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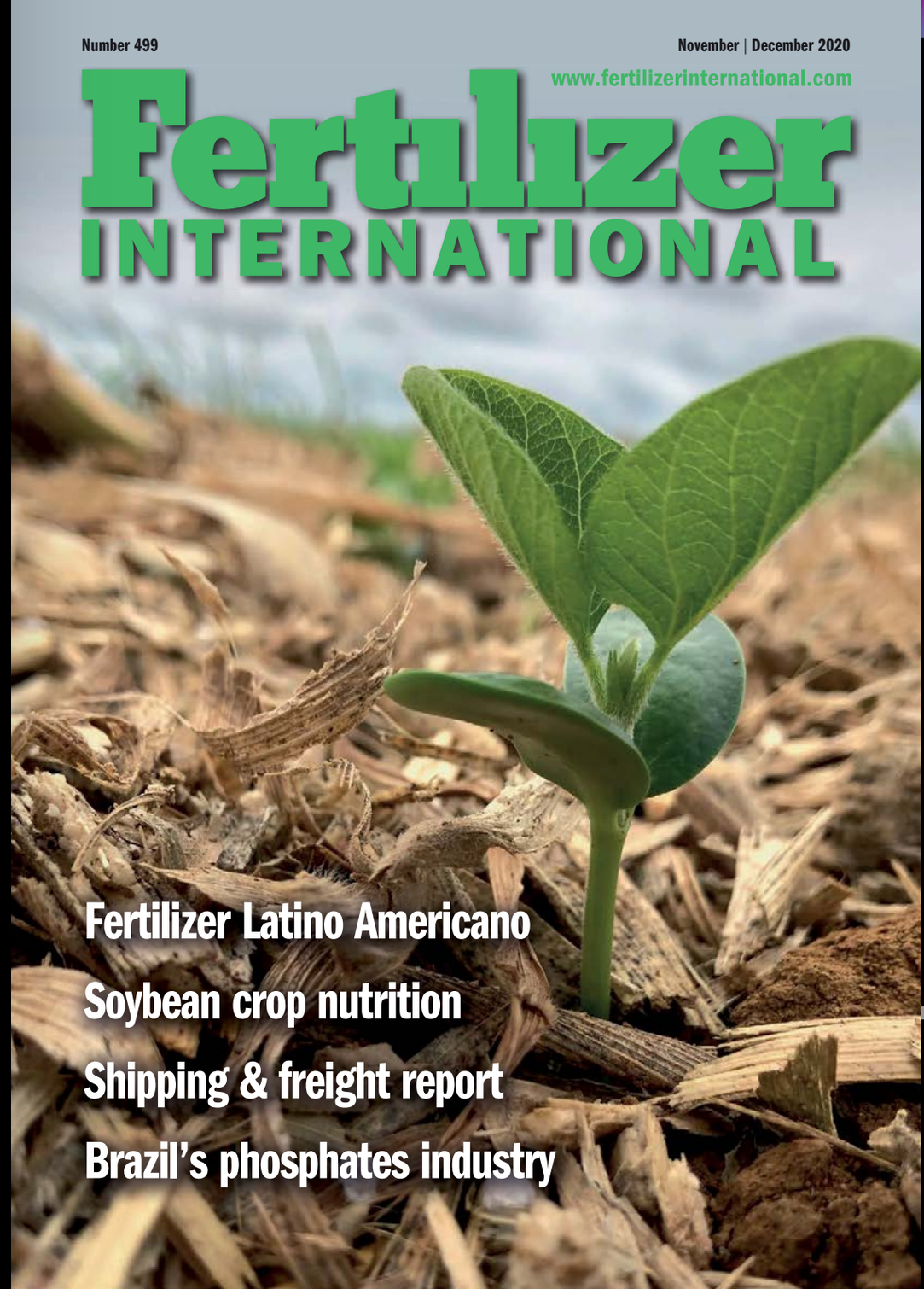

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Resilient ratings

> **The most important effect of Covid-19 on the fertilizer sector has actually been on prices.**

The late autumn gloom has darkened in recent weeks, as Europe slipped back into a lockdown that seemed as inevitable as the encroaching winter.

They say that the darkest hour is just before the dawn. It's a consoling refrain, one that's echoed down the centuries since Thomas Fuller first said it in 1650.

During these dark days, could Monday 9th November actually mark a new dawn – by becoming *the* turning point in the global fight against the coronavirus pandemic?

This was the moment when Pfizer and BioNTech confidently announced that their vaccine can prevent more than 90 percent of people from catching Covid-19. The two companies described it as a "great day for science and humanity". They are now gearing up to supply 50 million vaccine doses by the end of this year and around 1.3 billion by the end of 2021.

Sir John Bell, Regius Chair of Medicine at Oxford University and a member of the UK government's vaccine taskforce, was bullishly optimistic: "It's very important because there's no other way of getting on top of this thing, frankly." When asked by the BBC whether life could return to normal by spring, Sir John was unequivocal: "Yes, yes, yes. I'm probably the first guy to say that. But I will say that with some confidence."

Some confidence and optimism are also beginning to return to the fertilizer market too, as we enter the final months of what's been an unprecedented year. The autumn has allowed time to take stock – with first-half results providing a clearer picture of the effects of the coronavirus pandemic on the major fertilizer-producing companies.

It's been the industry's resilience to the coronavirus that's been most apparent. That's certainly the view of the American credit rating agency Fitch Ratings – one of the 'big three' agencies alongside Moody's and Standard & Poor's. As Fitch observed:

"Most [fertilizer] plants and mines… remained fully operational with enhanced health and safety measures in place during the coronavirus-driven lockdown, with some minor exceptions. The supply chains continued functioning and products were kept moving as most countries classified fertilizers as essential products."

Fitch concluded that fertilizers have been one of the sectors least affected by the pandemic. There were even upsides for the industry in countries like China and India where the virus hit hard initially.

"During the outbreak in China, the majority of its phosphate fertiliser plants were idled or operating at lower rates, which helped to further tighten supply, supporting prices," said Fitch. "India had one of the strictest lockdowns globally, which created some disruption at Indian ports, but these were offset by an increase in imports demand as most domestic plants were forced to shut down."

Lower feedstock prices and a surplus supply of ammonia have been two noticeable consequences of the pandemic.

"The negative effect coronavirus had on demand for fuel resulted in lower feedstock prices for fertilizers (gas in Europe and the US) and thermal coal (China)," commented Fitch. "In addition, industrial use of ammonia dropped substantially due to significantly disrupted manufacturing activity."

First-half results also revealed that volumes growth has been a key factor in offsetting price declines. Higher output this year, argues Fitch, has been more critical than the relative position of companies on the global cost curve. That's because lower feedstock prices have eroded the production cost advantage of those companies occupying the lowest quartile of the curve.

Fitch reported higher first-half production volumes for all of its rated fertilizer companies, reflecting the improved demand environment in the first half of 2020. That contrasted with the depressed weather-affected demand conditions of 2019, especially in the US.

The most important effect of Covid-19 on the fertilizer sector, suggests Fitch, has actually been on prices. Prior to the pandemic, it had expected nitrogen and phosphate fertiliser prices to increase year-on-year in 2020, as demand recovered from "three consecutive poor application seasons". In the event, this did not happen.

Correcting for market conditions in the year-to-date, Fitch moved to revise its pricing assumptions at the start of September. The agency reduced its medium- and long-term price assumptions for ammonia, while leaving those for urea unchanged. Its 2020 and 2021 price assumptions for diammonium phosphate (DAP), in contrast, went up, as did potash prices, albeit only slightly.

Fitch believes that the fertilizer industry's medium-term fundamentals remain strong – supported by a rising population and decreasing arable land. Outlooks for most of the companies in its global fertilizer portfolio are also stable this autumn.

The emergence of an effective Covid-19 vaccine offers the hope of brighter times in 2021. But society, like the fertilizer industry, will need to remain resilient in the months and years ahead. ■

Simon Inglethorpe, Editor

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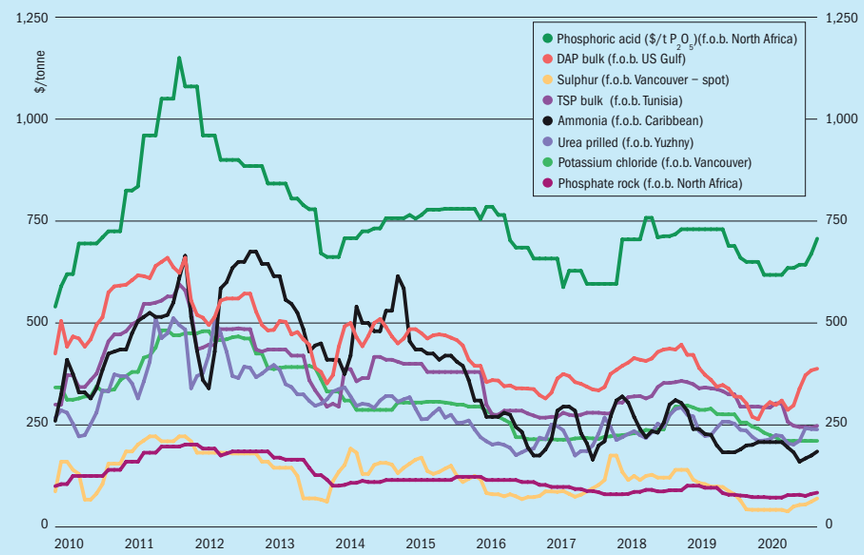
Market Insight

Historical price trends $/tonne



Source: BCInsight

Market Insight courtesy of Argus Media

PRICE TRENDS

Urea: Several factors acted together to pressure prices in the second half of September. India's tender was announced later than expected, Chinese export supply proved larger than anticipated, and a lack of trade west of Suez continued to depress f.o.b. values. Some European buying was triggered in late September after prices fell to more acceptable levels. India's RCF set a new record by awarding 2.18 million tonnes – the first time purchases in a single tender have exceeded two million tonnes.

Chinese prices rose at the end of October, driven by a spiralling domestic market. A fresh spot sale also reconfirmed Egyptian prices in the mid $250s/t f.o.b. range. Brazil remained a weak point, however, with prices drifting below $265/t cfr amid minimal buying activity. Europe was equally quiet as buyers mostly awaited lower values.

Phosphates: Recent prices in the main destination markets were mainly flat, despite new business. Brazilian fertilizer importers purchased a total of 36,000 tonnes of MAP at $367-370/t cfr. Saudi Arabia's Ma'aden also sold a vessel of DAP/MAP to the US for shipment in November. East of Suez, an importer in Pakistan bought 40,000 tonnes of DAP – the first sale to this market in a month – while India remained quiet. Demand in Australia picked up with two new purchases of non-Chinese product emerging.

Globally, key recent drivers of the market include OCP selling MAP to Australia, ports closing in the US and Morocco, and a sales tender being awarded by Fertinal. Argus has also launched two new DAP price assessments for Egypt and Romania. The new benchmarks are DAP f.o.b. Egypt and DAP bagged fca Romania. Prices for these two increasingly important phosphates markets will be assessed weekly.

NPKs: Chad has a tender closing 12th November for 22,400 tonnes (19-12-19+55+1.2B), together with 1,750 tonnes of urea, for February shipment. Similar to Burkina Faso and Cameroon, this NPK tonnage is lower than in 2019, as the cotton market struggles amid the Covid-19 pandemic. Nonetheless, the fresh demand was welcome in a largely quiet market. Mali, Benin and Togo have yet to tender in 2020. Last year, all three tendered for NPKs between September-November, seeking a combined volume of 419,100 tonnes of mainly 14-18-18.

In India, NFL secured a 30,000 tonne cargo (10-26-26) from Sabic at $315-320/t cfr (India duty unpaid). This was for shipment to India's east coast in the second half of November. Similarly, a 30,000 tonne Russian shipment (15-15-15) sold in October at $270/t cfr (India duty unpaid) is arriving early November. Key recent market drivers include uncertainty in the Romanian market and exchange rates limiting Turkish and Chinese exports.

Market price summary $/tonne – End October 2020

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	180-190	-	f.o.b. E. Europe 100-120	f.o.b. US Gulf	377-395	-	-
f.o.b. Yuzhny	200-210	230-245	-	f.o.b. N. Africa	345-359	235-260	654-759
f.o.b. Middle East	230-260	249-270**	-	cfr India	365-377	-	689*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	182-240	-	cfr US Gulf	40-59	f.o.b. Vancouver	65-75	-
f.o.b. Middle East	180-240	-	-	-	f.o.b. Arab Gulf	70-80	-
f.o.b. Western Europe	-	470-550	-	-	cfr N. Africa	75-90	-
f.o.b. Baltic	180-240	-	-	-	cfr India	82-96+	-

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.*

Sulphur: Spot granular business in China has been concluded at $92-95/t cfr. This followed several weeks of stagnation in the import market as end-users consumed domestic inventory and production. In India, business concluded in the range $92-95/t cfr (east coast India) at the start of the sugar season, with phosphate fertilizer producer CIL and Andhra Sugar among the buyers. Fellow fertilizer producer FAC issued a new tender – after it scrapped the previous one – for 15-25,000 tonnes for November shipment. Limited spot availability and Middle East pricing in November have been the two main market drivers recently.

OUTLOOK

Urea: Strong demand from India is expected to provide an outlet for Middle East and Chinese suppliers. In the west, fourth-quarter demand from Europe and Brazil will be a key determinant of granular prices. Although suppliers are comfortable for now, prices will likely come under pressure in between Indian tenders. The lack of buying activity outside of India means the timing of these tenders will set market direction in the medium-term. While India does still need substantial imports for the *rabi* season, there is little to sustain prices in the interim if a lengthy period of time elapses before tendering resumes again.

Phosphates: Looking ahead, Argus expect DAP and MAP prices to remain stable in November. East of Suez, Indian and Pakistan DAP import demand has subsided, being largely confined to cargoes arriving in November's first-half. Agricultural fundamentals in India are, however, likely to remain solid. Chinese producers will raise shipments to Australia next month while also focussing on domestic buyers.

Potash: In the US, Argus expects producers to lift prices in November on the back of tight supply and strong demand. In Brazil and northwest Europe, meanwhile, spot prices may settle at current levels as demand wanes.

NPKs: Argus expects that the stabilisation seen in raw materials prices will take some weeks to feed through to the NPK market. Market activity is being affected by soft demand in many markets and the large spread in bid-offers on several grades.

Sulphur: The push for firmer sulphur pricing – spurred by the relatively bullish phosphate market and healthy producer margins – is expected to peak. This will be followed by softening in both f.o.b. and cfr pricing in late-November and December. Spot deals are also expected to remain limited, as buyers and sellers have fixed contracts in place that will cover the majority of production output and market demand. ■

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UNITED STATES

CF Industries commits to net-zero

Illinois-headquartered CF Industries has made a long-term commitment to low-carbon ammonia production and net-zero emissions.

The leading nitrogen fertilizer manufacturer and the world's largest ammonia producer has pledged to completely decarbonise its global production base by 2050. In a landmark statement on 29th October, CF announced:

- A board-authorised 'green' ammonia project to be built at the large-scale Donaldsonville nitrogen complex in Louisiana
- Carbon dioxide (CO_2) sequestration and carbon abatement projects to enable the production of low-carbon 'blue' ammonia
- The direct linking of executive compensation to CF's environmental, social and corporate governance (ESG) goals – with these including a substantial reduction in carbon emissions across its global network
- A pledge to reduce CO_2 emissions over time – initially a 25 percent reduction in emissions intensity by 2030 followed by emissions cuts to reach net-zero by 2050.

