using HPD® crystallisation technology.

Fig. 1: **Schematic of the ECRP™ system**



Source: Veolia Water Technologies

Key advantages of ECRP™

Veolia's ECRP™ system enables the recovery of fertilizer from ash treatment purge. This allows mills with high potassium inputs to achieve high chloride and potassium removal rates while minimising sodium losses. The system provides:

- Rapid operational payback
- Reduced sulphate levels in mill effluent
- Returns potassium back to the forest via the production of SOP fertilizer – creating a closed nutrient loop
- Saves on cost and usage of chemical consumables such as caustic and sodium sulphate.

Enhancing chloride removal

With ECRP™ technology, Veolia has enhanced the chloride removal process (CRP) by:

- Increasing its efficiency
- Reducing discharge volumes
- Recovering high value SOP fertilizer.

At most pulp mills, the focus of chloride removal is to minimise corrosion and boiler fouling. A conventional CRP is therefore typically operated to maximise chloride removal while minimising soda losses. Potassium removal, however, is not controlled and generally 'floats' in the 70-90 percent range.

> **"Veolia's HPD® crystallisation technology is capable of manufacturing high-quality water-soluble potassium sulphate from pulp and paper mill waste streams."**

Additionally, in conventional CRP, optimising potassium and chloride removal can only be achieved by reducing sodium recovery to 60-80 percent. ECRP™, in contrast, can maximise chloride and potassium removal while maintaining high sodium recovery.

The ECRP™ process

ECRP™ is a two-stage crystallisation process (Figure 1). The first stage consists of a conventional CRP system operating close to atmospheric pressure. This crystallises sodium salts and returns these to the recovery cycle.

The second stage crystalliser, by operating at a lower temperature to reduce solubility, recovers the remaining potassium salts as crystallised solids. These are dewatered in a centrifuge and then partially 'melted' with water in mixer. Purified, high quality SOP crystals are finally obtained following subsequent centrifuge and drying steps.

A portion of the second stage crystalliser mother liquor is purged from the mill to further enhance overall chloride removal efficiency. The remainder of the mother liquor, meanwhile, is recycled to the first stage crystalliser to recover sodium salts.

As well as generating a valuable speciality fertilizer, Veolia's ECRP™ system is capable of achieving the following removal efficiencies:

- Chloride removal of 90-95 percent
- Potassium removal of 95-99 percent
- Sodium recovery of 90-95 percent.

Conclusion

Forward-looking companies can now seize on higher-margin opportunities in the fast-growing agricultural market by producing specialty fertilizer products. As the above case study demonstrates, these can be manufactured from previously unexploited feed stocks, both profitably and sustainably, by incorporating innovative processes such as HPD® ECRP™ crystallisation technology. ■

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ORGANICS GROUP

Ammonia recovery from wastewater

Keith Richardson, commercial director, Organics Group

At a time when resource recovery and the circular economy are of growing importance, this article highlights the exciting opportunity to remove, recover and recycle ammonia from wastewater using waste heat.

PHOTO: ORGANICS GROUP

The 3,250 m³/day rated thermal ammonia stripping plant at the West New Territories (WENT) landfill site, Hong Kong, China.

Anaerobic digestion – a commercial success story

In recent times, anaerobic digestion (AD) has become firmly established as a commercially viable form of renewable energy generation. For example, there are now 486 operational AD plants in the UK, according to the National Non-Food Crops Centre (NFCC), with a further 343 under development.

The AD process produces biogas. This consists of methane and carbon dioxide, as well as various traces gases, and is used in two main ways:

- It can generate power directly via combined heat and power (CHP) gas engines
- Alternatively, it can be upgraded into natural gas-quality biomethane for grid distribution.

Nutrient-rich digestate, a by-product generated by AD, can also be used as fertilizer.

Ammonia and anaerobic digestion

Ammonia is released in the AD process by amino acid degradation during acidogenesis. Although ammonia is an important nutrient source for bacterial growth during AD, at high concentrations it can be lethally toxic to bacteria – having an inhibitory effect on bacteria that benefitted from its presence at lower concentrations.

Due to the increasing global use of highly calorific food waste as a biogas-producing AD feedstock, examples of ammonia poisoning are now being encountered more frequently at AD plants.

Proteins generate ammonia

Protein-rich substrates in food waste make particularly good starting materials for methane generation, and are therefore of great interest for commercial biogas production. Unfortunately, high loadings with such materials often correlate with process instability, as they are associated with increased ammonia release during the acidogenesis phase of AD.

The same issues arise within landfill sites. In Hong Kong, for example, the high loadings of protein in the waste streams entering landfills, namely meat and meat products, have resulted in high ammonia concentrations within the landfill leachate. Readings of up to 6,000 mg/L are common. Similarly, during the outbreak of mad-cow disease in the UK, it was necessary to dispose of animal carcasses within sanitary landfills. In such sites, leachate was encountered containing ammonia concentrations of up to 9,000 mg/L.

Managing excess ammonia

Ammonia exists in two forms in wastewater – ammonia gas (NH_3) and ammonium ions (NH_4^+). Both forms can directly and indirectly cause inhibition in an AD system, although NH_3 is generally recognised as the main inhibitor.

Although the exact threshold will vary, biogas production (i.e., AD performance) typically drops off as ammonium concentration in the anaerobic digester increases above 1,000 mg/L – with digestion fully inhibited at around 5,000 mg/L concentration. Effective control of ammonia levels is therefore a key requirement at AD plants. Fortunately, a wide range of options are available to achieve this.

In the past, lowering the pH to decrease the free ammonia concentration, or dilution of the digester contents with water, were the two most common ammonia control methods used at AD plants. Alternatively, adding lignocellulosic biomass can also successfully increase the C:N ratio of the substrate in the digester.

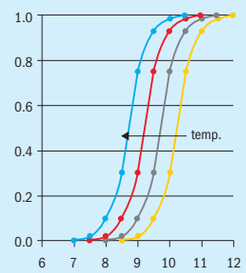
Thermal ammonia stripping

The Organics Group has developed another option to control and remove ammonia at AD plants – a thermally-driven air-stripping process capable of achieving 98.5 percent ammonia removal.

pH adjustment is not usually a requirement in this thermally-driven process, and the air flow necessary is substantially less than the requirement for pH-driven air-stripping. Heat is, however, essential to raise the temperature of the wastewater stream. This can lead to significant operational costs if a source of waste heat is not available.

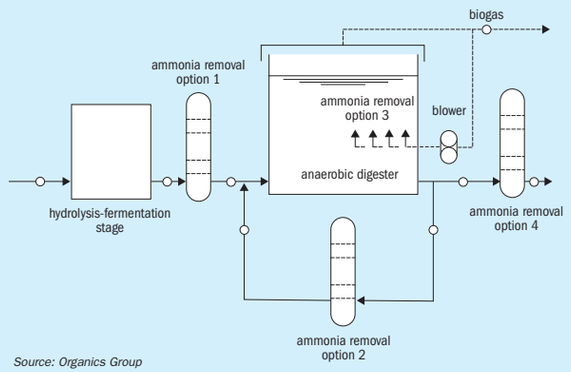
Thermal ammonia stripping and pH-driven ammonia stripping have a similar underlying approach to ammonia removal and employ similar techniques to achieve this. Both use air-stripping as a simple desorption process. The ammonium ion is also broken in both cases, by either heat (thermally-driven process) or the addition of a base (pH-driven process). While pH-driven ammonia stripping requires considerably larger quantities of air, as much as ten-fold higher, this process is not as temperature dependent as thermal stripping, which can be halted by a temperature drop.

Fig. 1: **Family of curves showing the relationship between pH and 'f' at different temperatures**



Source: Organics Group

Fig. 2: **Four ammonia removal options within AD**



Source: Organics Group

Process fundamentals

As mentioned above, the ionic form (NH_4^+) and the gaseous form (NH_3) of ammonia are encountered in wastewater. The equation governing the relationship between these two forms is as follows:

$$NH_4^+ + OH^- \leftrightarrow NH_3 + H_2O$$

In this reaction, dissociated ammonia ion (NH_4^+) is converted to undissociated ammonia gas (NH_3) by the addition of a base (OH^-), such as sodium hydroxide. As the temperature of the water increases, so the amount of free ammonia gas also increases. The balance of this equation is therefore a function of both pH and temperature – with low pH and/or low temperature pushing the balance towards NH_4^+.

The ratio of ammonia in the gas phase (NH_3) to the total ammoniacal nitrogen ($NH_3 + NH_4^+$), known as 'f', is expressed as follows:

$$f = [NH_3] / [NH_3] + [NH_4^+]$$

A family of curves illustrating the relationship between 'f' and pH at different temperatures is shown in Figure 1.

As the temperature increases (arrow to the left, Figure 1), the pH necessary to maintain a value of 'f' decreases. This shows the basic function of the thermal ammonia stripper, i.e., to reduce the need to increase pH while maintaining ammonia removal performance.

Examples of thermal ammonia stripping

Thermal ammonia stripping has been used in Hong Kong since 1997, the year the former crown colony reverted to Chinese sovereignty. The technology has been applied in Hong Kong to leachate from landfill sites, as well as the effluent from a food waste AD plant.

it is not surprising that Hong Kong has been the incubator for this world-leading technology, given its high population density, coupled with the demanding environmental standards enforced by its Environmental Protection Department.

The removal of ammonia is a recurrent challenge for wastewater engineers. In Hong Kong, this is accomplished with low operating costs, to high standards, by equipment with a small footprint, using novel thermal ammonia stripping technology. While, to date, thermal ammonia stripping installations have focused on the needs of Hong Kong, the technology is gaining ground in other countries where environmental compliance is being taken seriously. Its prime function is also moving from leachate clean-up applications into AD.

The systems developed in Hong Kong are for discharge flows. Thermally-driven air stripping was chosen in 1997 as the core nitrogen removal process for the West New Territories (WENT) landfill site in Hong Kong, currently operated by Suez. At the time, thermal efficiency was not a performance criterion. This was because, with a design flow rate of 1,800 m³/day, recently upgraded to 3,350 m³/day, as much landfill gas as necessary was available for use.

The initial design duty for this first plant was to reduce an influent ammonium concentration of 6,700 mg/L to 100 mg/L in the effluent. The WENT installation now removes 14.5 tonnes of ammonia daily. Building on this success, similar processes have been installed at six additional sites around Hong Kong subsequently.