"The world needs clean energy – and hydrogen is a key to meeting this need. Low-carbon ammonia is the critical enabler for storage and transport of hydrogen and thus has a major role to play," said Tony Will, CF's president and CEO. "Today's commitment, to decarbonize the world's largest ammonia production network, positions CF Industries at the forefront of clean hydrogen supply. Due to our unparalleled manufacturing and distribution network, our competitive advantage in producing low-carbon ammonia at scale is measured in terms of years and billions of dollars."

Green ammonia is manufactured using hydrogen generated by renewable electricity. This offers a carbon-free alternative process to conventional steam methane reforming (SMR) from natural gas which is in widespread use today.

CF's initial board-approved project will produce approximately 20,000 t/a of green ammonia at its flagship Donaldsonville nitrogen complex. To generate carbon-free hydrogen, the company will install a state-of-the-art water electrolysis system at the Louisiana site. This will then be supplied as feedstock to the existing plant to produce green ammonia. The costs of this initial project will be met from within the CF's existing capital expenditure, which typically ranges from $400-$450 million annually.

Donaldsonville is the world's largest nitrogen complex, with six world-scale ammonia plants, five urea plants, four nitric acid plants, three urea ammonium nitrate (UAN) plants and a diesel exhaust fluid (DEF) plant.

As well as focussing on 'green' ammonia production via a carbon-free process, CF is also looking to produce low-carbon 'blue' ammonia in future. This will be produced by the conventional SMR process but with CO_2 removed through carbon capture and sequestration (CCS) and/or other certified carbon abatement projects.

Over time, CF estimates that the implementation of CCS and carbon abatement projects across its production sites could eventually produce approximately 3.5 million tons of low-carbon ammonia annually – around one-third of its ammonia production capacity – without affecting its current product mix.

To execute these green and blue ammonia projects, CF will collaborate with leading technology providers and has already signed memoranda of understanding with Germany's thyssenkrupp and Denmark's Haldor Topsoe. It is also in discussions with global energy utilities and maritime shipping companies who are looking to source low-carbon ammonia fuel.

CF expects both green hydrogen and green ammonia to be critical contributors to achieving net-zero carbon emissions globally by 2050. Hydrogen will meet approximately 20 percent of the world's energy need by 2050, according to some industry experts, up from less than one percent today. Ammonia, because it contains three-parts hydrogen to one-part nitrogen, offers an efficient way of transporting and storing hydrogen – as well as being a fuel in its own right.

"Our existing scale and commitment to produce green and low-carbon ammonia establishes CF Industries as the clear leader in providing clean fuels for a sustainable world, while also providing a growth platform to drive long-term shareholder value," commented Tony Will.

CF's board has set up a new committee, the Environmental Sustainability and Community Committee, to oversee all aspects of the company's progress toward net-zero carbon emissions. It will also liaise with the local communities in which CF operates.

CF separately announced a $42.4 million investment in nitric acid production at its Donaldsonville complex. The project will increase the concentration of industrial-grade nitric acid generated at the site's 600,000 t/a capacity 'Nitric Acid No. 4' plant from 60 percent to 65 percent. The investment also covers the addition of an air chiller and the installation of extra product storage, as well as new rail car and truck loading capabilities.

"CF Industries is pleased to continue our long history of investing in and expanding our Donaldsonville Nitrogen Complex and creating jobs in Louisiana," said Tony Will. "The capital investment we are making to enhance nitric acid production at the site will further expand Donaldsonville's production flexibility and enable us to meet strong demand for the product, particularly from Louisiana's chemicals industry."

Large-scale Nebraska green ammonia plant

Technology company Monolith Materials has unveiled plans to build a 275,000 t/a capacity carbon-free ammonia plant in Nebraska. This will incorporate the company's proprietary methane pyrolysis process.

Monolith, founded in 2012, owns a patented process for converting natural gas into carbon black and hydrogen. This produces around three tonnes of solid carbon per tonne of hydrogen, thereby completely avoiding CO_2 emissions.

The new plant – Olive Creek 2 – will be located in Hallam, Nebraska, in the US Corn Belt, a vital grain-growing region that consumes over 1.7 million t/a of ammonia. Monolith says the plant – by integrating a new 180,000 t/a carbon black unit – will avoid the generation of one million t/a of carbon dioxide during the production of 275,000 t/a of ammonia. The plant will use 100 percent renewable electricity for its power train. Construction is expected to begin in 2021.

"This is great news for 21st-century agriculture, where we face the challenge of decarbonising age-old processes at the same time as we must scale up production to keep pace with population growth," said Trevor Brown, executive director of the Ammonia Energy Association. "We need to deploy every available technology to accelerate this energy transition and Monolith's methane pyrolysis process has potential to deliver low-carbon ammonia in the right place at the right scale and at the right cost."

The company's first commercial-scale plant, Olive Creek 1, is currently in commissioning and will produce approximately 14,000 t/a of carbon black. As a next step, Monolith is planning to use hydrogen generated at the site to produce ammonia cleanly – and potentially a wide range of other products that also require hydrogen.

"Since its inception, Monolith Materials has been committed to developing solutions that are environmentally transformative, technologically advanced and financially viable," said Rob Hanson, CEO of Monolith Materials and the company's co-founder. "Being able to produce one of the world's most essential products in a way that is carbon-free is a significant step not only for our company, but for the industry and even society as a whole."

New fertilizer technology prize fund

The Fertilizer Institute (TFI) has joined together with the US Environmental Protection Agency (EPA) and the US Department of Agriculture (USDA) to announce two new competitions. Winners will receive up to $10,000 in prize money or help with greenhouse and field trials.

The aim is to "accelerate the development of innovative fertilizer product technologies and to increase the use of existing enhanced efficiency fertilizers (EEFs) that maintain or increase crop yields and reduce environmental impacts to air, land, and water", according to TFI.

The EPA and USDA launched the two competitions at the end of August:

- Firstly, the *EEFs: Environmental and Agronomic Challenge*. This will identify existing EEFs currently on the market, or near-market, that meet or exceed certain environmental and agro-economic criteria.
- Secondly, the *Next Gen Fertilizer Innovations Challenge*. This will identify concepts for novel fertilizer technologies that are not yet near-market, but show great potential for reducing the environmental effects of modern agriculture, while maintaining or increasing crop yields. They may include EEFs and other product technologies used alongside or in combination with commercial fertilizers.

Winners of the two competitions will be announced in winter 2021.

Winners of the *Next Gen Fertilizer Innovations Challenge* will receive a cash prize of at least $10,000 from a total prize purse of $65,000. They will also be invited to a showcase event to share ideas and spur innovation.

There is no cash prize for winners of the *EEFs: Environmental and Agronomic Challenge*. Instead, they will receive recognition from the EPA and USDA and benefit from a full scientific evaluation. They will also receive help in proceeding to greenhouse trials and eventually field trials, subject to positive results and available funds.

"Today's fertilizer industry is built upon decades of innovation that… has helped farmers increase yields while fine tuning their fertilizer use," said Corey Rosenbusch, TFI president and CEO. "However, there is always improvement to be made, which is why we are excited to partner with the federal government and others in this challenge to spur the industry's creativity in finding sustainable solutions for tomorrow's fertilizer industry."

The two competitions were developed with input from corn grower representatives, individual fertilizer companies, university researchers, and environmental and industry groups. As well as working with TFI, the EPA and USDA are also collaborating with the International Fertilizer Development Center (IFDC), The Nature Conservancy (TNC) and the National Corn Growers Association (NCGA).

"The shared goal here is to accelerate the development of next-generation fertilizers for corn production that can either maintain or increase crop yields while reducing environmental impacts to our air, land, and water," said EPA administrator Andrew Wheeler.

"USDA is committed to encouraging the development of new technologies and practices to ensure that US agriculture is socially, environmentally, and economically sustainable for years to come," said US Secretary of Agriculture Sonny Perdue. "This challenge will stimulate innovation and aligns with USDA's Agriculture Innovation Agenda announced earlier this year."

SPAIN

Fertiberia targets green ammonia exports

Fertilizer producer Fertiberia and power company Iberdrola have announced a new €1.8 billion ($2.1 billion) partnership to produce green ammonia on a large scale.

The Spanish companies unveiled a new large-scale collaboration on the decarbonisation of ammonia production at the end of October. The two partners have set themselves the goal of making Spain a leading exporter of ammonia derived solely from renewable electricity.

Earlier this year, Iberdrola and Fertiberia announced a €150 million ($176 million) project to build the largest industrial green hydrogen project in Europe, located next to Fertiberia's Puertollano ammonia plant (*Fertilizer International* 498, p8). The new 20MW hydrogen plant is expected to become operational in 2021.

But the two companies have now confirmed they will expand their partnership by pursuing three additional projects between 2023 and 2027. These combined would deliver 800 megawatts of green hydrogen generating capacity, enough to decarbonise 25 percent of Spain's hydrogen production. This amount of installed capacity would also contribute 20 percent towards the Spanish government's green hydrogen capacity target of 4 gigawatts by 2030.

The plan is to locate one of the projects in the town of Palos de la Frontera, close to a maritime terminal that is already able to export ammonia.

"The production of green hydrogen through electrolysis, using renewable energy, is a key factor in the path toward achieving climate neutrality by 2050," said Iberdrola's chair and CEO Ignacio Sanchez Galan. "High-temperature industrial processes, or heavy transport, are hard to electrify for technology reasons."

NETHERLANDS

Large-scale electrolyser project for Sluiskil

Norway's Yara International has linked-up with Danish wind power company Ørsted on a new green ammonia project in the Netherlands.

The partners have plans to develop a 100 MW electrolyser to generate green hydrogen. The idea is to partly replace fossil fuel feedstock at Yara's Sluiskil ammonia plant. Renewable hydrogen generated

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by the project could generate 75,000 t/a of green ammonia per year, equivalent to 10 percent of the capacity of one of Sluiskil's ammonia units. The proposed electrolyser will be powered by Ørsted's 750MW Borssele I and II offshore wind farms.

Yara and Ørsted will be seeking public funding to help co-finance, develop and build the electrolyser. The partners say they hope to make a final investment decision in late 2021 or early 2022, subject to sufficient funding and a confirmed business case. This could see the project become operational as early as 2024/25.

BRAZIL

ICL buys Fertiláqua

Israel's ICL has agreed to buy Fertiláqua from Aqua Capital, a leading ag and food private equity firm, for approximately $120 million.

ICL announced a definitive agreement to acquire the Brazilian specialty plant nutrition company in October. The purchase will expand ICL's speciality product portfolio, grow its customer base and provide an in-country production presence in Brazil, one of the world's fastest growing agricultural markets.

Fertiláqua sells over a 100 different plant nutrition, biostimulant, soil revitalisation and seed treatment products, including the market-leading *Aminoagro*, *Dimicron* and *Maximus* brands. These are applicable to all of Brazil's key crops, including soybeans, corn, sugarcane, cotton, coffee, fruits and vegetables.

Fertiláqua has over 350 employees, two production sites and two research and development centres. The company, which has been growing at more than 15 percent annually, has a presence in 24 Brazilian states and serves over 500 customers, including ag retailers, cooperatives and large farms.

Raviv Zoller, ICL president and CEO, said: "The acquisition of Fertiláqua is an important part of the growth strategy of our crop nutrition business. Expected growth… will be supported… by increased demand for high-end specialty fertilizers and our focus on growth markets. Fertiláqua gives ICL a significant foothold in a major market, where demand growth for specialty plant nutrition products is increasing rapidly."

ICL expects the acquisition to close by early 2021, subject to customary conditions.

Araucária Nitrogenados up for sale

Petrobras has announced the sell-off of Araucária Nitrogenados, its fertilizer producing subsidiary located in the state of Parana.

Araucária has the capacity to produce 1,975 t/d of urea and 1,303 t/d of ammonia, but has been shut for economic reasons since January.

Petrobras hopes to sell 100 percent of its stake in Araucária. The divestment is part of a wider strategy by the state-owned oil giant to cut costs and improve its capitalisation. The company's financial situation has worsened this year due to low oil prices and the Covid-19 pandemic. It currently carries around $87 billion in outstanding debt.

TRINIDAD & TOBAGO

Nutrien closes ammonia plant indefinitely

Nutrien indefinitely closed of one of its four ammonia plants in Trinidad in September.

The Canadian fertilizer giant blamed the suspension of operations at its PCS-03 plant on market conditions and lower global ammonia prices. The closure is being accompanied by a 15 percent reduction in Nutrien's workforce on the island from October.

The company said in a statement: "Two of our ammonia plants and the associated urea facility will continue to operate at maximum capacity. Our other plant [PCS-02], which was taken offline in May 2020 due to market conditions, is expected to come back online as market conditions improve. The urea plant at the site will continue operating at normal rate."

Nutrien said the closure would not affect its existing contractual agreements.

WEST AFRICA

Dangote builds Nigerian NPK plant

Dangote started constructing a half a million tonne capacity NPK blending plant at its Lekki fertilizer complex in Lagos state in October.

Urea sourced on-site from Dangote's new production plant will be blended with imported phosphates and potash. The company's massive new 1.3 million t/a capacity urea plant in Lagos state is now scheduled to enter production this November – while the NPK blending plant is expected to come on stream by October next year.

Nigeria moved to ban NPK imports at the end of 2018. The country has refurbished and built a large number of blending plants over the last 2-3 years as part of an NPK self-sufficiency drive (*Fertilizer International* 498, p15). It already possesses some four million t/a of blending capacity, according to analysts Argus, although actual output from these is reportedly running at or below 50 percent of capacity.

Nigeria currently produces around 1.75 million tonnes of fertilizers annually, estimates Argus, mostly domestically-produced urea and blended NPKs. Domestic NPK blending still requires the import of diammonium phosphate (DAP) and muriate of potash (MOP) in large volumes.

Better fertilizer access in Côte d'Ivoire and Ghana

The Africa Fertilizer Financing Mechanism (AFFM) and OCP Africa are teaming-up to increase access to fertilizers in Côte d'Ivoire and Ghana.

In October, the African Development Bank (AfDB) gave approval for the AFFM to participate in a multi-million dollar trade credit guarantee project with OCP Africa.

This is designed to reduce agricultural supply risks and improve access to quality inputs, including fertilizers, in Côte d'Ivoire and Ghana. OCP Africa and the AFFM will each contribute $2 million in trade credit guarantees.

The three-year project, which will run from 2020-2023, will build on OCP Africa's existing *Agribooster* initiative. The main objectives are to improve smallholder access to high quality and affordable agricultural inputs, and also provide training in good agricultural practices. The project will support 430,000 smallholder farmers in the two West African countries, including 104,000 women.

By improving crop productivity, project activities are expected to help boost rice and maize yields by 35 percent in Ghana, and rice yields in Côte d'Ivoire by 30 percent.

Lahcen Ennahli, OCP Africa's senior vice president for West Africa, said: "The partnership with the African Development Bank will scale up and expand activities implemented under the *Agribooster* Initiative. We believe at OCP Africa that this initiative will… incentivize other private and development partners to enter into similar risk-sharing agreements."