Impressive efficiency gains

Landfill gas in Hong Kong was once seen to be more of a nuisance than an opportunity. However, thermal efficiency has gradually moved up the list of performance priorities since the first plant was commissioned, to the point where it is now a tightly measured variable. Impressively, the thermal power requirements of the ammonia removal process have been reduced to just 20 percent of that first 1997 installation – thanks to improvements in energy recovery, process optimisation and patented innovation. Options to capture and use waste heat have also been developed.

Ammonia removal options for AD

Over time, thermal ammonia air stripping technology has also become less specific to Hong Kong, due to the above efficiency improvements and a deeper operational understanding. This means the process is now better adapted for use in a range of varied applications in other countries. One major interest is its use for ammonia management in anaerobic digestion, both

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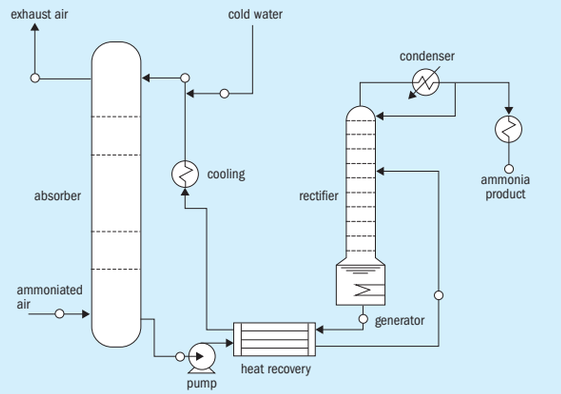
Table 1: **Summary of routes for ammonia gas disposal from stripper air**

Method	Summary
Thermal oxidation	Where the waste heat source is a gas, the ammonia may be converted to nitrogen by means of combustion
Catalytic oxidation	This is a lower temperature thermal conversion option.
Acid scrubbing	The use of a suitable acid, such as sulphuric acid or phosphoric acid, will produce a salt which may have commercial value.
Cold water scrubbing	In this case, the ammonia gas will be captured as ammonium hydroxide. Concentration of ammonium hydroxide will produce a liquid which may have commercial value.
Ammonia gas capture	By means of the processes involved in the ammonia-water absorption cycle, ammonia may be concentrated as a gas. Ammonia may be sold, to realise commercial value, combusted directly or used to generate electricity.

Source: Organics Group

Fig. 3: **Process flow diagram for Organics Group's ammonia recovery method**



Source: Organics Group

for ammonia process control purposes and for preventing the environmental release of ammonia in discharge flows.

Within a typical AD unit, there are four locations where reduction or removal of ammonia is possible.

1. At the hydrolysis-fermentation stage prior to digestion
2. In a recycle flow during digestion
3. Within the main digester vessel during digestion
4. Or post digestion, prior to discharge.

These four removal options are shown schematically in Figure 2.

Research into the feasibility of removing ammonia during or after the hydrolysis-fermentation stage (option 1) has met with limited success. The most practical removal options are therefore within the digester itself (option 3), in a recycle flow (option 2) or from the effluent (option 4).

Option 3 – stripping ammonia within the digester vessel – leaves limited scope for process control. However, work on this option has been successfully completed by several researchers using biogas as a stripping medium. Therefore, with low-strength ammonia, this may well be an option to consider in our view.

Options 2 and 4 – ammonia removal from recycle and discharge flows – therefore offer the main opportunities for ammonia control in large-scale commercial AD plants. While the former option will impact the AD process and lead to improved performance, the latter is essentially a matter of discharge compliance.

Key performance strengths

In reality, there are no perfect solutions for dealing with ammonia removal from wastewater in the industrial sector. The performance characteristics of each technology need to match up with the specific application and individual circumstances. For thermally-driven ammonia stripping, the following attributable benefits can help indicate situations where performance is optimised and deployment is merited:

- High removal rates may be achieved in a relatively small footprint
- The process is particularly suited to high-strength ammoniated wastewater
- No major costs are incurred for chemical additions
- Greenhouse gas (GHG) production is mitigated by avoiding nitrous oxide formation
- Compared to biological processes, relatively rapid start-up can be achieved (1 or 2 hours)
- There is no risk of biology failure
- Substantial savings may be available through the avoidance of carbon-source costs
- There is no sludge formation
- The system is relatively easy to operate compared to biological processes.

Ammonia recovery and use

Subsequent to ammonia stripping from wastewater, there is a need to remove ammonia gas from the stripping air. This can be recovered or disposed of, according to the operator's requirements. Several methods/routes for removing ammonia from stripper air are shown in Table 1.

Organics Group has developed a process that enables the recovery of either ammonium hydroxide or anhydrous ammonia. This approach further develops our two key, overriding process themes:

1. Employing waste heat
2. Avoiding the use of chemicals.

Ammonia-water systems are also already well understood, being widely applied in refrigeration and adsorption cooling.

The process flow diagram (PFD) for Organics Group's ammonia recovery system is shown in Figure 3. Clean, cold water is used to remove ammonia from stripping air. The water is then heated to concentrate the ammonia gas as ammonium hydroxide. Additional concentration and separation then makes the formation of anhydrous ammonia possible.

The obvious corollary to the recovery of ammonia is the question of what to do with it. In fact, there are many end-use options, ranging from simple on-site combustion, to use as an on-site fuel for modified engines or fuel cells, or various commercial applications requiring aqueous ammonia, anhydrous ammonia or ammonium salts. However, the main market for ammonia remains agriculture, with 85 percent of current global ammonia production being used in fertilizers.

Pilot projects

The waste and wastewater industry has recently woken up to the commercial opportunities presented by ammonia recovery, including its potential as a hydrogen carrier and source. The Organics Group – through our participation in two pilot projects – is at the vanguard in the wastewater sector when it comes to the practical implementation of innovations to recover ammonia and generate hydrogen.

The Organics Group, together with Northumbrian Water, Anglian Water, Cranfield University, Warwick University, and the Wood Group, has successfully won funding from the UK government's water regulator Ofwat. The six partners are collaborating on a pilot plant to recover ammonia from highly ammoniated wastewater generated by a large sewage treatment plant in northeast England. The aim is to produce green hydrogen – a first for the global wastewater industry – by cracking the recovered ammonia. The funding for this was secured through a competition launched by Ofwat to encourage innovation in wastewater treatment.

Organics Group is also investigating resource recovery from wastewater as part of a multi-partner pilot project funded by the Europe-wide REWAISE R&D programme. The project is led by the Spanish utility Aqualia, with Severn Trent and Coventry University also participating. It will firstly recover and concentrate ammonia and then produce hydrogen from wastewater via an enhanced electrolysis process.

Both projects take advantage of Organic Group's experience and track record in full-scale ammonia recovery from the wastewaters generated at landfill sites and anaerobic digesters located in Hong Kong.

Water utility companies the world over are seeking to mitigate their energy use and reduce GHG emissions. Indeed, many of these water companies, including those in the UK, are now committed to achieving the challenging target of net zero CO_2 emissions within the next 10 years.

Looking ahead, given the highly promising technological achievements to date, the impact of energy costs on conventional operations, and with the encouragement of forward-looking legislation, it is highly likely that ammonia recovery will be a key component in the drive for greater efficiency and carbon neutrality in the wastewater treatment sector. ■

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The role of colourants in the fertilizer industry

Nowadays, fertilizers can be produced in many different colours. But what is the significance of colour and its role in improving fertilizer product quality? In this article, **Jervis Bao** (Jiabin Bao), R&D director, Arkema-ArrMaz China, explores some common questions about colourants and their use in the fertilizer industry.

PHOTO: ARKEMA-ARRMAZ

The origin and importance of colour

When the industrial production of fertilizers first began, their natural colour was largely a reflection of their original constituents and the manufacturing process. In single superphosphate (SSP) and calcium superphosphate manufacture, for example, grey-to-dark colour phosphate rock is reacted with sulphuric acid or phosphoric acid to generate large concentrations of light-coloured calcium sulphate and calcium phosphate. Unsurprisingly, this colour combination results in grey fertilizer granules.

The light grey or green colour of diammonium phosphate (DAP) from Idaho, meanwhile, primarily comes from the phosphoric acid that is reacted with ammonia during its manufacture. Urea and carbonyl diamide, in contrast, are white in colour due to the absence of impurities in their ammonia and carbon dioxide starting materials.

During the first half of the 20th century, it became possible to manufacture many more types of fertilizer in greater quantities due to rapid advances in production technology – a transformation that propelled the fertilizer sector from its relatively modest origins into a fully-fledged standalone industry.

By the end of the last century, the fertilizer industry had developed a sophisticated range of complex speciality fertilizers suitable for many different agricultural applications globally. At the same time, the use of colourants emerged as an increasingly important way to brand or differentiate individual fertilizer types. DAP fertilizers from Florida and North Carolina, for example, became very popular and widely recognised as 'magic granules' in North American agriculture due to their signature natural dark brown colour.

Today, colour is an important differentiator for fertilizers. Producers use colourants:

- To differentiate their fertilizers from those of other producers
- To meet regional and customer colour preferences
- As functional additives or coatings to reduce dust formation and prevent caking.

What are colourants and why are they used?

A colourant is an added or applied substance that changes the outward or surface colour of a material[1]. Colourants are used for many processes, notably printing and painting, and for creating a distinct hue in many types of materials including foods and plastics[2]. They can be divided into two main types:

- Natural colourants, e.g. hematoxylin and humate
- Synthetic colourants, e.g. lemon yellow.

Colourants can be a dye or a pigment or a combination of both (Figure 1). A dye is a material that is dissolved in a solvent such as water or oil to colour other substances, whereas pigments are tiny solid particles dispersed in a substance to create colour without using a solvent[3].

As the fertilizer industry has developed, colourants no longer simply function as colouring agents. Instead, they have evolved into additives with a comprehensive range of qualities that can:

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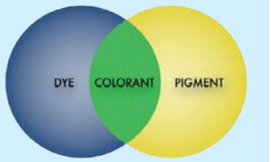
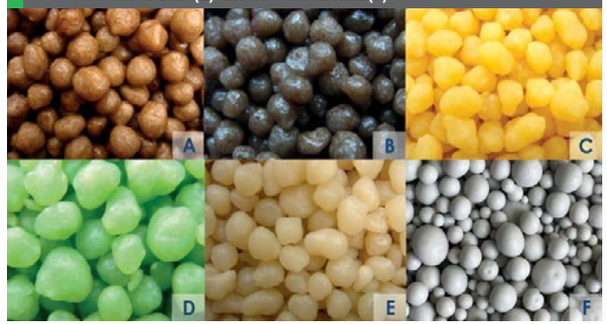
Fig. 1: **Dyes and pigments vs colourants**



Source: Arkema-ArrMaz

Fig. 2: **Differently coloured fertilizer granules, including coloured DAP (A-D), base colour DAP (E) and base colour NPK (F)**



SOURCE: ARKEMA-ARRMAZ

- Provide a uniform appearance
- Quickly and clearly differentiate different fertilizer types
- Offer improved quality
- Highlight product value or indicate nutrient type.

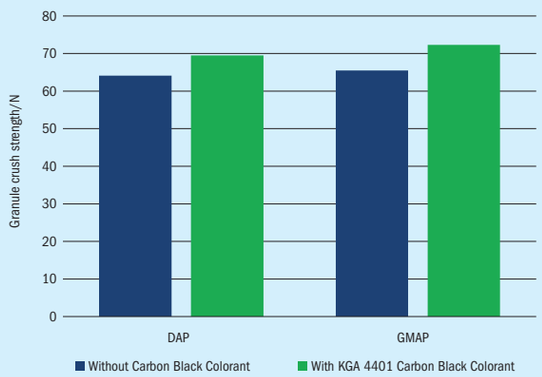
Uniform appearance

As already indicated, although the colour of fertilizers primarily depends on raw material composition, many other factors can affect colour – including process control, impurities, moisture content etc. Colourants are used by the fertilizer industry to overcome raw material fluctuations and ensure that manufacturing generates products with a consistent colour. Producers also create special colours to verify the authenticity of their products by functioning as anti-counterfeiting marks.

Differentiation

Most fertilizer manufacturers use distinctive and individual colours to classify different nutrient grades. This colour coding helps farmers to identify and apply the correct fertilizer substrates to crops at each growth stage (Figure 2). During the bulk blending of fertilizers, the different colours of individual fertilizer components make it easier to evaluate the overall homogeneity of the bulk fertilizer blend. In fertilizer production processes, colourants are also added as a tracer alongside micronutrients. In this way, the colourant is able to ensure homogeneity by visually showing the coverage and distribution of the micronutrient on granules or powders.

Fig. 3: **Impact of carbon black colourant on granule crush strength**



Source: Arkema-ArrMaz

Improved quality

Some inorganic chemical colourants also aid the fertilizer granulation process. For example, carbon dust (from coal slag) is added to phosphoric acid during the ammonium phosphate granulation process and reacts with ammonium to create small particles. By acting as seed crystals, these improve crystallisation and create higher strength fertilizer granules.

Water-insoluble liquid colourants are also used as coating agents. As well as imparting colour, these improve product quality by providing good anti-dusting and anti-caking properties. For example, coating with a carbon black colourant, by increasing granule strength, reduces dust formation and prevents caking (Figure 3).

An indicator of nutrient type or value

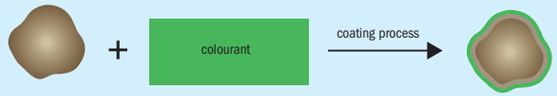
Some nutrients and biostimulants, and the value they provide, can be identified solely from their natural colour. Fulvic acid, for example, is a natural yellow-brown colourant that boosts crop growth as well providing colour. The same is true of red iron oxide. Sulphur-coated urea, which is valued as a slow-release fertilizer, is also identifiable from its yellow colour.

Fig. 4: **Three physical states of fertilizer**

Solid granular fertilizer | Solid powder fertilizer | Liquid fertilizer

Source: Arkema-ArrMaz

Fig. 5: **A coating process is used to cover the fertilizer granule surface with the colourant**



Source: Arkema-ArrMaz

Applying colourants

Fertilizers are commonly offered to the market as solid granules and powders as well as in liquid form (Figure 4).

Some colourants can be directly or indirectly applied to the surface of solid fertilizers. Talcum and iron oxide powders, for example, are used to impart a white and red colour, respectively. However, most colourants are formulated as oily liquid solutions. These are designed to maximise adhesion and completely cover the original appearance during coating (Figure 5). In contrast, aqueous solutions of colourants are hardly ever used because of the potential for fertilizer caking.

Other colourants are incorporated within the fertilizer during the production process. Water-soluble dyes are usually used for this purpose, as high concentrations of water are present for much of the fertilizer production process, eventually requiring a drying stage[4]. However, pigments can also be mixed with fertilizer raw materials (e.g. phosphoric acid, liquid urea) or fertilizer slurries (e.g. ammonium nitrate) to achieve good colouration. For a homogeneous colour, these pigments must dissolve easily in water or disperse very well in slurries, so ending up within the fertilizer's crystal lattice[5] (Figure 6).

Colourants are typically added to the fertilizer at 0.05-0.30 weight percent, the exact amount depending on the colour requirements of each market. Colourant performance – particularly the homogeneity of distribution with fertilizer granules (Figure 6) – is also the deciding factor for dosing levels.

Formulating colour

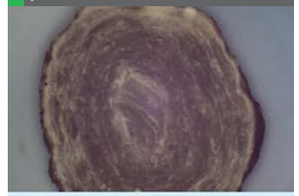
The colour of an object or substance can be determined using CIELAB 'colour space', an international standard developed by the Commission International del'Eclairage in 1976. Using CIELAB, suppliers such as Arkema-ArrMaz are able to formulate colourants to meet the colour needs of both fertilizer producers and the market.

The CIELAB colour space is composed of three values, L, A and B, as follows (Figure 7, Table 1):

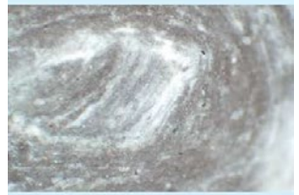
- **'L' value for brightness:** ranges from 0 to 100 for pure black to pure white.
- **'A' value for green to red:** ranges from -128 to +127 for dark green (low brightness) to grey (medium brightness) to bright pink (high brightness).
- **'B' value for blue to yellow:** ranges from -128 to +127 for bright blue (low brightness) to grey (medium brightness) to yellow (high brightness).

Colours can be mixed according to these values to produce the desired result[6].

Fig. 6: **Cross-section of a single fertilizer granule at different magnifications showing colourant performance and distribution**



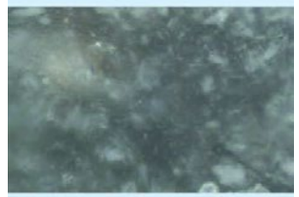
Magnification x 25



Magnification x 50

Magnification x 100

Magnification x 400



Magnification x 600

Source: Arkema-ArrMaz

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ISSUE 510
SEPTEMBER/OCTOBER 2022

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Colourant safety

Fertilizer safety is a priority for the whole industry. In China, for example, the government published a new fertilizer safety standard in 2019 (GB 38400-2019 Limitation Requirements of Toxic and Harmful Substance in Fertilizers) and implemented this the following year. The standard strictly controls heavy metal and phthalate ester content (Table 2). The levels of hazardous chemicals in fertilizers are also regulated (to some extent) in most countries globally. Consequently, many of today's fertilizer colourants – such as those provided by Arkema-ArrMaz – are developed to meet or exceed stringent safety and environmental standards.

Summary

In the early stages of the fertilizer industry, fertilizer colour was largely dependent on the raw materials used to make fertilizers. Subsequently, as additional and more complex varieties of fertilizer were developed, colourants were used to differentiate between these, as well as to achieve a homogeneous visual appearance. Today, fertilizer colourants are able to provide the following benefits:

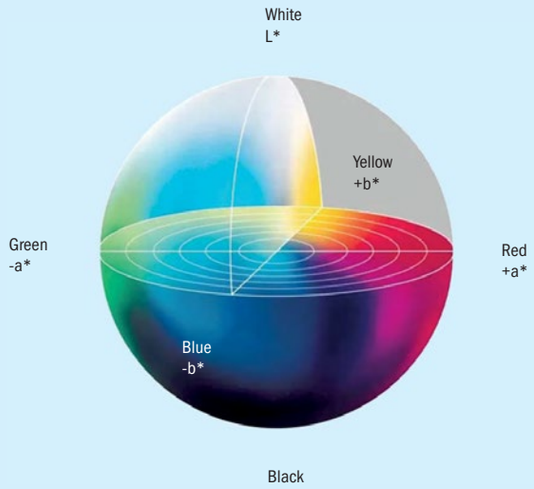
- Uniform visual appearance.
- Quick and efficient differentiation between different types of fertilizer, nutrient grades and micronutrients.
- Improved fertilizer quality with reduced dust formation and caking.
- Easy identification of nutrient type or product value.

Using CIELAB colour space, suppliers like Arkema-ArrMaz can formulate a colourant to meet customer needs and market preferences and comply with stringent regulatory standards. ■

References

1. Berns, R., 2002. *BILLMEYER & SALTZMAN'S Principles of Colour*. John Wiley & Sons. Inc.
2. Chunfang, C., & Zhexue, X., 2016. *Handbook of Chemicals Products, Pigment*. Chemical Industry Publisher.
3. Jianrong, G., Qing, Y., & Jianhong, J., 2021. *Dye Chemical Technology*. Chemical Industry Publisher.
4. Jinxin, H., 2016. *Dye Chemicals*. China Textile Publisher.
5. Senthikumar, R., 2016. *Pigment Dyeing*. Amazon Digital Services LLC-KDP Print US.
6. Venn, A., 2021. *Colours for Mind, Body & Soul*. China Bookstore Publisher.