Martin Fregene, director of agriculture and agro-industry at the AfDB, said. "[We are] pleased to partner with OCP Africa to achieve the increased agricultural productivity objective of the bank's Feed Africa Strategy."

"Through this project, the Africa Fertilizer Financing Mechanism is achieving its mission… to achieve the African Union target of application of at least 50 kg of fertilizer nutrients per hectare on the African continent," said Marie Claire Kalihangabo, AFFM coordinator.

People

Alzbeta Klein will become the new director general (DG) of the International Fertilizer Association (IFA) on 11th January 2021. She succeeds Charlotte Hebebrand who resigned in May to become Nutrien's chief sustainability officer and executive vice president (EVP) for stakeholder relations. Patrick Heffer is currently acting as IFA's interim DG.

Ms Klein brings significant experience of global finance, sustainability and emerging markets to IFA, including executive roles at the International Finance Corporation (IFC), part of World Bank Group. Following several years at Export Development Canada, Alzbeta went on to enjoy a successful career at World Bank Group, making rapid progress after joining in 1997. Her roles, both at Washington DC headquarters and overseas, have included: chief of staff to the CEO of IFC; global co-head of industrials and agribusiness; and global head of climate business. She has served on the corporate boards of leading agribusiness companies, including South African-headquartered Hans Merensky Holdings and Argentina's Grupo Los Grobo, and on advisory boards of Nespresso and the New York University Stern School of Business.

A citizen of Canada and Slovakia, Ms Klein is a chartered financial analyst who has worked in emerging markets throughout her career. She holds an engineering degree from Prague University and a master's degree in economics from the University of Ottawa. Alzbeta completed her executive education at Harvard Business School and INSEAD.

"We are delighted to welcome Ms Klein", said IFA chairman, Mostafa Terrab. "We are convinced that her breadth of knowledge, as well as her global expertise in finance, sustainability and emerging markets, together with her proven leadership skills, will serve the industry well."

IFA's board of directors also took the opportunity to thank Patrick Heffer for stepping in as interim DG, praising him for his proficient management and for ensuring operational continuity.

Sam Bell became the new chair of the Fertiliser Executive Committee of the UK's Agricultural Industries Confederation (AIC) at the end of October. She is CF Industries' UK commercial director.

Jo Gilbertson, AIC's fertilizer sector head, said: "Sam's appointment comes at a critical time for the sector and we are delighted that she has accepted the role. I am confident that Sam will build on the excellent work that Peter Scott, technical director, Origin Fertilisers, has driven over the last two years."

Steering the UK fertilizer sector along the right path, post-Brexit, will be one of Sam's main objectives. She said: "Significant change is on the horizon and we need to respond with creativity, diligence and energy to provide solutions to achieve a productive, sustainable future for UK agriculture."

Julie Scheck Freigang has joined CF Industries as vice president and chief information officer. She will be responsible for the company's global technology strategy, information technology operations and cybersecurity.

"Julie's strong track record as an information leader building progressive and innovative solutions will serve CF well in the years ahead," said Tony Will, CF's president and CEO. "We look forward to her insight and guidance as we continue to grow our technology capabilities to support the CF team and better serve our customers."

Prior to joining CF, Ms Freigang was vice president and chief information officer at Franklin Electric. She has also served previously in leadership roles at Eaton. Julie holds a bachelor's degree in mechanical engineering from Valparaiso University.

Jeff Ivan has joined Soilgenic Nutrients, a subsidiary of ESG Global Impact Capital, as CEO. He was previously international sales director at AGI Fertilizer Systems, and H J Baker's marketing and business director prior to that.

David Berg, ESG's CEO, said: "Jeff Ivan's experience and knowledge of the global fertilizer industry and distribution network, combined with his deep understanding of the growing demand for sustainable fertilizer alternatives will be instrumental in the future development of Soilgenic Nutrients. In addition, Mr Ivan's career in the agtech industry has provided him with exposure to a large international network of fledgling sustainable fertilizer companies. We believe as their partner, we have the potential to be an industry disrupter by sustainably impacting crop yields and quality by addressing nutrient imbalances."

! **The following events may be subject to postponement or cancelation due to the global coronavirus pandemic. Please check the status of individual events with organisers.**

Calendar 2020/21

NOVEMBER

17-18
IFA High Level Forum 2020, virtual event
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

JANUARY 2021

CRU/Argus Fertilizer Latino Americano 2021, virtual event
Contact: CRU Events
Tel: +44 (0) 20 7903 2444
Email: conferences@crugroup.com

FEBRUARY

16-18
CRU Nitrogen+Syngas USA, TULSA, Oklahoma, USA
Contact: CRU Events
Tel: +44 (0) 20 7903 2444
Email: conferences@crugroup.com

MARCH

1-3
CRU Nitrogen+Syngas 2021, ROME, Italy
Contact: CRU Events
Tel: +44 (0) 20 7903 2444
Email: conferences@crugroup.com

23-25
CRU Phosphates 2021, virtual event
Contact: CRU Events
Tel: +44 (0) 20 7903 2444
Email: conferences@crugroup.com

31 MARCH - 2 APRIL
IFA Annual Conference, NEW DELHI, India
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

JUNE

11-12
AIChE Annual Clearwater Conference, CLEARWATER, Florida, USA
Contact: Miguel Bravo, AIChE Central Florida Section
Email: vicechair@aiche-cf.org

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Latin America has confirmed its status as a pre-eminent global marketplace for fertilizers. We report on demand growth and fertilizer supply and capacity developments within this diverse region.

The salt flat deposits of Chile's Atacama desert are an abundant regional potash resource.

PHOTO: LUC STADNIK/SHUTTERSTOCK.COM

Latin America, a regional powerhouse

Latin America is a diverse, vibrant region of 19 countries with around 500 million people. But at times in recent years it has struggled economically, politically and socially – with the risk of the 2010s becoming another lost decade like the 1980s[1]. In particular:

- **GDP growth** has slowed and lags behind levels seen in other regions
- **Weak public services**, security and infrastructure have provoked social discontent
- **Politics** has been in flux across region with 15 presidential elections taking place in 2018 and 2019 alone
- **Populist regimes** have emerged in the three biggest regional economies – Argentina, Brazil, Mexico
- **Venezuela's crisis** and economic collapse has resulted in poverty, violence and mass migration
- **Price rises** – for transport in Chile and fuel in Ecuador – have sparked civil unrest
- **Corruption continues to be a problem** – the Odebrecht construction scandal in Brazil being a prime example.

Despite the turmoil and wider doubts, one bright spot remains the region's significant agricultural potential. Latin America generates 84 percent of global food and agricultural commodity exports, while consuming just four percent of corresponding global imports.

Agriculture on this scale has created a massive fertilizer import market. The region imports more than 35 million tonnes of fertilizers annually, two-thirds being destined for Brazil alone, making this one country the main driver of Latin American fertilizer demand[1]. This import reliance is likely to continue, given that Latin America consumes 13 percent of global fertilizer output, while only possessing just five percent of global production capacity.

Fertilizer demand in central and south American countries continues to grow strongly. Latin America is one of only three regions globally where fertilizer demand grew above the world average between 2011-2017, according to the International Fertilizer Association (IFA). It also one of the few remaining global regions where agriculture is still able to expand onto large tracts of unexploited land. There is also plenty of scope for improving Latin American crop yields. The region's relative abundance in raw materials – natural gas, phosphate rock and potash – also supports fertilizer production growth (Figure 1).

All these factors combined provide plenty of potential for increased fertilizer consumption.

Although global fertilizer demand growth generally slowed after the financial crisis of more than a decade ago, Latin American demand has consistently outperformed the global average and is substantial across all three major nutrients. Regional fertilizer demand grew at an average annual rate of 5.3 percent between 2000-2007, for example, and at 4.8 percent between 2010-2019. That corresponds to world averages of 2.8 percent and 1.4 percent, respectively, over the same two time periods[2].

Latin American urea demand – 13.4 million tonnes in 2019 – is relatively modest by global standards, placing the region behind China, India and North America. Although Latin America possesses 8.2 million tonnes of urea capacity, its current output capabilities only extend to five million tonnes annually. This means the region is import reliant for urea (84 percent), even though its natural gas reserves are relatively abundant[2].

Latin America consumes phosphate fertilizers at scale and is a major monoammonium phosphate (MAP) market (3.3 million tonnes P_2O_5). This demand is, again, mostly met by imports (83 percent), despite the availability of large phosphate rock reserves regionally. Brazil and Argentina are the second and seventh largest import destinations for phosphate fertilizers globally, importing 4.5 million tonnes and 0.9 million tonnes, respectively, on a product basis in 2018.

Latin America is a leading potash (KCl, muriate of potash, MOP) consuming region too (14 million tonnes) with nearly all its MOP requirements (92 percent) imported. Brazil is the main destination for six of the top 10 exporting countries, importing a total of 10.5 million tonnes of MOP in 2018.

Modest nitrogen demand

Latin American urea demand is expected to grow modestly over the next five years. Regional demand is generally capped by Latin America's less nitrogen-intensive crop mix. It has also been swayed by shifts in national policy and domestic tax regimes.

Extra urea consumption out to 2025 is expected to be relatively modest (2.3 million t/a), with two countries, Brazil and Argentina, being responsible for less than one million t/a of incremental demand.

Latin America remains an attractive urea export destination though. Brazil, in particular, remains at the frontline of global supply and price battles. The region's import supply is also experiencing a marked shift toward African dominance.

"Nigeria is the 'elephant in the room' with huge urea capacity additions in the coming years to further disrupt current supply patterns and increase competition for Brazilian market share," commented Argus at the 2020 Fertilizer Latino Americano conference last January. This surplus African urea capacity could weigh on way market all the through to 2024, according to Argus[1].

Nitrogen production vulnerable

Natural gas costs are the primary cost driver across the nitrogen industry, accounting for 90 percent and 70 percent, respectively, of ammonia and urea production costs. Significantly, Latin American gas costs are higher than some of the major urea exporters, so affecting their competitiveness[2].

Nevertheless, there is still headroom to develop and expand regional urea capacity, especially in Colombia, Mexico and Brazil where demand far outstrips domestic supply. Yet, even as demand is set to further increase, prospects for a corresponding growth in domestic production remain weak, with CRU, for example, not expecting the commissioning of any new regional nitrogen projects by 2024[2].

Trinidad & Tobago is the region's nitrogen production powerhouse, with an output of 5.3 million tonnes versus production capacity of 5.7 million tonnes in 2019. Caribbean producers benefit from good governance and low costs, by regional standards, while facing declining gas reserves[2]. Despite such advantages, cost and supply pressures have seen both Nutrien and Yara substantially curtail Trinidadian ammonia production during 2020.

Brazil produced 0.9 million tonnes of urea in 2019, a fraction of its 1.7 million tonne potential capacity. High costs have led Petrobras to idle its nitrogen plants, driving up Brazilian imports[2]. The state-owned oil company is mothballing Araucaria, its only operational urea plant, and trying to sell its partially constructed 1.1 million t/a capacity Tres Lagoas project in Mato Grosso du Sul state. This was originally designed to use gas supplied from Bolivia via the Gasbol pipeline. The Petrobras-owned Laranjeiras and Camacari nitrogen production sites have been idle since 2019. Both sites are leased to Proquigel Quimica. Rescue talks with Acron to takeover Petrobras' nitrogen production assets collapsed in early December 2019.

Low operating rates have affected production elsewhere in the region. In Bolivia, YPFB's 700,000 t/a BuloBulo urea plant operated at low rates in 2019 due to gas pipeline issues and political unrest. Some 80 percent of its output is targeted at neighbouring Brazil. Pequiven's urea production in troubled Venezuela, meanwhile, dropped to 250,000 tonnes in 2019, an operating rate of just eight percent.

Mexico imports 1.7 million tonnes of urea annually while its domestic production capacity – the dual train one million t/a capacity Pemex Pajaritos urea plant in Veracruz on the Pacific coast – remains largely dormant. Resumption of urea production at Veracruz remains a long shot, according to Argus[1].

Mexico's faltering gas production has been a particular issue, having fallen by almost one-third since 2014. Gas volumes produced by Pemex have deteriorated from 4 bcf/d to 2.8 bcf/d in recent years. The new 2.6 Bcf/d Sur de Texas-Tuxpan offshore gas pipeline from the US, launched in September 2019, is also operating well below capacity because of a lack of interconnections[1].

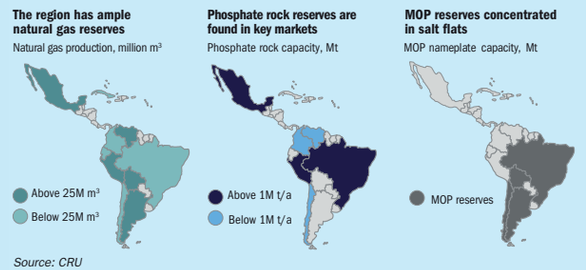
Phosphates on a rising trajectory

Latin America's finished phosphate production capacity current stands at 2.9 million t/a – and is forecast to climb by almost one million t/a by 2033. This means the region will remain in significant supply deficit over the forthcoming decade[1].

Yara's almost completed Serra do Salitre operation – an integrated phosphates project in Minas Gerais – will add significantly to Brazilian production capacity. The project is on-course to deliver annual production output of 1.2 million tonnes of phosphate ore and 1.5 million tonnes of finished phosphates by 2021. Its product mix will include diammonium phosphate (DAP), monoammonium phosphate (MAP), nitrophosphate (NP), single superphosphate (SSP) and triple superphosphate (TSP) (*Fertilizer International* 488, p45). CMOC is also expected to ramp-up its MAP/TSP capacity at Catalao by 0.5 million t/a by 2022[1].

Yet Brazil's domestic producers are still not capturing growth in phosphate consumption, according to CRU[2], as domestic production has largely flatlined. Brazilian MAP production (10-19-0) has actually decreased 0.9 percent since 2010, for example, while imports have risen on average by 8-9 percent annually. MAP remains

Fig. 1: **Latin America has well-distributed and ample reserves of key raw materials**



REGIONAL REPORT

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a key raw material for fertilizer blends with Saudi Arabia, Russia, Morocco and the US competing for market share.

Brazilian producers do have one key advantage, though – logistics. Major agricultural regions are located far inland, with Mato Grosso driving most of the country's fertilizer demand. This state is around 1,500 kilometres away from the Atlantic ports of Santos and Paranagua. Imported phosphates from Morocco, Russia and the US therefore need to travel long distances from their port of arrival. Domestic plants, in contrast, are much closer to premium agricultural markets and do not incur shipping or port fees. Queuing at ports can be a major problem in Brazil, due to strike action or a lack of berths or storage[2].

Elsewhere in Latin America, Pequiven's 450,000 t/a capacity Moron plant in Venezuela is said to be producing DAP/NPKs at very low operating rates. In Peru, Mosaic is unlikely to pursue further expansions in phosphate rock mining capacity at Bayovar, according to Argus[1].

Generally, there is more than enough regional phosphate rock supply to meet current demand levels, according to CRU[1]. Mexico, however, does not have enough rock capacity and has become increasingly reliant on Moroccan imports. Mexico's total phosphate rock imports have risen over the last five years, from around 0.8 million tonnes in 2014 to 1.7 million tonnes in 2019.

Summing up the state of the phosphates market at the 2020 Fertilizer Latino Americano conference last January[1], Argus said: "Issues of cost-competitiveness have dominated the market and 2020 prices will still be under pressure. The US is losing export share into Latin America, a region which remains on a trajectory for heavy increases in MAP and NPS consumption."

Potash – expect increased competition

Latin America, Brazil in particular, is one of the world's major markets for potash. Yet only a fraction of this strong demand is met by locally sourced supply. While the region possesses great potash reserves in desert salt flats, these only contribute a small portion to global capacity[2].

Chile is Latin America's main potash producer. SQM's Atacama operations (2.3 million tonnes nameplate capacity) produced about one million tonnes of MOP in 2019. Output is primarily used as a raw material for local NOP (potassium nitrate) production or else consumed domestically. Chile does, however, export product to Brazil via truck over the Andes. State owned Comibol in Uruguay is the second largest regional potash producer. Its Unuyi production site (400,000 tonnes nameplate capacity) produced 200,000 tonnes of potash in 2019. In Brazil, Mosaic Fertilizantes operates the Taquari MOP production plant (300,000 tonnes nameplate capacity). This, however, only produced 100,000 tonnes of product in 2019 and is scheduled to close in 2023[2].

Argus is confident about future growth prospects for potash in Latin America[1]: "With robust fundamentals and a crop mix particularly supportive of potash consumption, the Latin American region will boast the most significant MOP demand growth over the coming decade."

EuroChem's two large-scale Russian potash projects, Usolskiy and VolgaKaliy, began supplying Brazil for the first time in 2019. Both projects combined were expected to place around 1.2 million tonnes of potash on the market in 2020. K+S Canada's Bethune potash mine also ramped-up its supply to Brazil in 2019, and is projected to supply the market with 2.2 million tonnes of potash in 2020[1]. Potash supply to Brazil from these new entrants is, unsurprisingly, resulting in much more import competition.

Within the region, SQM was expected to raise its MOP output in 2020 due to 'dismal' lithium pricing. Bolivia's 350,000 t/a capacity CAMC plant, commissioned in 2019, had not fully ramped-up as 2020 began.

Summing up – grounds for optimism?

CRU offered the following key takeaways at the 2020 Fertilizer Latino Americano Conference in January[2]:

- Latin America, overall, has great demand prospects across all three nutrients
- There is room for more regional nitrogen fertilizer capacity – subject to gas prices
- Good regional phosphate rock reserves support local production – but do face import competition
- Potash extraction from salt lake deposits continues – although lithium recovery has taken priority and disrupted potash production
- NPK/NP demand and domestic production are on the rise – yet imports still predominate.

Delegates at Argus/CRU's January 2021 virtual conference will no doubt keenly await a detailed update on the state of play in various Latin American fertilizer markets. Some positive signs have emerged in recent months.

Brazil's demand for fertilizer could reach 37 million tonnes in 2020, according to a spring assessment by Rabobank, compared to demand of 36 million tonnes the previous year. The latest figures from ANDA also show that January-April fertilizer consumption in Brazil rose by 18 percent year-on-year to 12.7 million tonnes in 2020, up from 10.7 million tonnes in 2019. Brazil's 2019/20 grains and oilseeds harvest also reached a record 258 million tonnes, as total acreage increased and yields performed well. This was despite partly unfavourable weather conditions during the year.

In neighbouring Argentina, Argus reported a rise in DAP/MAP shipments to 908,000 tonnes in January-August 2020, up from 755,000 tonnes a year earlier. Scheduled arrivals for September of 143,000 tonnes were nevertheless slightly down on the 188,000 tonnes delivered in the same month in 2019.

Moroccan phosphate product made up the biggest slice of these January-August shipments – 399,000 tonnes – with OCP increasing its market share to 44 percent in 2020, up five percentage points year-on-year. DAP/MAP deliveries from the US over this period, some 253,000 tonnes, were also up significantly on the 162,000 tonnes shipped in 2019. Chinese and Russian DAP/MAP producers, meanwhile, contributed 114,000 tonnes and 45,000 tonnes, respectively.

Previous phosphate suppliers have also re-emerged. Tunisian producer GCT, for example, dispatched a 33,000 tonne DAP/MAP cargo to Argentina in July, according to Argus, the first such shipment since 2013. Mexican phosphates were also unloaded in Argentina in August, the first time this has happened since 2018. ■

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2. Derricott, A., 2020 Latin American Fertilizer Capacity Developments. *Argus/CRU Fertilizer Latino Americano 2020 Conference*, 20-22 January 2020, São Paulo, Brazil.

PHOTO: UNITED SOYBEAN BOARD

Soybean crop nutrition

More than 330 million tonnes of soybean are grown globally every year and processed to yield oil and meal, a major source of animal protein. Its cultivation in Brazil, the US and other countries requires large applications of potash and phosphate. The nutrient needs of this major oilseed crop are reviewed.

Soybean (*Glycine max.*) is a bushy, green legume species native to East Asia. Now widely grown in the Americas, it produces an edible bean prized as a source of high-protein meal and oil.

The pod-producing plant is related to clover, peas and alfalfa. It is typically planted in the late spring, each plant producing up to 80 pods in the summer on flowering. Individual pods contain 2-4 pea-sized beans which are rich in commercially-valuable protein and oil.

Crop nutrition – redefining soybean success

Until relatively recently, almost 80 percent growers in the top five US soybean-growing states were not applying either phosphorus or potassium to support their soybean crop, according to USDA research. That was largely because, prior to 2015, only sparse research was available on the importance of crop nutrition for soybeans – particularly the importance of micronutrients.

That is no longer true, however, thanks to more plentiful information on how modern soybean varieties – which are capable of producing far greater seed yields – are acquiring and using nutrients. This includes pioneering doctoral research work published by Dr Ross Bender, now Mosaic's director for new product development, and colleagues at the University of Illinois. Indeed, advances in plant genetics and agronomy have allowed farmers in Brazil and the US to achieve record soybean yields in recent years.

These record-breaking soybean harvests are being accompanied by the ever high uptake and removal of secondary nutrients and micronutrients such as sulphur, magnesium, boron and zinc. This is making the need for season-long macronutrient and micronutrient availability greater today than ever before. Fortunately, fertilizer producers have responded to this challenge by developing innovative, new fertilizer products and designing sophisticated, tailored fertilizer programmes for soybean.

Nutrient uptake and plant growth

Soybeans are known for their efficient use of residual soil nutrients, although modern, high-yielding varieties require more careful nutrient management and higher nutrient inputs.

Proper and well planned crop nutrition is known to be one of most effective ways of influencing both soybean yield and quality. Fertilizer management, and the alleviation of soil acidity, for example, generally have commercially valuable and positive effects on the oil and protein levels of soybeans. Maintaining soil fertility also protects soybean plants from environmental stresses such as weather, disease and nematodes.

In soybean production, soil pH has been singled out for its influence on soil fertility and plant growth. Soybeans thrive at soil pH between 6.0 and 6.8, and both nutrient uptake and yield are maximised at this pH range.

Soybean plants remove nutrients from the soil in large quantities from emergence until the point of maximum accumulation is reached at the pod-filling stage around 75 days later. After this point, plants mobilise their accumulated internal stores of nutrients from vegetative parts to the grain.

Nutrient uptake is highest at 45 days after plant emergence during the start of soybean flowering. Soybean plants will have taken up around half of their total nutrient requirement at this point. The following 30-day interval between flowering and pod-filling is the critical period for soybean crop quality and yield. Several factors such as drought, nutrient deficiency, pest attacks and diseases may dramatically reduce yields during this stage in the plant's growth cycle.

Nitrogen-fixing

Soybean is a nitrogen-fixing crop with an ability to fix as much as 175 kilograms of nitrogen per hectare. It therefore requires little, if any, mineral nitrogen, although minor application to seedbeds is commonly advised. High soil nitrogen levels may even be counterproductive as they can cause excess vegetative growth,

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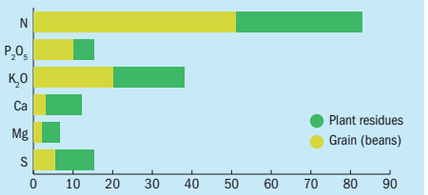
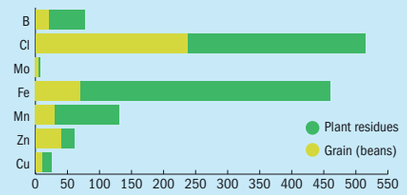
Fig. 1: **Typical soybean macro nutrient removal rates, Brazil (kg/t)**



Source: Yara

Fig. 2: **Typical soybean micronutrient removal rates, Brazil (g/t)**



Source: Yara

reduce nitrogen fixation, increase disease pressure and delay plant maturity.

Soybean plants are able to satisfy their large nitrogen requirement (Figure 1) by fixing the majority of this from the air. They do this via nodules formed on their root system by *Rhizobium* bacteria. Soybean seeds require inoculation with this bacterium to promote nodule formation and, as a consequence, ensure good nitrogen supply.

High potassium demand

Soybeans also require large amounts of potassium (Figure 1), especially during the period of rapid vegetative growth. Potassium has a major effect on both yield and quality of the crop and is therefore essential for healthy, high-yielding plants. For certain soils, potassium application rate has been shown to correlate with both yield and seed oil content.

As well as being vital for vegetative growth and pod and seed formation, potassium also:

- Reduces pre-harvest pod shedding
- Improves seed quality by keeping the numbers of shrivelled, shrunken, mouldy and off-colour beans to a minimum
- Promotes root nodulation and nitrogen fixation from *Rhizobium* bacteria
- Improves transpiration by reducing water loss from the leaf
- Helps minimise the effects of frost in prone areas.

Phosphorus benefits roots, yield and quality

As with many crops, phosphorus availability is important for good root development and crop establishment. Under certain soil conditions, applications rates have been shown to correlate with yield, seed oil content and seed protein content. Phosphorus is involved in:

- The development of roots
- The production of root nodes and hence nitrogen fixation ability
- The movement and uptake of other nutrients
- Plant growth and maturation
- Seed numbers, seed size and seed germination.

Phosphorus, together with potassium, can also limit damage from several plant diseases.

Other nutrients such as magnesium, sulphur and iron are also required during photosynthesis and maintain good growth.

Calcium has a direct influence on crop yield. It strengthens cell walls and is involved in pollen tube growth and pollen germination. It is also an essential nutrient for flower impregnation, flower bud fixation and pod formation. Deficiency causes the shedding of flowers and pods.

Sulphur helps optimise yield and quality and is involved in the formation of nitrogen-fixing nodules on soybean roots. Sulphur availability is directly linked to the quality of harvested seeds, as it promotes oil formation and helps makes oil easier to extract.

Micronutrients maximise yields

As growers aim for ever higher soybean harvests, the likelihood of nutrient deficiencies holding back yield improvements also increases. This means soybean farmers are now having to look beyond 'the big three' – nitrogen, phosphorus and potassium – in their fertilization plans. Indeed, micronutrients, particularly zinc, boron and manganese, are known to be yield-limiting. Iron, manganese and chlorine removal rates for soybean are notably high (Figure 2).

Boron is required for pollen tube growth and pollen germination, and also ensures good fruit set. Boron-deficient plants show poor pod fill and as a consequence produce small, poor-quality seeds. This element also promotes nitrogen-fixation and counteracts aluminium toxicity. Foliar applications of boron and manganese help to ensure consistently high yields, especially for intensive cultivation in poor soil conditions. Manganese is involved in chlorophyll formation and can helps increase seed protein content. It also improves disease tolerance. Zinc enhances photosynthesis.

Balanced fertilization

Nutrient management for soybean firstly requires soil testing of macro-nutrient and micronutrient levels. Soil pH is also an important consideration because of its influence on nutrient availability, as The Mosaic Company notes:

"As soil pH increases, the availability of phosphorus (P), zinc (Zn) and iron (Fe) decreases. Although variety selection can help manage iron deficiency in soybeans, fertilizer application is still needed to address the P and Zn deficiencies prevalent in high-pH soils."

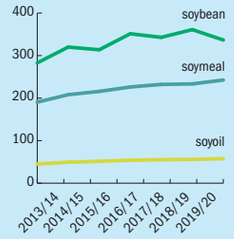
One of the main formulations offered by Mosaic for soybean is zinc-fortified *MicroEssentials SZ* (12-40-0-10S-1Zn). This combines 12 percent nitrogen, 40 percent phosphorus and 10 percent sulphur with one percent zinc (*Fertilizer International* 478, p 24). With a balanced mix of nutrients in every granule, *MicroEssentials SZ* is able to maximize soybean yields, according to Mosaic, by counteracting the influence of pH on P and Zn availability.

Soybean production and consumption

World production and consumption of soybean oil is second only to palm oil (*Fertilizer International* 479, p14). Soybean meal is also the world's largest protein source for farm animals, being a major feed ingredient for chickens, pigs and cattle.

Soybean was one of the first crops to be cultivated agriculturally, having originally been grown for food in China nearly 6,000 years ago. In recent decades, soybean growing, processing and trading has turned into a multi-billion dollar global industry – and a cornerstone of world farming and agricultural trade – because of the millions of livestock it feeds across the planet.

Fig. 3: **World soybean, meal and oil production, 2013/14-2019/20**



Source: USDA

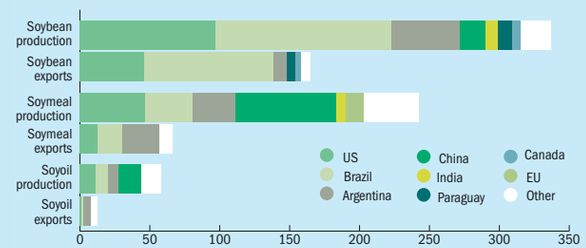
Global soybean production grew almost ten-fold during the 50-year period between 1960 and 2010. World production has expanded by almost 20 percent in the last six years, increasing from 283 million tonnes in 2013/14 to reach 337 million tonnes in 2019/20 (Figure 3). Approximately 75 percent of that total is ultimately destined for animal feed.

Soybean can be successfully grown in tropical, subtropical and temperate climates. Global production is concentrated in seven main growing countries, Brazil, the US, Argentina, China, India, Paraguay and Canada (Figure 4). Of these, three countries in the Americas, Brazil, the US, and Argentina, collectively account for more than 80 percent of global output. Furthermore, the US and Brazil also dominate the soybean export market, being responsible for over four-fifths of world trade. Argentina has adopted a different approach, choosing to process much of its domestic soybean harvest at home, and export soybean meal and oil in large tonnages instead.

China is the world's biggest soybean importer by a large margin, and the main destination of Brazilian exports. Thanks to its importance to global agriculture, this trading route even has a name: the Brazil-China soybean pipeline. The 97 million tonnes of soybeans imported into China in 2019/20 represents 60 percent of global trade in this commodity. By processing these imports, China has also become the world's largest soybean meal and oil producer (Figure 4).

The EU is the biggest importing region for soybean meal globally (18 million tonnes in 2019/20), and also imports large tonnages of soybeans (16 million tonnes). South-east Asian countries (Vietnam, Indonesia Thailand and the Philippines) collectively imported a further 16 million tonnes of soybean meal in 2019/20. ■

Fig. 4: **World soybean, meal and oil production and exports, 2019/20 (milion tonnes)**



Source: USDA

Traditionally, in corn-soybean crop rotation systems, enough nutrients are provided at the start of the corn crop to cover both its needs and the needs of the subsequent soybean crop. But a series of University of Illinois trials commissioned by Mosaic suggest this approach may cause soil nutrient mining and leave insufficient nutrients for the soybeans.