Fig. 7: **LAB colour panel**



Source: Linshang Technology

Table 1: **CIELAB values for popular granular fertilizers**

Fertilizer	Colour	L value	A value	B value
Urea	White	92.0 to 96.0	-1.0 to +1.0	0.0 to +2.0
DAP	Dark brown	25.0 to 29.0	+3.0 to +5.0	+9.0 to +13.0
DAP	Yellow	56.0 to 62.0	+7.0 to +8.0	+38.0 to +46.0
DAP	Green	48.0 to 56.0	-14.0 to -10.0	+22.0 to +28.0
NPK	Black	12.0 to 15.0	-0.5 to +0.5	0.0 to +1.0

Source: Arkema-ArrMaz

Table 2: **Limits specified by China's GB 38400-2019 fertilizer safety standard**

No.	Items	Limits	
		Inorganic fertilizer	Other fertilizer
1	Total Cd	≤ 10 mg/kg	≤ 3 mg/kg
2	Total Hg	≤ 5 mg/kg	≤ 2 mg/kg
3	Total Se	≤ 50 mg/kg	≤ 15 mg/kg
4	Total Pb	≤ 200 mg/kg	≤ 50 mg/kg
5	Total Cr	≤ 500 mg/kg	≤ 150 mg/kg
6	Total Tl	≤ 2.5 mg/kg	≤ 2.5 mg/kg
7	Biuret	≤ 1.5%	≤ 1.5%

Source: Arkema-ArrMaz

September-October 2022

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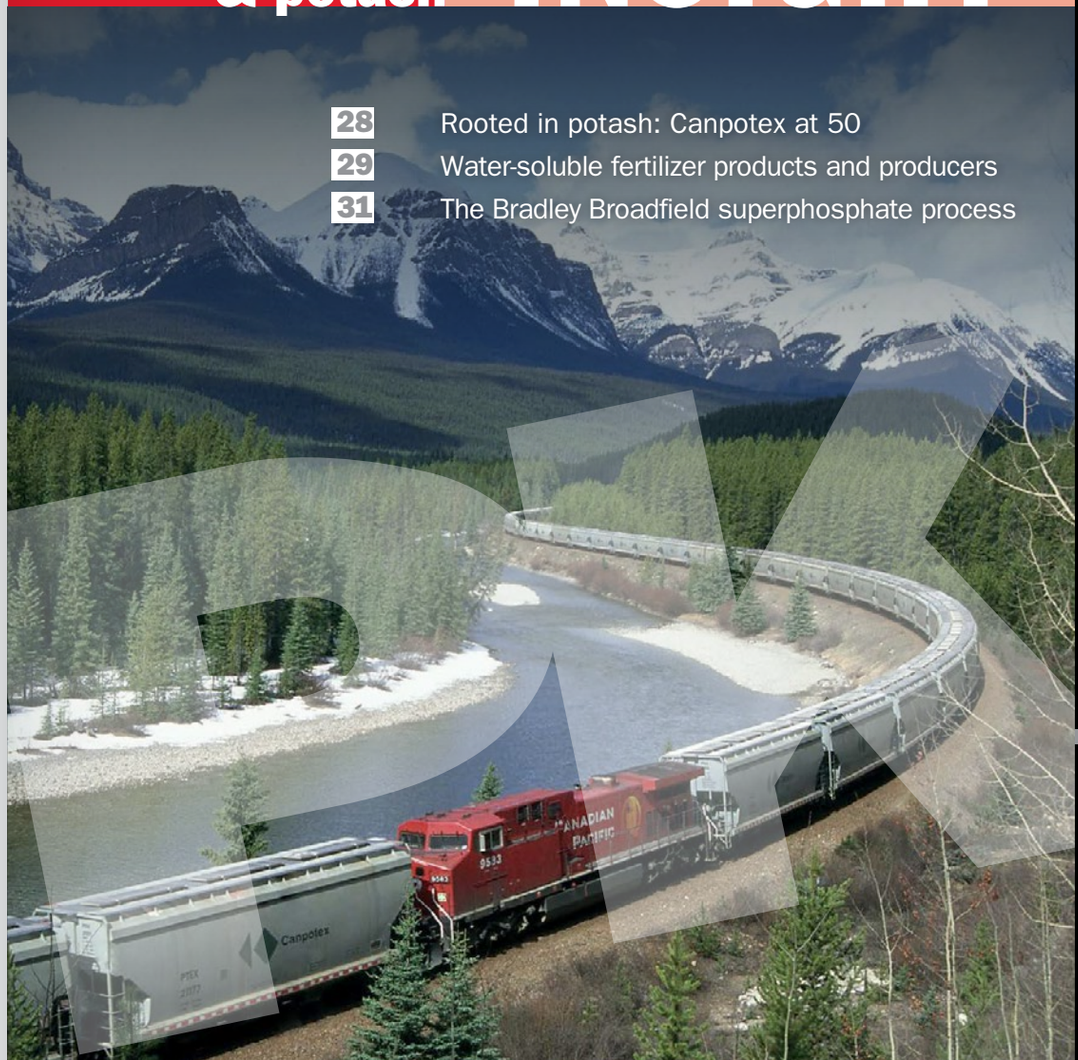

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Rooted in potash: Canpotex at 50

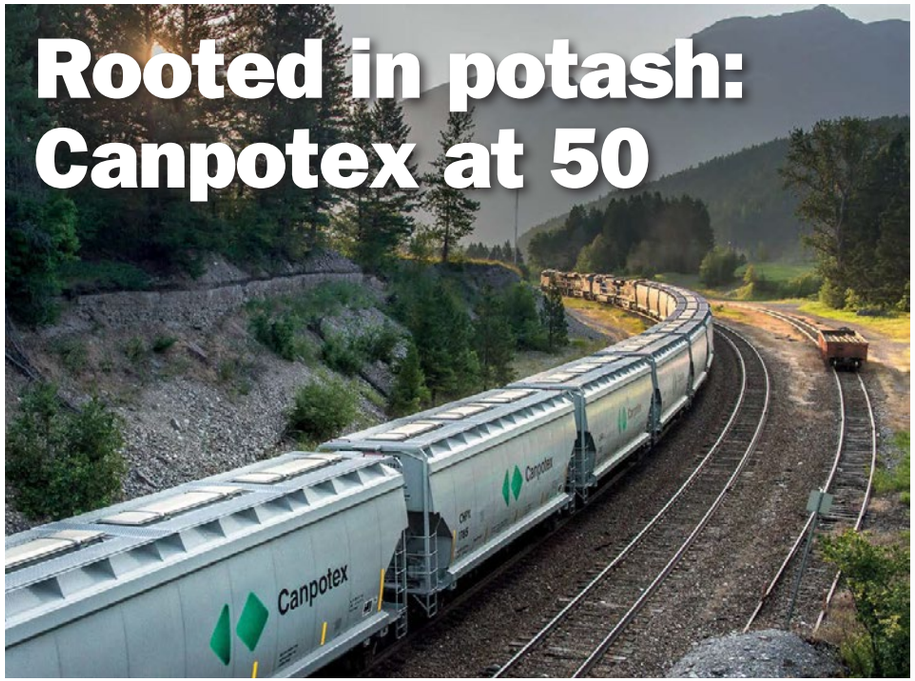

PHOTO: CANPOTEX

Canpotex is celebrating its 50th anniversary year in 2022. The world's premier potash exporter has been exclusively marketing and distributing Canadian potash overseas since 1972. In this article, we profile this potash export colossus and look back at its landmark achievements over the past five decades.

Above: Long Canpotex trains made up of more than 200 railcars can transport over 21,000 tonnes of potash across thousands of kilometres from mine to port.

Taking millions of tonnes of potash from the middle of a landlocked Canadian province, transporting it thousands of kilometres across plains and through mountains to both the Atlantic and Pacific coasts, before finally shipping it to customers around the world by ocean, is a Herculean task. Yet this is exactly what Canpotex has been doing, year in, year out, for five decades.

Canpotex is jointly owned by two North American potash producers, Nutrien Ltd and The Mosaic Company. Collectively, they own and operate 9 Saskatchewan potash mines – the largest concentration of potash capacity anywhere in the world. Over the last five decades, Canpotex has shipped more than 250 million tonnes of potash to more than 60 countries.

Delivering potash to the world

Each year, around 13 million tonnes of Canadian potash is delivered to approximately 120 customers in 40 overseas markets. To accomplish this, Canpotex has developed a sophisticated and efficient supply chain. Notable assets include:

- Two major port terminals on the west coast of North America – Neptune Bulk Terminals in Vancouver, British Columbia, and Portland Bulk Terminals in Portland, Oregon.
- An east coast port terminal in Saint John, New Brunswick
- The use of a Great Lakes terminal at Thunder Bay, Ontario, providing access to the St Lawrence Seaway.
- Storage capacity for more than 700,000 tonnes of potash.
- A fleet of over 6,000 purpose-built rail cars developed in collaboration with Ontario-based National Steel Car.
- A state-of-the-art rail car maintenance facility in Saskatchewan to ensure railcars meet the highest quality, safety and efficiency standards.

Canpotex uses rail for the large-scale transport of potash to its east and west coast

CANPOTEX: 50 YEARS IN THE MAKING

PHOTOS: SASKATCHEWAN MINING ASSOCIATION (TOP), CANPOTEX (ALL OTHER PHOTOS).

1962

With IMC's K-1 mine at Esterhazy, Saskatchewan, entering commercial production, this is arguably the breakthrough year for the Canadian potash industry. Successful shaft sinking at Esterhazy was possible thanks to the introduction of innovative Blairmore ring technology. These enormous, 28-tonne steel rings (right) were used to hold back the frozen, water-saturated sands of the Blairmore Formation, making conventional potash mining possible in the province.

1970

Ten potash mines are operating in Saskatchewan. This was also the year that Potexco Ltd (renamed Canpotex in October 1970) is formed to efficiently market Canadian potash to countries outside Canada and the United States from a registered office in Regina, Saskatchewan.

1972

Canpotex becomes responsible for overseas potash sales and general distribution on behalf of its 12 member companies and shareholders. Roger Hatch becomes the first president of Canpotex from 1972-1984.

1974

Canpotex Shipping Services Ltd, a wholly owned subsidiary, opens in Vancouver, British Columbia, to coordinate ocean freight and terminal activities.

1976

Canpotex establishes an office in Singapore – still operating today – to market Canadian potash in Southeast Asia and Oceania.

1979

Canpotex member companies, through Canpotex Bulk Terminals Limited, purchase an interest in Neptune Bulk Terminals at the Port of Vancouver (left), British Columbia.

1983

Canpotex initiates its first 'grassroots' market development programme in China to promote balanced fertilization and better quality, healthier crops. Canpotex has subsequently invested $57 million in farmer education across 25 countries.

1984

Canpotex establishes an office in Saskatoon, Saskatchewan, to coordinate market development activities. It also relocates its inland transportation office from Regina to Saskatoon. Erik Ekedahl is appointed president.

1985

Canpotex moves its Toronto head office to Saskatoon.