"We think that growers are not adequately fertilizing phosphorus because they don't know how much the corn is removing, and they're not actually fertilizing their soybeans," says Dr Fred Below, a lead scientist on the Illinois trials. "That's what we've demonstrated in our trials over the past few years."

He continues: "This leads [on] to the idea of balanced crop nutrition. For some reason, when the potassium is adequate, the plant seems to use the phosphorus better – it can squeeze another bushel or two out of it."

Mosaic's trials show that nutrient removal rates for soybean, especially for potassium, can be as high if not higher than for a standard corn crop.

"Compare a 60-bushel soybean crop [4 t/ha] to a 230-bushel corn crop [15.5 t/ha]: That corn crop is going to remove about 80 pounds of P_2O_5 [36 kilos], while the soybean crop is going to remove about 40 pounds [18 kilos]," comments Dr Matt Clover, former research manager at Mosaic. "But when we look at potassium, that 230-bushel corn crop is going to remove about 58 pounds of K_2O [26 kilos], and that soybean crop is actually going to remove about 75 pounds of K_2O [34 kilos]."

Manganese is one of the most common micronutrient deficiencies in soybean, and a particular problem in high-pH soils. Soil alkalinity, in turn, may be caused by calcium, magnesium and iron soil imbalances. Manganese deficiency is most acute in high organic matter soils during cool spring months when soils are waterlogged, and symptoms often disappear as soils dry-out and soil temperature rises. Mosaic suggests several ways of correcting manganese deficiencies:

- Keep soil pH below 6.5 if liming is causing the deficiency
- Mix a soluble form such as manganese sulphate ($MnSO_4$) with the starter fertilizer and apply in bands, as a high-phosphorus starter fertilizer helps move manganese into the plant
- Correct field deficiency symptoms with a foliar application.

Please see our previously published article (*Fertilizer International* 481, p33) for further information on fertilizer products for soybean and manufacturer recommendations. ■

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CIBRA agronomists Rafael do Val (left) and Jeferson Oliveira (right) inspect the 2019/20 Brazilian soybean crop.

SOURCE: ANGLO AMERICAN CROP NUTRIENTS

More bags of soybeans with *POLY4*!

The polyhalite product *POLY4* offers a balanced and sustained supply of essential plant nutrients throughout the crop cycle – making it a highly-attractive, natural, multi-nutrient option for soybean fertilization. **Lino Furia**, **Valter Asami**, and **Reinaldo Bello** of Anglo American Crop Nutrients outline its many crop benefits.

Soybeans are widely grown for their high protein and oil content. They also provide an excellent source of dietary nutrients, including fibre, iron, manganese, phosphorus and folate. Because of this, soybeans have undoubtedly become one of the world's most important crops, being widely consumed as a source of vegetable oil, animal feed, soy sauce and milk, tofu and textured vegetable protein.

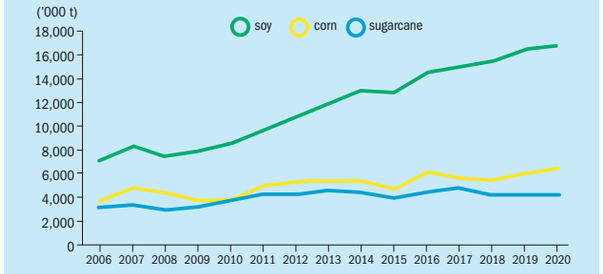
Three countries – Brazil, Argentina and the United States – produce approximately 82 percent of the world's soybeans at present, with Brazil leading the pack as the primary producer. Indeed, Brazil's farmers are expected to deliver a record 133 million metric tonne soybean harvest in 2020/21, according to USDA's latest forecast, up six percent from last season's record. Soybean yield for this year's crop is also forecast at 3.45 tonnes per hectare (t/ha) – the second highest on record – only slightly down on the record yield of 3.47 t/ha achieved in 2017/18. Furthermore, Brazil has now overtaken the US to become the world's top soybean exporter, a position the country is projected to retain through to 2029.

A number of key factors have contributed to the rapid rise in Brazil's soybean production over recent decades. They include:

- Brazil's favourable climate which provides the ability to produce two crops from the same acreage in a single year
- The ability to use this same land for livestock pasture during dry seasons
- The emergence of new soybean varieties with a reduced growth cycle and higher nutrient demand
- The expansion of the area of land under cultivation in the Cerrado (Brazilian savannah).

Brazil has grown into one of the world's largest fertilizer consumers, relying heavily on imported potash, phosphate and nitrogen fertilizers. This has been necessary to maintain the country's status as a global agricultural powerhouse and sustain domestic crop productivity levels.

Fig. 1: **Fertilizer consumption by Brazil's top three crops, soy, corn and sugarcane, 2006-2020**



Source: ANDA

Fig. 2: **Brazilian soybean demonstration trials for *POLY4*, 2019/20 season**

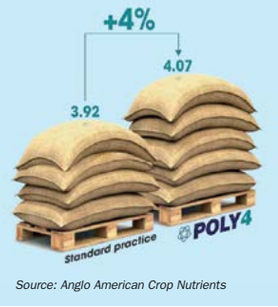
Source: Anglo American Crop Nutrients

Typically, Brazil's soybean farmers use muriate of potash (MOP) as their primary source of potassium, consuming more than 10 million tonnes of MOP a year. Traditionally, sources of phosphorous, sulphur and calcium are also provided by applying monoammonium phosphate (MAP), single superphosphate (SSP) and triple superphosphate (TSP). Soybean alone accounts for almost half (47 percent) of overall Brazilian fertilizer consumption (Figure 1). Around two-thirds of fertilizers in Brazil are applied as NPK blends, with the remainder applied as straight fertilizers.

Treatment transformation

Soybean production accounts for forty percent of Brazilian agricultural output. It is therefore unsurprising, given its prevalence, that Anglo American Crop Nutrients has made testing the effects of its polyhalite-based fertilizer – *POLY4* – on soybean performance a priority in Brazil. Fifty-seven successful crop demonstration trials were completed in the 2019/20 season in collaboration with CIBRA, our Brazilian partner (Figure 2).

Fig. 3: **Brazilian 2019/20 soybean demonstrations: average yield improvement (t/ha)for *POLY4* fertilizer plan vs standard practice**



Source: Anglo American Crop Nutrients

Soybean has a notably high phosphorous and potassium demand. Regionally, Brazilian soybean farmers typically apply these in equal amounts. Farmers in the south, for example, usually use 70 kg of P_2O_5 and 70 kg of K_2O per hectare. In the north of Brazil, meanwhile, where soils are not as fertile, 90 kg of P_2O_5 and 90 kg of K_2O per hectare are applied. Nitrogen, in contrast, is not applied in large amounts because soybean is a nitrogen-fixing legume.

Lime and gypsum are also commonly used by Brazil's farmers for soybean fertilization. Lime, which offers magnesium and calcium carbonate, is an important soil amendment that helps adjust soil pH. However, its limited solubility means lime is generally unable to meet crop nutrient needs, especially at times when these are most required.

Gypsum supplies both calcium and sulphur. It also reduces the aluminium toxicity of highly-weathered Brazilian soils. Frequent gypsum application, as a standard practice, promotes potassium and magnesium availability. But it only achieves this at a medium rooting depth. *POLY4* – in contrast – promotes these same nutrients throughout the entire rooting depth.

What is often most important to soybean farmers is nutrient availability. The increased nutrient demand of newer, higher-yielding soybean varieties means nutrient supply must be correspondingly improved. Trial results show that *POLY4* successfully boosts agronomic performance by supplying potassium, sulphur, magnesium and calcium in one product. Importantly, it supports season-long crop nutrient demand while also increasing resilience to leaching.

Polyhalite granules are also effective at helping meet soybean's high sulphur demand. Additionally, the combination of nutrients supplied by *POLY4*, including soluble magnesium and calcium, not only improves soybean yields, it also improves residual soil nutrient levels for the following rotation crop.

More bags of beans

In Brazil, the adoption of a *POLY4* fertilizer plan has achieved positive results in 75 percent of soybean crop demonstration trials. During these trials, the composition of dry blends was varied to match regional nutrient requirements, with individual treatments being tailored in line with local recommendations.

EMBRAPA, the National Brazilian Agricultural Research Corporation, states that for a soybean yield of 4.2 t/ha, the following amounts of nutrients are exported by the crop:

- 85.3 kilograms of K_2O
- 14.1 kilograms of S
- 8.6 kilograms of Mg, and
- 12.2 kilograms of Ca.

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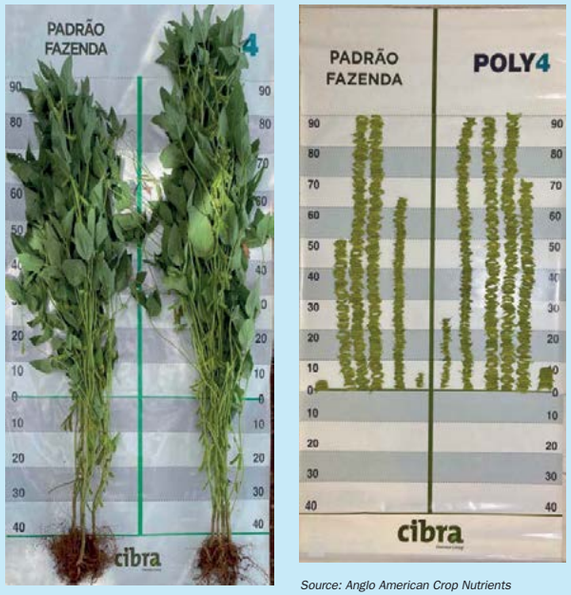
Fig. 4: **Brazilian 2019/20 soybean demonstrations: visual comparisons of *POLY4* performance (right) versus standard practice (left)**



Source: Anglo American Crop Nutrients

For *POLY4* fertilizer plans, dry blends were formulated by mixing *POLY4* with MOP, to complement potassium supply, and with either MAP or TSP to provide a source of phosphorous.

The application of two hundred kilograms per hectare of *POLY4*, as a common baseline component, transforms the performance of fertilizer plans – by delivering 28 kilograms of K_2O, 38 kilograms of S, 7.2 kilograms of Mg and 24 kilograms of Ca per hectare

Brazil's soybean farmers are generally receptive to new products and innovative technologies. That makes them very interested in any fertilizer source that offers prolonged nutrient availability and increased productivity.

This is especially true for the cultivation of new soybean varieties as these demand a timely nutrient supply due to their shorter production cycle. While traditional soybean varieties with a 130-day growing cycle are still used in some regions, new plant breeds with a 90-day cycle are being grown more and more in the majority of Brazil's soybean-growing areas. The adoption of soybean varieties with a shorter production cycle is advantageous as it allows the cultivation of succession crops – mainly corn, wheat and cotton – in the same year.

On average, *POLY4* achieved a four percent yield advantage (Figure 3), with nine demonstration trials showing yield improvements in excess of ten percent. The progress of the recent crop demonstration trials was regularly observed by CIBRA and Anglo American agronomists. The team monitored and collected a range of biometric data, including the number of pods and beans per pod, and determined plant nutrient levels using leaf analysis. Visual differences, such as crop size and root length, were also recorded for *POLY4* treatments versus standard practice (Figures 4 & 5).

Positive results confirm that *POLY4*, by providing a balanced mix of nutrients and a sustained nutrient supply, ensures the continued delivery of nutrients at the time when crops most need these.

Smooth operation

Within Brazil, soybean cultivation is mainly divided between eight states, with most farms ranging in size from 1,000 to 10,000 hectares. At the upper end of this size range, operational costs are a big focus for Brazil's mega farmers. To efficiently cover the large land area on such farms – whether for fertilization, planting or harvest – good farm infrastructure is necessary. Farmers also need to start applying fertilizers at least thirty days before planting to ensure timely coverage. However, application this early exposes fertilizers to nutrient losses through leaching.

Moreover, soybean farmers in Brazil typically undertake three fertilizer runs each season. Phosphorous is applied firstly, then potassium, followed by the separate application of gypsum. While phosphorus and potassium sources are spread at 36 metres, gypsum, being in powdered form, is spread at 12 metres. This necessitates the use of different spreading equipment and additional resources. Each additional pass also results in another zone of soil compaction in the crop.

When it comes to simplifying on-farm operations, *POLY4* provides an effective and much needed solution. Polyhalite-based granules, because they offer all the required nutrients in one product, can be supplied to crops in one application. This makes life easier for the farmers by dramatically reducing both the number of field runs and their labour costs. *POLY4*, due to its gradual and sustained dissolution, also fits in well with the farmer's business cycle. An early application of the product meets coverage demand and then ensures nutrients continue to be available throughout the growing season whenever required by crops.

Better blends

Soybean farmers in south Brazil prefer to apply NPK blends in-furrow as starter fertilizers, traditionally using blends such as 0-18-18 or 0-20-20. This is far from ideal, however, as the high potassium concentration within the furrow suppresses root growth due to the osmotic effect of increased soil salt levels. Agronomists and cooperatives in south Brazil are currently running a major campaign to combat this. The campaign recommends the broadcast application of potassium and also promotes the replacement of traditional blends.

Fig. 5: **Soybean root development with *POLY4* versus standard practice**

Source: Anglo American Crop Nutrients

An NPK starter blend that partially replaces MOP with *POLY4* and replaces SSP with TSP offers many benefits. *POLY4*-based blends provide a comprehensive and better balanced mix of nutrients, with more sulphur and magnesium and – beneficially – less chloride.

The provision of two different sources of potassium within the blend (Figure 6) also guarantees its season-long availability for plant root absorption. These changes to standard blends, especially the inclusion of *POLY4*, matches nutrient release to the soybean growth cycle. They also confer positive advantages in terms of farm logistics and soil structure.

Supporting soil

When asked, Brazilian soybean farmers will often rank the weather as their highest challenge. Less than ten percent of agricultural land in Brazil is irrigated, the majority being rain-fed. This reliance on rainfall can be a disadvantage, given that Brazil is experiencing longer periods of dry weather and drought as a consequence of climate change and extreme weather conditions. These increasingly arid conditions have repercussions as they force plant roots to grow deeper in search of water and nutrients.

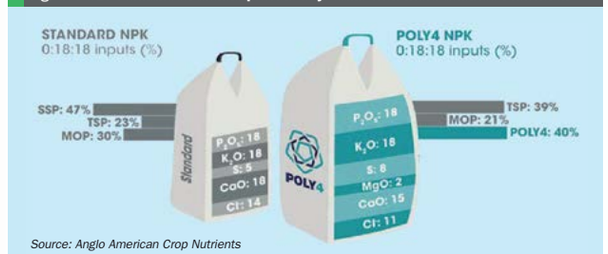
Aluminium toxicity and nutrient deficiency in Brazil's acidic soils are two other issues of major concern to farmers. Indeed, the aluminium toxicity of soils is a primary constraint on crop biomass production in Brazil and the main factor limiting plant growth. Because of this, farmers need to regularly re-apply lime or gypsum to depress soil aluminium concentration. However, the neutralisation of aluminium by gypsum is only a temporary fix, especially within the deep soil profile (20-40 centimetres). Toxicity generally returns quickly after applications stop.

In 2018, a São Paulo State University (UNESP) study examined the soil benefits of *POLY4* versus those of gypsum. The study compared sulphur and calcium delivery and observed potassium and magnesium distribution within the soil profile. Results showed that gypsum only improves calcium availability in the upper soil profile, while the calcium released by *POLY4* was available at all depths. In doing so, *POLY4* encouraged root growth, supported nutrient and water uptake, and helped to protect crops from drought stress. In addition, the higher solubility of the sulphate in *POLY4*, relative to gypsum, enhanced soil SO_4 concentrations at both shallow horizons and deeper in soils.

Additionally, the 2018 study showed that *POLY4* improves potassium availability to roots as deep as 60 centimetres. The product also enhances magnesium availability in the root zone at soil depths of 40 centimetres and below. It was concluded that *POLY4* was able to add more magnesium to soils both at shallow depths and deep down. Gypsum, in contrast, promoted the leaching of magnesium. After nine months, it increased magnesium availability at a depth of 40 centimetres but depleted availability at shallow soil levels.

Overall, our 2020/21 trial results show that *POLY4* offers a balanced and sustained supply of essential plant nutrients throughout the crop cycle – making it a highly-attractive, natural, multi-nutrient option for soybean fertilization.

Fig. 6: ***POLY4*-enhanced blends provide soybeans with more balanced nutrition**



Source: Anglo American Crop Nutrients

A sustainable solution

Soybean cultivation in Brazil has improved in recent years, due to greater understanding of agronomic and climate factors, and the introduction of soil conservation management practices. Over the years, this has allowed degraded land to be converted for productive agricultural use. Likewise, no-tillage systems and more efficient fertilizer use have both contributed to greater productivity in the Cerrado region, and made management systems possible that allow two crops to be harvested annually.

Using *POLY4* as part of a soybean fertilizer plan delivers a range of obvious benefits. These include yield improvements, more balanced crop nutrition, sustained nutrient delivery, and more efficient on-farm operations. But ensuring the sustainability of our agriculture and food systems is also an economic and environmental imperative.

In particular, every effort needs to be made to maintain the existing fertility of arable land and ensure that resources are used efficiently. Balanced nutrient supply undoubtedly plays a vital role here, being the key driver of fertilizer use efficiency. The use of *POLY4*, a natural resource with an inherent low carbon footprint, can clearly help. In Brazil and other countries globally, we believe *POLY4* will contribute to the development of sustainable agricultural solutions that will be economically viable for farmers and their communities for generations to come. ■

About the authors

Lino Furia is the lead regional agronomist and Valter Asami a regional agronomist for Latin America at Anglo American Crop Nutrients. Reinaldo Bello is the company's head of the Americas. For more details of the company's under-construction, UK-based Woodsmith Mine project go to page 49.

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Soybean crop, Brazil.

PHOTO: ANGLO AMERICAN CROP NUTRIENTS

Season-long soybean nutrition maximises yields

Kyle Lilly, senior product manager at Compass Minerals Plant Nutrition, outlines how a season-long approach to soybean crop nutrition can be created using a variety of tools. When combined together, these can optimise soybean fertilization and deliver impressive yields – as has been shown in both Brazil and the US.

A quick look at the research on soybean fertilization reveals extensive information about the recommended broadcast rates for macronutrients. This article builds on that knowledge by describing additional techniques that have improved soybean crop yields in both North and South America through season-long crop nutrition. The techniques include:

- More even nutrient distribution in fertilizer blends
- Treating seeds with nutrients
- Time specific foliar applications of nutrients.

In 2019, the United States (US) set a new soybean yield record[1] of 12.79 tonnes per hectare (t/ha) – nearly four times the average soybean yield[2] that year of 3.34 t/ha. Meanwhile, the average soybean yield in Brazil last year[3] was an estimated 3.37 t/ha. Brazilian farmers have also shown themselves capable of growing high yielding soybeans, with the 2017 *Comitê Estratégico Soja Brasil* yield winner[4] producing 8.94 t/ha.

These examples from the US and Brazil, the world's two largest soybean producers, illustrate the 'yield gap' – the difference between the average soybean yield and its genetic potential. While weather may be outside of the farmer's control, crop nutrition is a critical and controllable factor capable of increasing soybean yield and return on investment (ROI).

A season-long approach

Most soybean farmers subscribe to sufficiency fertilization. This involves applying 'just enough' fertilizers to the crop, no more, no less. It is unsurprising to find, therefore, that such farmers are nowhere close to achieving the crop's ultimate genetic potential. However, increasing numbers of farmers are finding that a season-long approach to soybean nutrition provides the ideal framework for maximising both yields and ROI. The 4Rs fertilizer concept – right source, right rate, right time, right place – underpins this approach by helping identify gaps and shortfalls in the farmer's sufficiency-based fertilization programme.

Fertilizer distribution

Large amounts of macronutrient fertilizers are applied across soybean fields. However, micronutrients are also necessary for a high-yielding crop. Results from over 42,000 tissue samples in the US show that over 75 percent of soybeans are not only deficient in potassium (K) but also in copper (Cu)[5]. Copper plays a critical role in photosynthesis. It also improves the structural strength of soybean plants by promoting lignin formation in plant cell walls.

However, evenly distributing micronutrients is a challenge, highlighting the importance of the 'right place' part of the 4Rs fertilizer approach. The typical application rate for granular copper sulfate is 6.4 kilograms per hectare (kg/ha). If added to a bulk blend, such a small amount cannot be spread evenly across the field, leaving some areas Cu deficient or, even worse, experiencing Cu toxicity.

PHOTOS: COMPASS MINERALS

Fig. 1: Uneven micronutrient fertilizer distribution (left) in a bulk fertilizer blend. The patchy distribution of granular copper oxysulphate (dark) within the urea (white) is clearly visible. This contrasts with the even distribution of a copper dry dispersible powder (right). Every urea prill in the blend is coated with copper.

Applying micronutrients as dry dispersible powders solve this dilemma, as research from Compass Minerals Plant Nutrition has shown (Figure 1). The dry powder evenly coats macronutrient fertilizer granules due to its small particle size and high surface area. The same effect can be observed by placing your hand inside a bag of flour and noticing how the tiny flour particles stick. Multiple field trials show that dry dispersible powder micronutrient coatings increased zinc (Zn), manganese (Mn), and iron (Fe) uptake in soybeans by 12.4 percent, 15.3 percent and 22.0 percent, respectively, against an untreated control.

Treating seeds with nutrients

Many growers are aware of the importance of early-season fertilization for achieving high soybean yields – and often meet this need by applying a starter fertilizer. However, evidence from recent agronomic trials, together with the higher nutrient demands of new genetic varieties of soybean, suggests that the starter fertilizer may not be supplying enough nutrients or entering the crop early enough in the growth cycle.

There is a fundamental need to get nutrition to the seed as early as possible. This reinforces the importance of the 'right time' in the 4R approach. Applying small

PHOTOS: COMPASS MINERALS

Fig. 2: Applying nutrients to seeds as a liquid coating via a commercial seed treater (left). Nutrients can also be applied dry via a powder additive feeder as a seed finisher (middle). Dry nutrient powders can also be added directly in a seed planter box as a coating and seed flow aid (right).

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PHOTO: COMPASS MINERALS

Fig. 3: Three soybean crops grown with a dry nutritional seed treatment applied in a planter box (right). Representative untreated soybean crops included for comparison (left). Photo was taken in North Dakota on 16 July 2019.

amounts of nutrients directly to the seed is one method showing great promise – by improving stand count, early crop vigour and nodulation. Applying nutrients to soybean seeds, having become standard practice in Brazil, is now slowly gaining traction in the US too.

Nutrients are commonly applied to seeds as either a dry powder or liquid coating (Figure 2). Liquid coatings are applied with a commercial seed treater. This enables them to be applied at the same time as fungicides, insecticides, inoculants and other crop protection inputs. Dry powders can be applied during the liquid treatment of seeds or, alternatively, at planting when seeds are in the planter box. If applied during the liquid treatment process, seeds can also be treated with a drying agent or a pearlescent pigment alongside the nutrient powder. This simultaneously improves seed flowability and appearance, as well as providing crop nutrients. The planter box application method is a direct replacement for other seed flow aids such as talc or graphite.

Critical nutrients to apply on-seed

Soybean farmers in both Brazil and the US have found success applying molybdenum (Mo), cobalt (Co), and nickel (Ni) – as well as Zn and Mn – directly to the seed, either as a dry powder or as a liquid coating. These nutrients offer specific benefits to early germinating soybean plants.

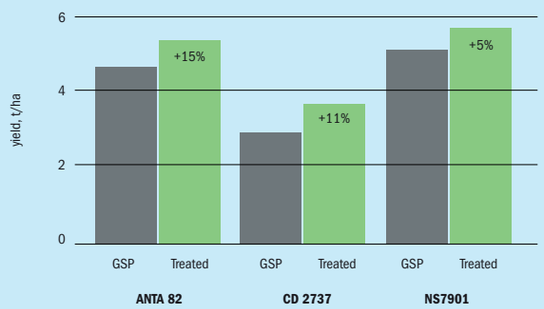
While nitrogen (N) is king in terms of soybean nutrient demand, its role as a crop nutrients is supported by micronutrients. Soybean crops are, in fact, rarely fertilized with nitrogen as they have the ability to take up 82 kilograms of N per tonne, mostly by 'fixing' this from the atmosphere. The establishment of functioning nodules is absolutely critical to this nitrogen fixation process. The micronutrients Mo, Co, and Ni all play important roles in nitrogen metabolism. These nutrients are key to unlocking unusable nitrogen. They do this by converting urea-N into plant-available nitrogen (ammonia-N and nitrate-N) containing amino acids and proteins. This combination of nutrients ultimately builds biomass and yield. Liquid seed application of these nutrients resulted in a 45 percent increase in soybean yields, university trial results from Brazil have shown[6].

As plants begin to grow, Mn and Zn create longer, more developed root systems, and also play a critical role in improving plant resistance to early-season cold and moisture stress. Results from 11 large-scale US soybean field trials showed that a dry seed nutritional application containing Mn and Zn with Fe and Mo delivered a 3.95 percent average yield increase[7]. Common benefits of on-seed application of micronutrients include bigger and greater numbers of nodules, thicker stalks, and taller, greener plants (see Figure 3).

Time-specific foliar applications: vegetative stages

As previously mentioned, nitrogen metabolism in soybean is improved by the on-seed application of Mo, Co, and Ni. Foliar applications of these nutrients at the vegetative growth stages have also been shown to improve soybean nutrition and yields. Research from 33 large-scale field trials in the US has shown that foliar application of Mo, Co, and Ni during vegetative growth stages results in a soybean yield improvement of 4.82 percent[8]. The author suggests these three nutrients function by delaying ethylene synthesis inside the soybean plant. This allows the nodules in the crop to continue to produce nitrogen and build proteins. However, this is only one hypothesis and further research is needed to conclusively demonstrate this.

Fig. 4: **Yield improvements across three soybean varieties, ANTA82, CD2737 and NS7901. Foliar application of B, Mo, Ni, and seaweed extract at R1 growth stage vs grower standard practice**



Source: UNIFIMES, Centro Universitário de Mineiros (2019)

Time-specific foliar applications: reproductive stages

Flower retention and pod set in soybeans are critical to yield success. Boron (B) plays a key role during these stages, supporting both pollination and seed production. A foliar application of seaweed extracts containing B, Mo, and Ni was applied to soybeans at the R1 growth stage by researchers in Brazil[9] (Figure 4). This treatment delivered a yield increase of up to 15 percent, based on the results of these small plot replicated trials. The treatment also improved the number of pods per plant by up to 18 percent. This again highlights the need for the 'right time' in the 4Rs fertilization approach.

> **In Brazil, the Compass Minerals nutrition programme has increased soybean crop yields by an average of six percent.**

A season-long approach to soybean crop nutrition

This article outlines how a season-long approach to soybean crop plant nutrition can be created using a variety of tools. These include optimised nutrient applications, even nutrient distribution, seed-applied nutrients and timely foliar nutrient applications. When combined together, this system can optimise soybean nutrition and deliver impressive yields. In Brazil, the Compass Minerals season-long nutrition programme for soybean has increased crop yields by an average of six percent in over 500 field trials. US data for the programme is still being collected currently, but is sure to show similarly positive findings. One highlight for the Brazilian programme was the setting of the national soybean yield record of 8.94 t/ha in 2017 by a participating farmer. We conclude that this new approach to soybean crop nutrition shows great promise by encouraging the adoption of 4R fertilizer principles to improve yields. ■

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Polysulphate: A unique fertilizer for soybean

Across all the world's major soybean-producing regions, more and more farmers are now choosing to include *Polysulphate* in their soybean fertilization strategies. **Patricia Imas**, ICL's chief agronomist, explains how this new product benefits both crop yield and quality.

Economically, the soybean (*Glycine max*) is the most important bean in the world, providing vegetable protein and oil for millions of people to eat and ingredients for manufacturing hundreds of chemical products. This annual legume of the pea family (*Fabaceae*), being a rich and cheap sources of protein, has become a dietary staple for people and animals in many parts of the world.

Soybean nutrient needs

Soybean's demand for nutrients varies according to its growth stage. Generally, the amount of nutrients needed to support growth increases as the soybean plant accumulates biomass. Nutrient demand eventually reaches a maximum during seed fill. Soybean crops therefore need a prolonged, adequate and balanced supply of plant nutrients to maintain healthy growth and achieve their yield potential. For example, a good soybean crop yielding 4 t/ha can take-up around:

- 230 kg/ha of potassium (K_2O)
- 90 kg/ha of sulphur (SO_3)
- 120 kg/ha of calcium (CaO)
- 73 kg/ha of magnesium (MgO).

Balanced and prolonged nutrition

Polysulphate is a new multi-nutrient fertilizer from ICL. Mined and produced in the UK, this natural mineral product (polyhalite) has a low carbon footprint and is approved for organic agriculture. *Polysulphate* contains four nutrients – sulphur, magnesium, potassium and calcium – in the following amounts:

- 48 percent SO_3
- 6 percent MgO
- 14 percent K_2O
- 17 percent CaO.

> ***Polysulphate* is especially suitable for application to soybean crops, as it provides an adequate and balanced supply of four essential nutrients – S, K, Mg and Ca – in just one application.**

All these nutrients are in sulphate (SO_4) form. Additionally, *Polysulphate* is low in chloride, has a very low salinity index and does not affect soil pH.

Being a natural crystalline material, *Polysulphate* also has a unique dissolution pattern – gradually releasing its nutrients after being applied to the soil. Its prolonged-release characteristics mean that *Polysulphate* behaves as a fresh supply source throughout the growing season, providing four nutrients to the growing crop. Its nutrient release pattern matches plant uptake, thereby minimising the risk of loss of sulphate through leaching.

Polysulphate is especially suitable for application to soybean crops, as it provides an adequate and balanced supply of four essential nutrients – S, K, Mg and Ca – in just one application. The product steadily releases a continuous supply of each of these key nutrients to the growing soybean plant.