1986

Canpotex inaugurates a new distribution route through Thunder Bay, Ontario.

1991

Steve Dechka is appointed president and CEO of Canpotex, remaining in post until his retirement in 2015.

1993

Canpotex completes a $30 million investment in Neptune Bulk Terminals in Vancouver. This increases storage capacity to 210,000 tonnes and throughput capacity to 6.0 million tonnes.

1997

This marks Canpotex's 25th Anniversary. To celebrate, Canpotex opens Portland Bulk Terminals, its new bulk handling terminal at Portland, Oregon in the United States.

1999

Canpotex, in collaboration with National Steel Car of Hamilton, Ontario, designs and introduces a new, high-capacity, dedicated potash railcar. These are built to preserve potash quality and increase operational efficiency.

2001

Investments in Neptune Bulk Terminals, Vancouver, increases terminal throughput to 8.5 million tonnes.

2007

A storage building extension at Portland Bulk Terminals, Portland, increases its capacity to 135,000 tonnes.

2009

An investment in track reconfiguration at Neptune Bulk Terminals, Vancouver, increases its throughput capacity to 9.0 million tonnes.

2011

Further major upgrades to Neptune Bulk Terminals raises it throughput capacity to 10.0 million tonnes.

2012

Canpotex's Railcar Maintenance Facility near Lanigan, Saskatchewan, begins operations. This ensures that railcars are efficiently maintained for safe and timely transportation of Saskatchewan potash to offshore markets.

2013

Canpotex relocates its Chinese office from Hong Kong to Shanghai, to provide more direct service to its regional customers.

2015

Ken Seitz becomes the new president and CEO of Canpotex. Throughput at Portland Bulk Terminals, Oregon, increases thanks to the installation of a new high-speed shiploader.

2016

The addition of Saint John Terminal, New Brunswick, Canada, adds two million tonnes of extra capacity to Canpotex's export supply chain.

2017

The construction of its second warehouse at Portland Bulk Terminals, Oregon, increases storage capacity to 250,000 tonnes and throughput to eight million tonnes.

2018

Agrium and PotashCorp merge to form Nutrien. As a consequence, Canpotex's two shareholders are now The Mosaic Company and Nutrien. Both companies have an equal ownership stake and equal board level representation.

2020

Current President and CEO, Gordon McKenzie, is appointed by Canpotex's board of directors.

2022

Canpotex celebrates its 50th anniversary with the opening of its newly built head office in the River Landing complex in Saskatoon, Saskatchewan.

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Canpotex's Ultra Regina shipping vessel.

PHOTO: CANPOTEX

terminals. Every year, Canpotex trains make over 800 individual trips to its four ports, carrying millions of tonnes of potash across Canada's vast prairies and through rugged mountain ranges, often under the extreme weather conditions. The longest trains are made up of 205 railcars and transport over 21,000 tonnes of potash per journey.

For onwards seaborne shipment, the company also manages roughly 270 ocean vessel voyages each year, these making over 600 port calls annually. On any given day, Canpotex is managing 60 or more vessels carrying Canadian potash to its overseas customers.

This complex supply chain is matched by an equally sophisticated logistics operation controlled from Canpotex's head office in Saskatoon.

Canpotex not only moves potash, it also sells it. As well as running a marketing team at its Saskatoon head office, the company also serves its customer base through an established network of international marketing offices. These are located in Singapore, Shanghai and Sao Paulo, its newest office which opened in 2018.

Food security and balanced fertilization

Canada is home to the world's richest potash deposits, and the amount of potash farmers use is directly related to the amount of food that the world consumes. With the world's population at over seven billion currently and rising, and a growing middle class in Asia, the potash shipped by Canpotex has become a vital contributor to global food supply and security.

Potash, for example, is a key fertilizer that has helped to improve the nutrient status of Brazil's potassium-deficient soils. In Brazil, Canadian potash has played a critical role in improving the yields of major crops such as soybean, sugarcane, corn and coffee.

The company partners with its customers to work alongside farmers, teaching them about fertilizer best management practices and how to maximise the crop benefits that potash offers.

Since 1983, Canpotex has invested upwards of $57 million on education programmes in more than 25 countries. These have focussed on regions with low or imbalanced fertilizer applications. Activities such as region-specific training sessions, demonstration plots, field days and farmer days have all helped to demonstrate the benefits of balanced fertilization.

A successful half century

Commenting on its 50th anniversary and contribution to global food security, Gordon McKenzie, Canpotex's president and CEO, said: "None of this would have been possible without our customers, employees, shareholders, and communities, and we need to thank them all for their contributions to our success. Although Canpotex has evolved over the years, we have consistently remained a responsible global company with a uniquely Canadian core that supports jobs right here in Saskatchewan.

"Looking to the future, Canpotex is well-positioned to build off our solid foundation as a reliable and responsible exporter of quality Canadian potash. In the next 50 years, food security will be more important than ever – we will continue to be a vital link in helping the world grow more food." ■

PHOTO: CANPOTEX

Canpotex muriate of potash (MOP) is widely applied to potassium-deficient soils globally by farmers in countries like Brazil, China, India and Indonesia.

Water-soluble fertilizer products and producers

Applying dissolved fertilizers via micro-irrigation systems or leaf sprayers offers commercial fruit and vegetable growers clear-cut gains – in terms of input costs, nutrient use efficiency, labour, time and energy.

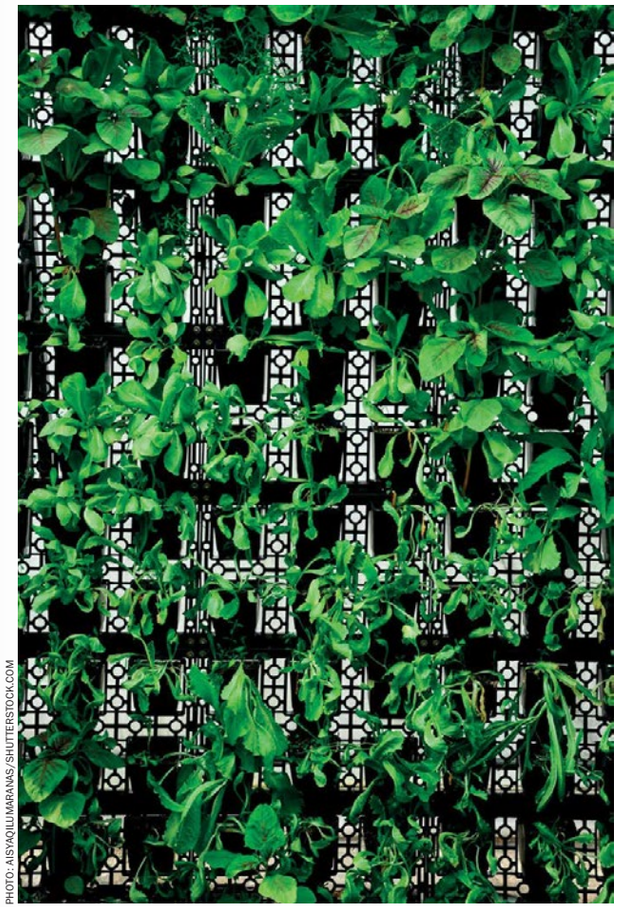

PHOTO: AISYAQILUMARANAS/SHUTTERSTOCK.COM

Vegetable growing using a fertigation system.

Water-soluble fertilizers (WSFs) occupy a niche but strongly growing segment of the global fertilizer market. The world market for WSFs – valued at $14-15 billion according to some estimates – generates around $3.6 billion in wholesale revenues annually[1].

Recent global sales volumes are estimated at 3.6 million t/a, up by around 360,000 tonnes in two years, a rise of more than 10 percent. East Asia and Europe are the leading regional consumers of WSFs with a market share of 33 percent and 23 percent, respectively. Latin and North America combined are also responsible for a further 24 percent of world WSF consumption[1] (Figure 1).

These figures are based on a 2019 market assessment by Rams & Co commissioned by the International Fertilizer Association (IFA)[1]. A separate 2019 assessment by CRU estimated total WSF demand at 4.3 million tonnes[2]. This represents roughly 55 percent of the total global market for calcium nitrate (CN), technical monoammonium phosphate (tMAP), monopotassium phosphate (MKP) and potassium nitrate (NOP). This excludes other end markets for these products such as foodstuffs, industrial products, open-field agriculture and liquid fertilizers[2].

Applying fertilizers in dissolved form, via irrigation systems or leaf sprayers, offers commercial vegetable and fruit growers clear-cut cost gains, in terms of input costs, nutrient use efficiency, labour, time and energy. The adoption of WSFs also comes at a time of agricultural intensification – the drive to get more crop per drop and per acre – a trend that is in turn linked to constraints on water and land availability.

The market for WSFs is split between fertigation, with a two-thirds share of consumption, and foliar applications which account for most of the remaining one-third of usage.

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Fig. 1: **World consumption of water-soluble fertilizers, 2018**

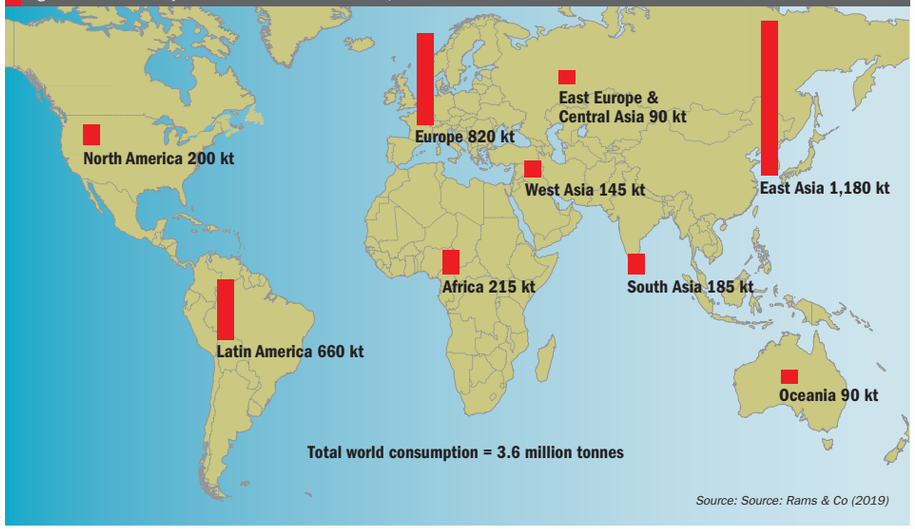


Fig. 2: **Micro-irrigation: top ten countries by land area, 2020/21**

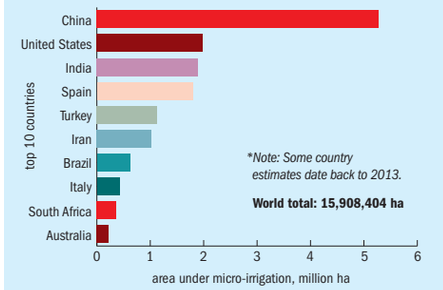
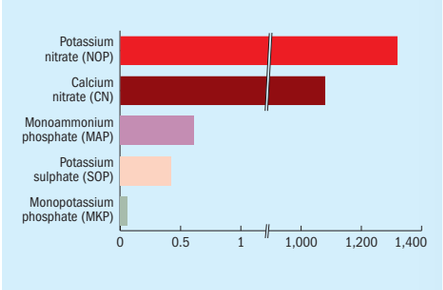


Fig. 3: **Water-soluble fertilizer consumption by product, 2018**



Key market drivers

Growing demand for WSFs has been a natural consequence of the adoption of drip irrigation systems in fruit and vegetable growing. The rise of fertigation – the delivery of water-soluble fertilizers via drip irrigation systems – has been a particular strong driver of market growth.