Key advantages

The main advantages of using *Polysulphate* in soybean fertilization are:

- It combines better nutrition with higher operational performance and efficiency.
- It supplies mobile calcium and magnesium to the soil profile, correcting common deficiencies for these nutrients in no-till systems.
- It reduces the risk of potassium-induced calcium and magnesium deficiencies. These can be frequent when high doses of potassium are applied to deliver higher crop productivity.
- Its gradual release pattern helps to lower losses due to nutrient leaching, especially for sulphur.
- Its prolonged release also provides soybean plants with more time to absorb the nutrients throughout their growth period.
- Its low salt index – due to the low amounts of chlorine and sodium naturally present – improves root growth and rhizobia nodule development, both essential for nitrogen fixation.
- It is versatile and can be used straight or in blends for furrow or broadcast fertilization.

Expected benefits

The application of *Polysulphate* to soybean has multiple benefits. As well as delivering higher overall yields, it can raise the plant's photosynthetic rate and increase grain weights. By supplying more balanced nutrition, plants are healthier with better resistance to pests, diseases and drought. Furthermore, the uptake of other nutrients is also boosted. The sulphur in *Polysulphate*, for example, promotes the biological fixation of nitrogen, thus increasing nitrogen use efficiency (NUE).

An application rate of 150-200 kg/ha for *Polysulphate* is generally a suitable dose for soybean. There are two main recommendations for application to the crop. *Polysulphate* can be incorporated

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straight, directly into the soil before planting, or applied as part of a fertilizer blend at sowing.

Agronomic research results

Research trials are providing a large and growing body of evidence about the benefits of *Polysulphate* application to soybean. In Brazil, a trial showed that application in the planting furrow provided a highly viable source of sulphur for fertilizing soybean. An increase in productivity of more than 16 percent was observed, in comparison to fertilization without sulphur (Figure 1). Compared to other sulphur sources, the increase in productivity ranged from 9.5-14 percent.

In another soybean trial in Brazil, the application of *Polysulphate* as part of an NPK blend delivered a yield increase of 18 percent, versus the normal NPK blend (Table 1). This increased the profit to the farmer by 20 percent.

The positive effects of *Polysulphate* can be observed in soybean at an early stage (see photo) due to better crop establishment as a result of improved root development. This can be explained by the product's ability to supply sulphur in ready-available sulphate (SO_4) form, as well as the extra calcium and magnesium it provides in the blend.

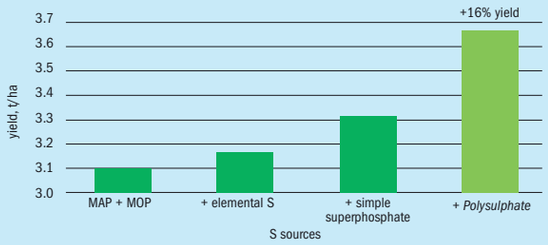
In China, a soybean trial in Fujian province showed how fertilizing soybean with *Polysulphate* can increase the number of rhizobium nodules on plant roots which fix atmospheric nitrogen.

Excellent results were also obtained in other soybean trials in Brazil, Argentina, Paraguay, China and the US. All in all, these global trials have demonstrated that soybean crops show a very good response to *Polysulphate*, both in terms of yield and quality.

A better strategy for soybean nutrition and productivity

The benefits of balanced nutrition for soybean crops are becoming more clearly understood. Practical information on how to deliver balanced nutrition, in terms of fertilizer product selection and field application, is also being more widely shared. As a consequence, in all the major soybean-producing regions across the world, more and more farmers are now choosing to include *Polysulphate* in their soybean fertilization strategy. ■

Fig. 1: **Effectiveness of *Polysulphate* as a sulphur source for soybean**



Rio Verde Foundation, Lucas do Rio Verde-MT, Brazil (2016/17 harvest). All treatments contained 80 kg/ha P_2O_5, 80 kg/ha K_2O and 25 kg/ha S, except for the control treatment (MAP + MOP).

Source: ICL

Table 1: **Results of a soybean trial at Piraju, Sao Paulo state, Brazil: a normal NPK blend vs an NPK blend containing *Polysulphate***

	Normal blend	*Polysulphate* blend	Difference
	6-34-11 + 7.5% S*	6-30-10 + 7.5% S + 4% Ca + 1.2% Mg	
Yield (kg/ha)	4,091	4,835	744
Yield value ($/ha)	1,391	1,644	253
Fertilizer blend cost ($/ha)	123	123	0
Income ($/ha)	1,268	1,521	253
Profit (%)			**+20**

** S as elemental sulphur*

Blend 6:30:10 Premium Top (with *Polysulphate*) **Blend 6:34:11**

PHOTO: ICL

Polysulphate improves soybean root development.

PHOTO: CANPOTEX

Left: The Canpotex-operated MV Ultra Regina delivers potash by sea to ports globally.

With around 90 percent of global trade requiring sea transport, shipping remains the life blood of the world economy. Intercontinental trade, the bulk transport of raw materials, and the import/export of food and manufactured goods all rely on affordable and effective shipping.

Shipping and freight report

Merchant shipping has grown into a large-scale global industry that generates in excess of half a trillion dollars in freight rates. A global fleet of tens of thousands of ocean-going vessels transports every kind of cargo between ports. Individual ships are technically-sophisticated, high-value assets that can cost over $200 million to build.

In early 2019, the total world fleet stood at 95,402 ships, with a total combined capacity of two billion dead-weight tonnes (dwt). Bulk carriers and oil tankers predominate, having a 43 percent and 29 percent share of capacity, respectively.

Fertilizer shipping – a niche segment

The international fertilizer trade occupies a relatively-small niche segment of the global shipping market, accounting for around three percent of total dry bulk trade. Nevertheless, more than 150 million tonnes of fertilizers and fertilizer raw materials are shipped across the globe annually (Figure 1). Fertilizer shipments are also heavily associated with certain ports and dedicated terminals – such as the Neptune Bulk Terminal in the port of Vancouver, Canada, those in the Baltic such as the Russian port of Ust-Luga and Klaipéda in Lithuania, as well as Yuzhny in the Black Sea and Jorf Lasfar in Morocco.

Fertilisers are mainly shipped, from their country of origin to destinations worldwide, in relatively small Handysize or Supramax bulk carriers, as well as larger Panamax carriers to a lesser extent (Figure 2).

A volatile market

The dry bulk freight market has endured a rocky ride over the last two decades, experiencing periods of growth, collapse and rebalancing. Key market events include:

- The capacity build-up during the commodity super cycle of 2000-2008, leading to the gross oversupply of vessels.
- The financial crisis that ended this period which precipitated a general commodity/freight market collapse.
- Latterly, following the dry freight market's historic low in 2016, a slow rebalancing of vessel supply with cargo demand.

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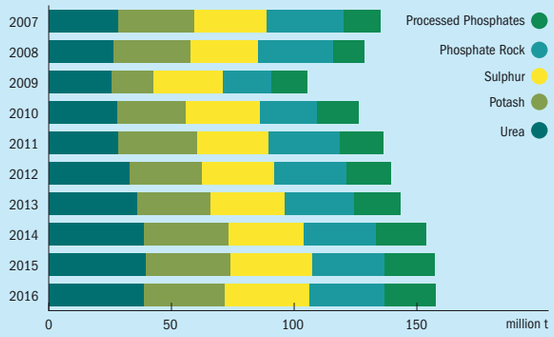
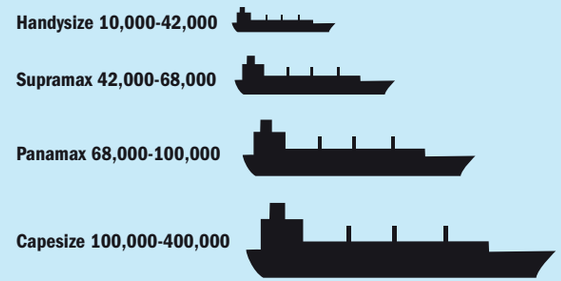
Fig. 1: **Global shipping of fertilizer and fertilizer raw materials**



Source: Clarksons

Fig. 2: **Vessel sizes, deadweight tonnage (dwt)**



As freight indices show (Figure 3), shipping market trading conditions have mostly remained tight since the financial crash of a decade ago. In May 2008, freight rates hit a peak – $141,000/day for Supramax and $82,000/day for Handysize cargoes. But a precipitous crash in the dry bulk market saw these rates collapse by the end of that year – to around $5,000/day for both Supramax and Handysize vessels. Although freight rates partially rebounded subsequently, they have remained a fraction of 2008 peak levels, with Supramax and Handysize rates averaging around $12,000/day and $9,000/day, respectively, between 2009 and 2018, for example[1].

The Baltic Dry Index

The Baltic Dry Index (BDI) is the generally accepted measure of the cost of transporting bulk raw materials by sea (Figure 3). Created by the London-based Baltic Exchange, this shipping and trade index is actually a composite of three sub-indices for different size bulk carriers: Capesize, Panamax and Supramax. The BDI takes into account 23 different shipping routes carrying coal, iron ore, grains and many other commodities.

Freight, like many commodities, is more volatile today than it was pre-2008. This is particularly true of Capesize. Because the BDI is weighted more to Capesize shipping (40 percent), relative to Panamax and Supramax sizes (30 percent each), any volatility in the Capesize sub-index tends to skew the overall BDI (Figure 4).

However, for fertilizer shipments – which are not generally carried in larger Capesize vessels – less volatile indices such as the Baltic Handysize Index (BHSI), Baltic Panamax Index (BPI) and the Baltic Supramax Index (BSI) are more representative of freight rates. Freight rates for these smaller vessels tend to move in tandem[2].

Landmark peaks and troughs in the BDI since 2000 include:

- Commodities super boom peak in excess of 11,000 in May 2008
- Collapse to below 700 in December 2008 during the financial crisis
- Partial rebound to 4,600 by November 2009
- Historic low of 290 in February 2016
- Peak of 1,800 in July 2018 when China trade sanctions kicked in
- An eight-month slide from a 2,500 high in September 2019 to below 400 in mid-May 2020, as the Covid-19 pandemic took hold
- Partial rebound to 2,100 by mid-October 2020.

While freight rates have been in a general upward trend in the past two to three years, they remain historically low. Vessel owners are operating in a volatile market buffeted by multiple issues such US-China trade dispute, IMO 2020 (see box) and the Covid-19 pandemic.

Rising freight demand

Dry bulk freight is subject to the same fundamentals as other markets. The general maxim that 'the market is what the market will bear' therefore also holds true for freight. In practice, this means that freight rates are set according to what the charterer is willing to pay – not based on the vessel's running cost. This means that the margins between freight rates and operating costs can be tight.

World seaborne trade grew from under five billion tonnes in 1995 to 11 billion tonnes in 2018 – an all-time high – with 7.8 billion tonnes being classified as dry cargo. Overall growth in seaborne trade has been relatively sluggish since 2013, compared to the 4-7 percent growth rates seen in the years following the 2008 financial crisis. Nevertheless, dry cargo shipments increased by more than forty percent over the decade to 2018.

Global seaborne trade in bulk commodities has risen every year this century – except for 2009 and 2015 – to reach a record level of 5.2 billion tonnes in 2018[2].

Weak freight rates of recent years are therefore not linked to a lack demand. Instead, the oversupply of vessels has been a key factor. The global fleet grew at an extraordinary rate between 2008 and 2013 but has moderated since. Although shipping capacity still grew by 2.6 percent in 2019, the upward trend, with the exception of 2017, has slowed year-on-year since 2011. For bulk carriers, world tonnages on order have also slid from above 150,000 dwt in 2016 to below 50,000 dwt last year.

There's also an expectation that uneconomic vessels will be demolished in reaction to the introduction of IMO 2020 regulations.

Vessel oversupply and scrappage

The delivery of new ships into a market already at over capacity will make increased scrapping of vessels necessary. Much of the scrapping activity in recent years has been driven by the obsolescence of Panamax ships. However, this process halted in 2018 due to the increasing value of these vessels.

An all-time record of over 670,000 twenty-foot equivalent units – TEUs, the standard measure of container capacity – was scrapped in 2016. The following year, however, higher freight demand coupled with falling scrap prices resulted in a lower than expected total in 2017, with only 427,250 TEUs ultimately scrapped. This trend continued in 2018 when scrapping dropped to a seven year low of 111,200 TEUs.

Despite the lower numbers of vessels scrapped in 2017 and 2018, totals were predicted to rise again in future years due to the introduction of new International Maritime Organisation (IMO) fuel regulations this year (see box).

The IMO's 0.5 percent sulphur cap on fuel – introduced from the start of January – was expected to prompt an up-tick in scrapping rates.

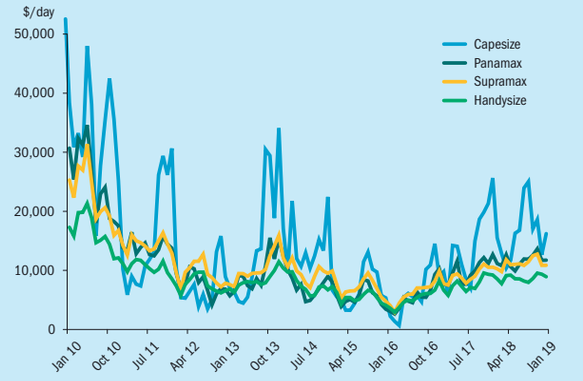
The new regulation requires vessels to switch to Very Low Sulphur Fuel Oil (VLSFO), or install scrubbers so they can continue using conventional heavy fuel oil (HFO).

Consequently, older, smaller, less fuel-efficient vessels are expected to be scrapped in response to the IMO sulphur cap – projected at 26 million dwt equivalent in 2019 and 44 million dwt equivalent in 2020. The cost of adding scrubbers to such vessels may exceed their asset value. These same vessels are in a double bind as – being less fuel-efficient – they could also prove too expensive to operate using VLSFO.

Fig. 3: **The Baltic Dry Index, 1995-2020**

Source: tradingeconomics.com

Fig. 4: **Historic freight rates for Capesize, Panamax, Supramax and Handysize vessels**



Source: Clarksons

Covid-19 pandemic hits seaborne trade

The global Covid-19 pandemic is likely to depress seaborne trade by one billion tonnes in 2020, according to a half-year assessment by Clarksons in July. The London-based shipping services provider is forecasting the most severe contraction in sea freight in almost four decades.

In a July statement, Steve Gordon, managing director of Clarksons Research, said: "The severity of the Covid-19 economic shock on the shipping industry is becoming clearer: we estimate seaborne trade fell by 10.6 percent year-on-year (y-o-y) in May. Our annual projections suggest trade will contract by 5.6 percent across 2020, representing one billion tonnes of 'lost' trade and the sharpest decline for over 35 years."

The Baltic Dry Index (BDI), having started 2020 at 976, also slumped to a low of 343 by mid-May, before recovering to 2,097 by mid-October. Indeed, the BDI slumped by a dramatic 19 percent in the

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IMO 2020: a false dawn?

Fuel prices remain one of most significant determinants of shipping industry profitability. The price of bunker fuel has risen significantly in recent few years. Its average price (Rotterdam, New York and Shanghai) increased from $170/t in 2015 to $300-350/t by 2017, before rising above $420/t by the end of 2018. Furthermore, new International Maritime Organisation (IMO) regulations introduced at the start of 2020 had been expected to prompt a rise in the cost of shipping fuel to $650/t, according to some forecasts.