Globally, almost 16 million hectares of cropland are now watered via drip irrigation – also known as micro-irrigation. Adoption is particularly high in China, the US, India, Spain, Turkey and Iran (Figure 2).

CRU also attributes WSF market growth to the rising adoption of micro-irrigation, as well as other drivers such as:

- Increasingly sophisticated agricultural technologies
- Higher nutrient efficiency targets
- Expanding fruit and vegetable cultivation.

Micro-irrigation in turn is being driven by the need to optimise agricultural water use in countries with growing populations and rapidly rising water demand, suggests CRU[2].

Generally, only high value crops such as fruit, vegetables and tree nuts justify the premium price of WSFs. The land devoted to such crops, however, now accounts for around nine percent of global crop area (120 million hectares) and has been steadily climbing for decades[2].

Europe, where deployment of high-tech hydroponic and micro-irrigation systems is relatively widespread, represents a sizeable and mature market for WSFs. The WSF market in Africa has also benefitted from the growth in horticulture to serve the European market and the attendant rise in micro-irrigation that has accompanied this.

The scale of the WSF market in North America, in contrast, has been constrained historically by competition with liquid fertilizers (*Fertilizer International* 508, p18). and relatively weak vegetable cultivation in the region. India, meanwhile, is a small (around 150,000 t/a) but skyrocketing growth market for WSFs[1].

The world market for WSFs is forecast to grow at around 5-7 percent p.a. during the current decade to reach 6.4 million tonnes by 2028[1]. Underlying long-term growth fundamentals remain good, with the strong expansion potential for fruit and vegetable growing in Asia providing a particularly strong demand push. The future trajectory of Chinese agriculture – including tighter environmental regulation, rising labour costs and efficiency improvements – also offers favourable growth prospects[1].

The water-soluble fertilizer market can be divided into four main product categories (Figure 3):

- Potassium nitrate (NOP)
- Calcium nitrate (CN)
- Water-soluble phosphates – mainly monoammonium phosphate (MAP) supplemented by monopotassium phosphate (MKP)
- Potassium sulphate (SOP)

Potassium nitrate (NOP)

Potassium nitrate (KNO_3) is a soluble source of two major and essential plant nutrients. It is typically marketed as a speciality NK (13-0-45) fertilizer for higher value crops that prefer chloride-free potassium and the nitrate form of nitrogen (*Fertilizer International* 503, p28). The fertilizer – also known as NOP (nitrate of potash) – is commonly sold in water-soluble crystalline form for fertigation and foliar use or as prills for soil application.

The total value of the world potassium nitrate market – including both agricultural and industrial segments – reached $ 1.66 billion in 2021, and is projected to grow at more than three percent p.a. to reach $2.02 billion by 2027.

Potassium nitrate is a high-value niche product with a two percent share of the global potash market. World production capacity (primary and secondary) is around 1.3 million tonnes K_2O. On a product basis, the size of the global market for agriculture was estimated at 1.8 million tonnes in 2016. Production was forecast to grow at around four percent p.a. out to 2021.

Leading global producers and products include:

- SQM: Ultrasol K and Ultrasol K plus and Qrop K
- Haifa Group: Multi-K
- Yara International: UNIKA PLUS and KRISTA K/ULTRASOL™ K PLUS
- Kemapco
- Uralchem: Solar Potassium Nitrate
- Kingenta
- Wentong Group
- Migao Corporation.

Prayon also markets Kemapco potassium nitrate as part of its Hortipray product portfolio.

Chile's **SQM** is the world's largest supplier and exporter of potassium nitrate. The company is a primary producer and sources nitrates from natural caliche ore and brine deposits in northern Chile. Its production complex at Coya Sur includes four potassium nitrate plants with a total capacity of 1.3 million t/a.

SQM's largest international competitor is Israel's **Haifa Group** with a potassium nitrate production capacity of around 300,000 t/a. Haifa is a secondary producer, manufacturing crystalline, prilled and special grades of potassium nitrate from ammonia and nitric acid. These are sold as standalone products and also incorporated into water-soluble NPKs and controlled-release fertilizers. Haifa helped pioneer the use of potassium nitrate in the fertilizer market and its high-quality Multi-K product portfolio remains a market-leading brand.

Jordan's **Kemapco**, a fully-owned subsidiary of the Arab Potash Company (APC), is a major primary producer. Its main markets are Europe, Mediterranean countries and Asia. Kemapco successfully completed a $19 million expansion project in May 2018. This has raised its annual production capacity by nearly 30 percent, from 135,000 tonnes to 175,000 tonnes. A feasibility study for a second expansion to double Kemapco's current production is currently underway.

China is a key market for potassium nitrate, with annual demand from agriculture estimated at 400,000-420,000 tonnes, although this is largely fulfilled by domestic producers. The country currently imports just 20,000-30,000 tonnes of potassium nitrate annually. China's tobacco growers and horticultural sector are the main consumers, with an annual requirement of around 130,000 tonnes and 120,000 tonnes, respectively.

The Qinghai Salt Lake Nitrate Industry Stock Co – part of Chinese chemicals conglomerate **Wentong Group** – is said to have a potassium nitrate production capacity of 400,000 tonnes. It was formed in 2016 from the merger of Qinghai Salt Lake Yuantong Potash Fertilizer Co with Qinghai Wentong Yanqiao Fertilizer Co.

The **Migao Corporation** operates an 80,000 t/a capacity potassium nitrate production plant in Sichuan and a 400,000 t/a capacity potassium nitrate/NPK plant in Yunnan. The company's secondary production process is based on combining potassium chloride with ammonium nitrate. SQM constructed a 40,000 t/a potassium nitrate production unit in China as part of a joint venture with Migao dating from 2008. This plant has been operational since 2011.

Calcium nitrate (CN)

The calcium nitrate (CN) market and its key producers are outlined in our article on secondary nutrients (Ca and Mg) on page 28.

Monoammonium phosphate (MAP)

The water-soluble phosphates market (*Fertilizer International* 497, p48) is a sizeable global market of almost one million tonnes[3] – roughly equivalent to around 25 percent of the total world market for WSFs. Main products include:

- Monoammonium phosphate (MAP, 12-61-0)
- Monopotassium phosphate (MKP, 0-52-34)
- Phosphoric acid
- Diammonium phosphate (DAP, 18-46-0)
- Urea phosphate (UP, 18-44-0)
- Polyphosphates

MAP and MKP combined account for almost 90 percent of consumption. MAP is the dominant product in the global marketplace, with a market share of more than 70 percent[3].

MAP is by far the most widely produced and consumed type of water-soluble phosphate globally. World consumption is around 680,000-690,000 t/a, with China alone accounting for almost six-tenths of the global market. The EU, Latin America – particularly Brazil and Mexico – and Med-

MARKET REPORT

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iterranean countries such as Turkey also represent sizable regional markets for water-soluble MAP[3].

Average global growth in the water-soluble MAP market (4-5% p.a.) masks distinct regional variations. Much strong growth prospects in Asia (14% p.a.) contrast with the more stagnant growth rates (1-2% p.a.) seen in the mature markets of North America and the EU[3].

Global water-soluble MAP production capacity is circa 695,000-745,000 t/a, with the majority of this capacity (400,000-450,000 t/a) being located in China. Major global producers include[3]:

- Prayon: 70,000 t/a capacity
- Israel's ICL Specialty Fertilizers and Haifa Group: combined 75,000 t/a capacity (including MKP)
- Russia's Uralchem, GMZ and EuroChem: 70,000 t/a capacity combined
- North America's Innophos: 50,000 t/a capacity
- China's Monband and Kingenta with 30,000-40,000 t/a and around 60,000 t/a capacity, respectively.

Having rapidly expanded its production capacity since 2010, China now dominates global production, consumption and trade in highly water-soluble, technical-grade monoammonium phosphate (tMAP), according to CRU. China and Russia have both emerged as major tMAP producers in recent years taking market share from incumbents in Europe and Israel. New North African entrants are also capturing export volumes from established producers. Global tMAP exports have grown rapidly over the past decade to reach around 600,000 tonnes p.a., CRU estimates[2].

Monband (Hebei Monband Water Soluble Fertilizer Co), founded in 2009 and headquartered in Shijiazhuang, Hebei, was one the first Chinese companies to register and produce water-soluble fertilizers. The company has been one of China's biggest suppliers of technical-grade MAP and water-soluble fertilizers since 2013. It currently operates six water-soluble fertilizer production lines with a combined annual output of 60,000 tonnes. These produce water-soluble MAP, MKP, NOP, NPK with micronutrients and SOP.

Monband also produces 20,000 tonnes of granular fertilizers annually from two production lines, and has a further three production lines dedicated to liquid fertilizers. Its main product lines include ammonium sulphate, calcium nitrate, technical-grade MAP and MKP.

The company exports around 50-60 percent of its output, supplying speciality fertilizers to more than 50 countries globally. Its main international markets are Southeast Asia (50%), Africa (30%) and South America (20%).

Prayon has been manufacturing horticultural phosphates in Europe for over 40 years. The Belgian company markets a comprehensive range of water-soluble fertilizers. These were consolidated under the single Hortipray® brand in 2011. The Hortipray® range of fertilizer products are designed for application to fruits, vegetables, flowers and plants by fertigation. All these products are recognised for their purity and high solubility. They include:

- Monoammonium phosphate (MAP)
- Monopotassium phosphate (MKP)
- Potassium nitrate (NOP)
- micronutri Fe
- Pbooster

Notably, Prayon also markets the Hortipray® anticalc range of water-soluble fertilizers for fertigation. This includes 'anticalc' versions of both of its standard Hortipray® MAP and Hortipray® MKP products. These prevent the build-up of limescale and phosphates on irrigation pipes and the growth of bacteria. This reduces the risk of blockages and uneven irrigation. It also extends the life of irrigation pipes.

Monopotassium phosphate (MKP)

Fertilizer-grade monopotassium phosphate (MKP) is a high-analysis product (0-52-34) that provides plants with a concentrated supply of both potassium and phosphorus. MKP is primarily marketed as a speciality fertilizer for use on high-value crops. Its high purity and water solubility makes it ideal for hydroponics.

MKP is fully water-soluble with a low salt index and is free of chloride, sodium and other deleterious constituents. It can be used as a buffering agent in fertigation solutions due to its moderately low pH. Applications are said to increase the sugar content of fruit crops. Its use is especially valuable in situations where nitrogen fertilization needs to be limited.

Estimates of world MKP production vary widely, although a recent CRU study reported global production of around 500,000 t/a and exports in excess of 200,000 t/a[2]. Despite China taking a growing production share over the last decade, ICL and Haifa remain significant MKP producers/exporters and – together with Prayon – are the most important manufacturers outside of east Asia[2].

Israel's ICL Specialty Fertilizers (Nova PeaK) and Haifa Group (Haifa MKP) both have the capacity to produce around 35,000 tonnes of MKP annually, with Belgium's Prayon (Hortipray MKP) producing a further 20,000 tonnes each year. Yara International (YaraTera Krista MKP) is another notable producer.

Historical growth set to continue

The adoption of water-soluble fertilizers is part of a wider shift to more lucrative speciality products within the global fertilizer market. More than 20 million tonnes of speciality fertilizers were consumed globally during 2018, excluding micronutrient products. Although this still represents a minor – if growing – proportion of overall sales volumes, the higher margins achieved by speciality products generated $5 billion in added-value for fertilizer producers[1].

Historical growth in the WSF market (circa 6% p.a.) has been driven by the adoption of micro-irrigation, as well as wider market factors such as the need for crop quality and yield improvements, better water and nutrient use efficiency, and environmental concerns over greenhouse gas emissions and eutrophication.

Looking ahead, the positive growth of the last decade is likely to be maintained, supported by production cost reductions and technological advances. There are early signs that the rise of speciality products, in general, marks a fundamental shift away from commodity fertilizers (market de-commoditisation) and their future move into the mass market as mainstream products[1].

References

1. Rams & Co, 2019. Assessment of the global market for special products. *IFA Annual Conference*, 11-13 June 2019, Montreal, Canada. Prepared for IFA.
2. Kurokawa, G., 2021. WSF market trends and a decade of rapid growth. *CRU/Argus Fertilizer Latino Americano 2021 Virtual Conference*, 25-28 January 2021.
3. De Rijcke, R., 2018. The water-soluble phosphate market. *CRU Phosphates 2018*, Marrakech, Morocco, 12-14 March 2018.

The Bradley Broadfield superphosphate process

The Broadfield process has remained a mainstay of the global phosphate industry since its introduction in the 1930s. **Ian Hancock**, vice president sales & operations, Bradley Pulverizer, explains it continuing success in superphosphate production worldwide

The Bradley Broadfield process is the global standard for single superphosphate (SSP) manufacturing. Its flexible and reliable design is based on more than 100 years of SSP manufacturing experience and can produce SSP economically from all known phosphate rock sources.

The process is also used to make:

- Triple superphosphate (TSP)
- Monoammonium phosphate (MAP)
- Diammonium phosphate (DAP)
- Monocalcium phosphate (MCP)
- Dicalcium phosphate (DCP)
- Partially acidulated phosphate
- Synthetic gypsum
- Iron sulphate
- Other acidic salts.

Bradley's Broadfield process has been the workhorse of the phosphate fertilizer industry since 1936 and is offered in two designs:

- The Broadfield Den – typically used in applications of more than 30 t/h capacity
- The Broadfield Belt Den – its smaller 'cousin' for applications of less than 30 t/h capacity.

These two process options have been successfully employed worldwide to produce SSP, TSP, MAP and other finished phosphates. Its latest application is the production of partially acidulated superphosphate, a slow-release fertilizer used in end markets such as forestry.

Bradley's long experience with the process has allowed the basic concept to be modified to suit individual products and the requirements of each manufacturer. The capacities and types of Broadfield Den design have also been expanded, with current models being able to offer maximum flexibility at the most economic cost. These intrinsic strengths make the Broadfield process ready to cater for industry changes over the next 85 years.

Origins of superphosphate manufacturing

It is well known that crops require a supply of nitrogen, phosphorus and potassium for their sustenance – and that using fertilizers to correctly control the soil's NPK balance is therefore essential for the long-term sustainability and commercial viability of agriculture.

> **"Bradley's Broadfield process has been the workhorse of the phosphate fertilizer industry since 1936."**

While phosphorus is abundant in nature, the majority is locked away in insoluble form within crystalline phosphate rock. Indeed, phosphorus in its natural form offers little nutritional benefit to plants, as these can only absorb nutrients from the soil solution. That means there is a need to convert insoluble phosphate rock into plant-available soluble phosphates to support the productivity of global agriculture.

Shortly after Justus von Liebig set out his theories for the acidulation of phosphate for fertilizer manufacturing, John Lawes patented a landmark superphosphate process in 1842 for converting insoluble phosphate rock into calcium phosphate (which is both water and citric soluble). Judged by later standards, the equipment initially developed for Lawes' acidulation-based method was incredibly crude and far from ideal. To quote Lawes from the original patent, "with 4 common farm labourers and 2 cast iron pans I have mixed 2 tonnes in a day" in an open pile.

The process did improve subsequently, with ground phosphate being thrown into a stream of acid running into a brick lined pit. This was agitated by men standing around with rakes – which, understandably, was a thoroughly miserable job. Early mechanical manufacturing was also limited to batch production performed by a variety of different machines.

William Bradley became the first US manufacturer of single superphosphate in 1873 when he started production at the Bradley Fertilizer works in North Weymouth, Massachusetts. In 1886, his son, Peter Bradley, established the Bradley Pulverizer Company, to provide grinding and acidulating equipment for the fertilizer industry and general sale.

Then, in 1936, Bradley applied its 50+ years of experience in manufacturing equipment to the fertilizer industry by developing the Broadfield process, the first turnkey continuous superphosphate processing machine known as the Broadfield Den. Bradley's long association with the fertilizer industry continues to this day.

In this article, we focus on single superphosphate (SSP) and triple superphosphate (TSP) production by the Broadfield process. We also highlight the innate flexibility of the process, particularly its ability to provide multiple revenue streams and accept variations in phosphate rock composition.

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Making SSP and TSP

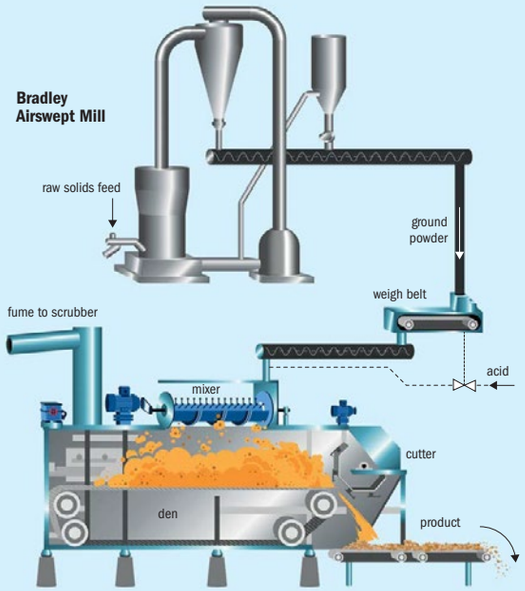
SSP is made by reacting non-soluble fluorapatite (the mineral present within phosphate rock) with sulphuric acid to produce soluble monocalcium phosphate and calcium sulphate. Gaseous by-products from the reaction include SiF_4 and CO_2 (released from associated calcium carbonate in the rock). The overall chemical reaction is summarised in equation 1 below.

TSP is made by reacting the phosphate rock with phosphoric acid. The reaction is faster than for SSP as deposition of calcium phosphate on the rock surfaces, which slows diffusion, is avoided. The TSP obtained is also a better grade product with a higher concentration of monocalcium phosphate. The overall chemical reaction is summarised in equation 2 below.

$$2Ca_5(PO_4)3F + 6H_2SO_4 + 3H_2O \rightarrow 6CaSO_4 + 3Ca(H_2PO_4)_2 \bullet H_2O + CaF_2 \quad (1)$$

$$2Ca_5(PO_4)3F + 12H_3PO_4 + 9H_2O \rightarrow 9Ca(H_2PO_4)_2 \bullet H_2O + CaF_2 \quad (2)$$

Fig. 1: **Schematic of the Bradley Broadfield Den**



Source: Bradley Pulverizer

Superphosphate acidulation in the Broadfield Den

The Broadfield Den is a turnkey system specifically designed to continuously acidulate inert phosphate rock into water soluble superphosphate (Figure 1). In detail, it is actually comprised of a series of individual and interlocking equipment systems. Ultimately, proper calibration and maintenance of this entire system is required to ensure continuous production and profitable operation.

The information provided in this article assumes 'typical working conditions' based on general operational experience. In practice, however, each Broadfield Den is individually engineered for optimal output. Units are designed to meet the conditions specified by the end user, as well as the results of laboratory trials and testing, with confirmation of raw material composition being of primary importance.

Superphosphate production begins with the grinding of insoluble phosphate rock (mainly fluorapatite, $Ca_3(PO_4)_2CaF_2$) to a fine powder. This upstream process is carried out by a **milling system**, such as the Bradley BM20 Airswept Roller Mill, to generate phosphate rock particles of specified fineness (Figure 2). Typically, for sedimentary rock, the specified size is 75-90 percent passing 75µm (200 Tyler mesh), whereas igneous rock, due to its lower reactivity, is typically ground finer to 90+ percent passing 53µm.

Grinding significantly increases the particle surface area available for decomposition by acid. The finer the phosphate rock is ground, the faster the rate of reaction will be. The mill allows particle fineness to be adjusted to allow for differences in rock reactivity, so ensuring that adequate surface area is available for proper acidulation.

Mills which include properly specified and integrated classification systems enable more precise control of particle fineness – which requires adjustment for different rock types. Typically speaking, a properly maintained mill system will generate consistent particle size and yield rates, unless or until changes are introduced, such as differences in rock type.

The phosphate rock powder obtained is decomposed in two steps:

1. Firstly, dilute sulphuric acid reacts with part of phosphate rock to produce phosphoric acid. This reaction step takes place mainly in the Broadfield Mixer.
2. The free phosphoric acid produced then reacts with the remaining phosphate rock to produce monocalcium phosphate. This step takes place mainly in the Broadfield Den.

The first SSP reaction step occurs as soon as the diluted sulphuric acid (produced on-site) comes into contact with rock particles within the **Broadfield Mixer** (Figure 3), and takes just 1-2 minutes at typical rock fineness. The reaction is exothermic and releases steam, CO_2 and SiF_4 into the vapour space above the paddles. The paddles use shear forces to constantly create new reaction surfaces. This helps to minimise any reaction slowdown due to calcium sulphate deposition on unreacted rock particles.

The reaction slurry solidifies at the exit to the mixer and is discharged into the Broadfield Den. Mixer settings ensure that the slurry spreads evenly across the den to give a level cake. Variations in the chemical analysis and temperature of the reactants, and in rock size analysis, must be minimised to allow good operation. The operator has tools at his disposal – such as the variable speed mixer drive and paddle design – to use in response to any change in mixer conditions.

The second part of the reaction takes place in the **Broadfield Den** (or Broadfield Belt Den). This is where the slurry solidifies into a cake and can take from 10-60 minutes (average 40 minutes), depending on the rock type and grinding fineness.

The Broadfield Den unit is a rugged, gas-sealed, continuous, metal slat conveyor which moves slowly in a horizontal plane. It prevents the slurry from sticking to the sides by incorporating reciprocating sides at the inlet. Inside the unit, the reaction mass is kept in one block to minimise heat loss and maximise reaction rate. (Maintaining temperature is important as reaction rate typically doubles with every 10°C.) The conveyor of the **Broadfield Belt Den** differs from that of the original Broadfield Den, with a rugged polyurethane belt replacing the metal slats. Both units have similar reaction times. However, while relatively easy to maintain and clean, the Belt Den runs into capacity limitations above 30 t/h.

At the end of the den, a continuous **rotary cutter** is used to disintegrate the reaction mass and shave off SSP powder. This falls onto a wide, slow moving cutter belt which then passes through a gas-sealed transfer point for storage and final reaction outside of the Den. The floor of the Den is inverter driven. This avoids overloads during emergency shutdowns by allowing the hardened reaction mass to be fed slowly to the cutter.

PHOTOS: BRADLEY PULVERIZER

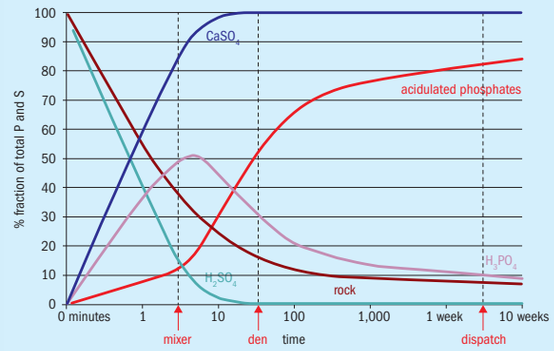
Fig. 2: Upstream milling system, Brazil.

Fig. 3: Broadfield mixer unit, Ballance Agri-Nutrients, New Zealand.

PHOTO: BRADLEY PULVERIZER

Fig. 4: Complete Broadfield process unit, Aswan, Egypt.

Fig. 5: **Acidulation reaction timeline for the Broadfield process**



Source: Bradley Pulverizer

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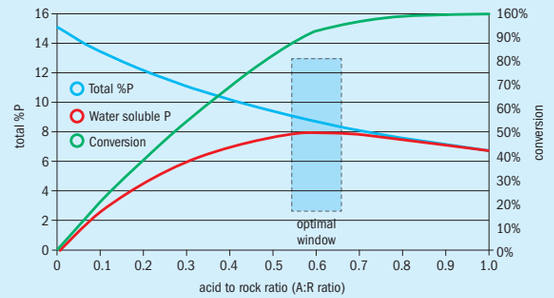
Fig. 6: **'Optimal Window' for acid-to-rock (A:R) ratio**



Source: Bradley Pulverizer

Fig. 7: **Reaction rate vs. acid strength**

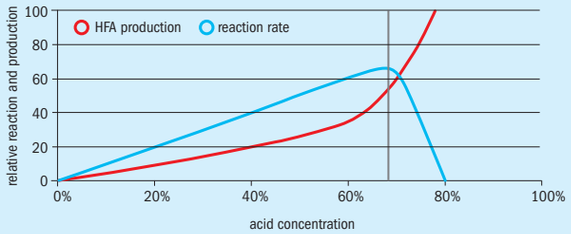


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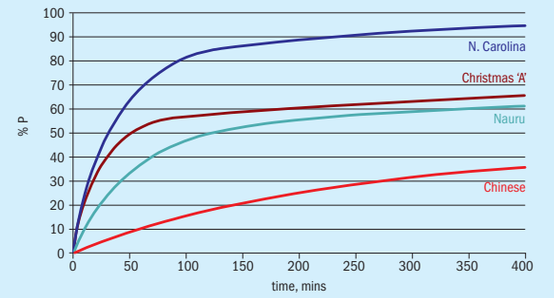
Fig. 8: **Reaction rate for four different phosphate rock sources, as measured by P solubility in two percent citric acid**



Source: Bradley Pulverizer

Disintegrated SSP generated by the rotary cutter is transported to **storage** for the final curing stage. Curing allows the reaction to reach its end point and reduces residual free phosphoric acid (Figure 5). Sufficient storage capacity is required to ensure that the bagging machines (or granulation plant) have enough SSP powder to handle after an average curing period of 15 days, or at least 10 days minimum.

An exhaust fan extracts fluoride-containing gases from the mixer and the den and sends these to a **gas scrubbing system** where a series of water sprays remove fluoride from the air stream. This generates HFA (hydrofluosilicic acid – H_2SiF_6) solution which is recycled back to the SSP/TSP mixer to provide fluorine for acidulation. This closed loop system is unique to the Bradley Broadfield Den.

The overall process for TSP manufacture is essentially the same. In fact, the Broadfield process uses the same den for both SSP and TSP production, although smaller turbine or cone mixers are used for TSP as the reaction is much faster. TSP powder takes 1-2 weeks to cure and can then be granulated as a straight or blended fertilizer with standard equipment.

Operational considerations

Acidulation in the Broadfield Den is a continuous process that requires good coordination between the various feed streams and equipment so they operate together in equilibrium. However, as ideal process conditions are almost never met in practice, Bradley's Broadfield Dens and Belt Dens are designed to operate effectively at between 60-110 percent of their rated output. This provides operators with the necessary flexibility to adjust for changes in feed composition and/or plant conditions while ensuring that consistent end-product quality is maintained. Some of the key operational considerations are highlighted below.

Rock blend. Individual phosphate rock sources and shipments will have different parameters for total phosphorus content, reactivity rates, impurity levels (i.e., cadmium), fluorine volatilisation, and odorous compounds. To adjust for these differences, rocks from different sources are blended to establish the desired chemical composition and achieve the necessary 'operational window'. This is important as the chemistry of the rock blend will directly influence the equilibrium of the entire system, including milling fineness, acid concentrations, mixer speeds, den residence time, and granulation conditions etc.

Acid-to-rock ratio (A:R ratio). The phosphoric acid that is produced in the acidulation process initially increases the A:R ratio, even though it reacts subsequently to form calcium phosphate. This bump in acid generation must be properly accounted for when accurately determining the ideal A:R ratio. Additionally, high iron, aluminium, and magnesium levels must also be considered, as these will also reduce the achievable A:R ratio. These elements slow down the reaction rate by increasing the viscosity of the liquid phase and making the ex-den product sticky. These effects can be offset by increasing the fineness of the rock, increasing the residence time in the den, and increasing the reaction temperature.

Acid strength. Optimal acid strength is around 68-70 percent (Figure 7), depending on the phosphate rock blend. Acid strength is an important parameter as it can negatively affect the reaction rate, as follows:

- If it is too weak, acid strength slows reaction rate by reducing reaction temperature and/or reducing reaction 'chances'.

Commercial superphosphate production requires Broadfield process equipment that is both rugged and flexible.

- If it is too strong, acid strength slows reaction rate by reducing liquid diffusion and particle-liquid contact, and/or blinding rock reaction surface with insoluble calcium sulphate. Strong acid also increases gaseous emissions.

Reaction surface area. Reaction rate (as measured by two percent citric acid solubility, Figure 8) is affected by the available reaction surface area, which in turn is influenced by particle-size distribution, particle porosity, and crystal structure. Available surface reaction area is increased by milling fineness – although it is important to note that fineness:

- Only affects rock reactivity
- Does not change overall conversion
- Has a strong effect on reactive rock, but a weak effect on non-reactive rock.

Summary

Large-scale commercial superphosphate production requires Broadfield process equipment that is rugged enough to:

- Continuously crush up to 50 t/h of phosphate rock
- Mix it with a steady stream of acid
- Enable the exothermic reaction required for proper acidulation.

Yet, this large-scale equipment must also be flexible enough to cope with, and adjust for, unavoidable changes to process variables – such as the natural disparities in phosphate rock chemistry. At any given time, the ongoing process reaction will be affected by:

- Reactivity of the rock and mill fineness
- Acid strength
- Reaction temperature
- Acid-to-rock ratio
- Mixing efficiency (mixer performance, time in mixer)
- Impurities, poisons and blinding effects.

In our experience, if just one of the above conditions is not correctly adjusted for, then acidulation will be sub-optimal. ■

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