On 1st January this year, the new IMO 2020 rule change required ships to switch from Heavy Fuel Oil (HFO), with a 3.5 percent sulphur content, to a 0.5 percent sulphur fuel known as Very Low Sulphur Fuel Oil (VLSFO). Only those ships equipped with exhaust-gas scrubbers can still burn cheaper HFO.

The 0.10 percent sulphur limit, introduced by the IMO for fuels in Emission Control Areas (ECAs) in 2015, remains the same. This require ships in these areas to use either Ultra Low Sulphur Fuel Oil (ULSFO) or Marine Gas Oil (MGO).

Prior to the introduction of IMO 2020, virtually the whole industry predicted that VLSFO would command a high premium over HFO, meaning that ships fitted with scrubbers would garner formidable fuel cost savings. The general expectation was that – because VLSFO would be much more expensive than pre-2020 marine fuel and not available in sufficient volumes – IMO 2020 would result in the installation of scrubbers to vessels on a mass scale.

Yet these predictions have largely failed to transpire. At the end of September, for example, the average price of VLSFO at the top 20 ports was $330/t. That compares to an HFO price of $462/t in the same month last year. This means that, despite the implementation of IMO 2020, the price of marine fuel is down almost 30 percent year-on-year.

In May, reflecting on the introduction of IMO 2020 this year, Richard Joswick of S&P Global Platts, offered the following explanation: "Platts and virtually every other analytics organization expected there would be a very large price spike for VLSFO and a very depressed high-sulphur fuel price."

Indeed, such forecasts did seem to playing out in 2019's fourth-quarter, with HFO-VLSFO spread at $300/t. Two things then happened, said Joswick:

"First, one of the warmest winters on record reduced demand for middle distillates by 900,000 barrels per day. Then came Covid. This didn't depress demand for marine fuel, but it did reduce refinery runs because demand for jet fuel and [initially] gasoline was really down."

In Rotterdam, the average price of VLSO in April 2020 was $201/t. That is less than half the average price of $421/t for HFO in 2019, the prevalent marine fuel last year, S&P Global Platts data show.

Spot prices of marine fuel hit their lowest in four years this spring. This precipitous drop has delivered savings. For example, the drop in VLSFO prices of $325/t between January and April this year means ship owners would have saved $16,266/day during April, for a vessel consuming 50 t/day of fuel.

This goes to show that the dynamics of the marine fuel market during the pandemic have reversed the prior fears of a 2020 price spike, which initially saw the sector rush to stockpile IMO-compliant fuels. ■

first week of May alone, closing at 514 points. The Capesize index was the hardest hit that week, with freight rates falling to just $4,858/day. Those Capesize vessels without fuel scrubbers fared even worse, with Clarksons reporting average spot rates of just $2,357/day that week.

Clarksons' half-year assessment also revealed a shipbuilding decline, with a 20 percent y-o-y decline in new vessel deliveries.

Covid-19's shipping impacts did, however, appear to peak in spring with a partial respite as the year progressed. There were even signs that port activity in China had normalised by July.

Nevertheless, Clarksons still predicts "huge multi-year risks" and a "difficult and bumpy road" ahead for shipping – albeit offset by periodic improvements in freight rates linked to large swings in month to month demand.

Directly comparing the current Covid-19 pandemic with the financial crisis of a decade ago, Clarksons suggested that shipping would experience "a significantly deeper initial impact but sharper rebound".

Covid-19 and fertilizer freight

Analysts Argus monitor a basket of fertilizer freight rates together with low-sulphur marine fuel costs. The basket covers four trade routes to key destinations east and west of Suez:

- Phosphates: Saudi Arabia-India East Coast, 25,000-35,000 tonne shipments
- Urea: Algeria-Brazil, 30,000 tonne shipments
- Sulphur: Middle East-Brazil. 30,000-35,000 tonne shipments
- Potash: Red Sea-India East Coast, 25,000-35,000 tonne shipments
- Fuel oil bunker (0.5% sulphur): Singapore price.

Argus reported a continuing rally in fertilizer freight rates in a half-year report in June. Average rates for dry bulk fertilizers rose for seven consecutive weeks, after hitting a low at the end of April. This was supported by a rise in bunker prices. For the four key routes selected by Argus, fertilizer freight rates rose by an average of $4/t between end-April and mid-June.

Prior to this, average rates across the four routes fell for six weeks in a row. On average, the cost of shipping fell by $5.75/t between the 19th March and 23rd April. From that point onwards, the $11.875/t average freight rate for this basket of routes rose week-on-week to hit $15.875/t by mid-June. The rise in freight rates, that began at the start of May, reflected a climb in marine fuel prices.

Fertilizer shipments have continued throughout the pandemic despite the slowdown in overall global trade, reports Argus, due to the designation of fertilizers by governments as a crucial part of the food supply chain. ■

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The Shahjalal LAUNCH FINISH™ design granulation plant, Bangladesh.

PHOTO: STAMICARBON

Challenging larger granulation capacities

As urea plants grow in capacity, so does the need for finishing technologies with higher capacities. **Barbara Cucchiella**, senior process engineer at Stamicarbon, describes how her team has risen to the challenge of the global trend for larger granulation plants.

Stamicarbon, the licensing and innovation centre of Maire Tecnimont Group, has always been at the forefront of developments and innovations in urea granulation. This has resulted in the company significantly increasing its global market share for granulation licensing over the last five years.

Urea granulation plants are typically constructed in countries with access to abundant low-cost feedstocks. Because of their competitive production economics, such plants are able to manufacture low-cost, high-margin granulated urea products for the export market. While there are several finishing options to choose from, fluid bed granulation still remains the best choice for urea that is destined for export and/or transported over large distances – due to the better strength, handling and shipping behaviour of the resulting granules.

Over the last decade, Stamicarbon has seen a rapid rise in the design of plants with higher maximum capacities (Figure 1).

At the moment, annual growth in market demand for urea is running at about 1.5 percent, equivalent to the construction of 2-3 new large-scale granulation plants every year.

Optimised granulation plant design

Stamicarbon introduced its optimised *LAUNCH FINISH*™ granulation design in 2008 (Figure 2). This optimised design incorporates a minimal number of equipment items and features CAPEX and OPEX cost reductions, while keeping to its original performance parameters and high onstream times.

The new design delivers a 20 percent cost saving in power consumption – mainly achieved by the omission of three fans. Increasing the length of the cooling zone, compared to the original granulator, also allowed the fluid-bed granulator cooler to be omitted. This enabled the fan and all the pumps associated with the granulator cooler scrubber to be discarded too. Additionally, the fluid-bed product cooler was replaced by a solids flow cooler. The granules produced are now cooled down in the last compartment of the granulator. In the new design, only one separate fluid bed cooler is needed – a crusher feed cooler (fluidised bed cooler) – for cooling down the coarse product.

Process description

Liquid melt is still fed to the granulator as per the original design. However, the last compartment of the granulator, where the end product is now cooled down to a lower temperature, does differ from the previous design.

On exiting the granulator, having passed the lump screen, the product is lifted directly to the screening equipment via a bucket elevator. All the solid product then flows through the main screens under gravity.

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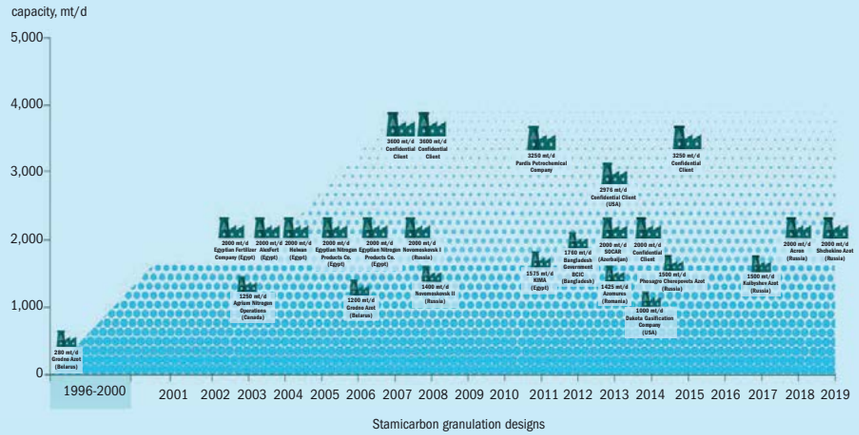
The coarse oversize generated is fed to the crusher, after firstly cooling to a temperature of 70°C. The undersize from the main screens and the crushed product are combined and recycled back to the granulator as so-called seeds.

Meanwhile, on-specification product emerging at the outlet of the main screens is cooled to storage temperature in a solid flow cooler. This makes use of cooling water instead of cooling air. Dust-loaded air is collected from the granulator and all the de-dusting points and fed to a single granulator scrubber.

Finally, to reduce the amount of fluidisation cooling air, a water injection system is provided at the discharge of the fluidisation air fan. This is only operated on exceptionally hot days to increase the relative humidity while at the same time reducing the total air consumption.

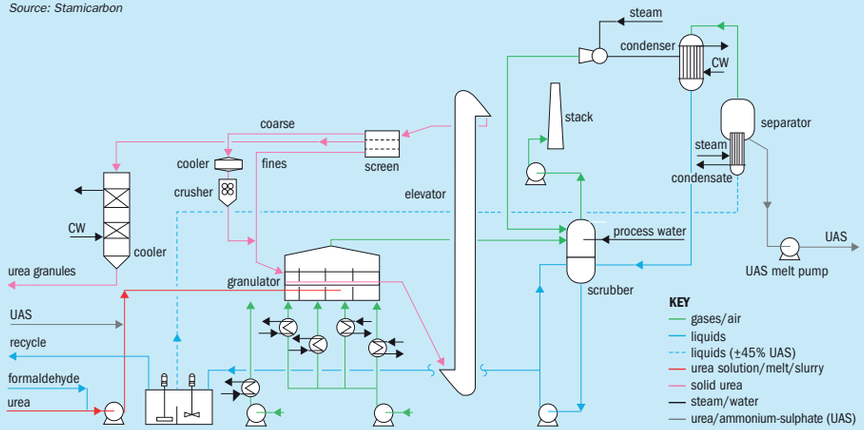
Fig. 1: **Stamicarbon urea granulation plants: timeline showing increasing capacity, 1996-2019**



Source: Stamicarbon

Fig. 2: **Process flow diagram for Stamicarbon's optimised granulation design**

Source: Stamicarbon



The lower number of equipment items significantly reduces the overall capital cost of the plant and its installation footprint. Additional cost savings in transportation (shipping), insurance and construction also contribute to the CAPEX cost reduction. Fewer equipment items, by cutting maintenance costs, also deliver an OPEX saving.

Reference plants

> **Investigations into scaling-up granulation plant design capacity to more than 5,000 t/d have concluded that there are no actual showstoppers.**

The first granulation plant based on the new *LAUNCH FINISH*™ optimised design was the 1,760 t/d capacity plant commissioned for Shahjalal in Bangladesh in 2015 (see main photo). The plant started up very easily and still operates extremely reliably and smoothly with minimal operator attention required. The power consumption met expectations, being 20 percent lower than the conventional design, and plant maintenance costs have also been significantly reduced. Product specification exceeds standard commercial quality requirements for urea, even at formaldehyde levels lower than 0.30 percent in very humid ambient conditions.

Further experience of the optimised design was gained from the construction and commissioning of the 13 plants that followed subsequently.

Although granulation plants with higher capacities are currently on the drawing board at the design stage, a plant with a nameplate capacity of 2,676 t/d is the highest capacity optimised design plant currently operating. This granulation plant, originally contracted in 2012 and subsequently started up in 2018, finishes urea produced by a Stamicarbon-designed pool reactor plant. As well as overall plant design, Stamicarbon also provided all the necessary equipment, including the granulator and the *MicroMist*™ venturi scrubber. The plant is currently operating above nameplate capacity although it can also operate at a turndown capacity of around half this output level.

Scaling-up to really large capacities

Stamicarbon has seen a rapid increase in the design capacity of urea plants over the last 10 years. Nowadays, urea granulation plants with a capacity close to or higher than 3,000 t/d are in operation. But the biggest challenge is scaling-up beyond this level to even larger capacities.

Recent experience from starting-up a 3,250 t/d granulation plant with Stamicarbon's original granulation design have been highly positive, with client expectations being met. Such large capacity plants can easily meet their performance guarantees, despite having different product requirements, different ambient conditions and different configurations.

Moreover, investigations into the possibility of scaling-up granulation plant design capacity to more than 5,000 t/d have concluded that there are no actual showstoppers – provided that extra measures to anticipate the risks of scaling-up are implemented. Furthermore, it's estimated that a single train 5,000 t/d plant requires around 30 percent less CAPEX (total investment) versus a plant design based on two trains of 2,500 t/d each. Consequently, Stamicarbon is now fully prepared and ready to offer and build its first single train 5,000 t/d *LAUNCH FINISH*™ granulation design. ■

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Advances in granulation

Recent innovations in fertilizer granulation include thyssenkrupp's new process for premium ammonium sulphate production. Eirich has launched new equipment for NPK granulation, while Rhewum is also offering new screening technology.

Eirich – mixing, granulation & coating in a single machine

Headquartered in Hardheim, Germany, mixing technology company Eirich offers both stand-alone granulation equipment and turn-key fertilizer systems. The company's equipment allows:

- Mixing, granulation and coating within one single machine
- Optimised distribution of micronutrients and binding agents
- The incorporation of secondary raw materials, such as filter cakes, sludges and nutrient solutions
- Environment-friendly granulation without fine dust generation or aerosol emissions.

Fertilizers granules need to be able to withstand the mechanical stresses and strains associated with modern farming equipment. The latest centrifugal spreaders, for example, have working widths of 24, 36 or 48 metres and accelerate granules to 150 kilometres per hour in just a fraction of a second. This means that granules need to be round and smooth and as dense and compact as possible. In addition, the risk of granules clumping together, or dust generation, needs to be eliminated. Finally – last but not least – the size distribution of granules needs to be as uniform as possible.

Eirich's *SmartMixer* machine

The *SmartMixer* machine from Eirich enables the complete production of fertilizer granules in a single process step. Optimised mixing is ensured by combining a variable speed primary mixing tool (rotor) with an independently-moving rotating mixing pan. Uniquely, this design allows the machine to perform different process functions simply by altering the rotor speed. Mixing is performed first dry, then wet, followed by granulation – with coating at the end, if required.

The mixer can also be combined with a disk pelletiser for when customers have more rigorous grain roundness and size requirements. In these circumstances, the mixer is used to generate a feed of micro-granules for the disk pelletiser. Eirich mixers, with a usable volume of up to 12 cubic metres, can provide these at a throughput of up to 1,500 tonnes per hour.

The mixing process can be easily scaled-up. The layout and design of the smallest *EL1* mixer (1 litre capacity), for example, is identical to the *RV24* unit (3,000 litre capacity), the largest mixer in the series. The mixing times and speed parameters are also directly transferrable between different size mixers, making the development of new granulated fertilizers particularly easy, according to Eirich.

The mixing-dosing-granulation-coating process

Fertilizer raw materials generally need to be ground prior to granulation as a first step. For NPK fertilizers, this ensures that all three major nutrients are evenly distributed in every single granule. Eirich recommends its *TurboGrinder* for this preparatory step – as this machine is well-suited to the grinding and drying of fertilizer raw materials.

The ground raw materials are then weighed out in the correct proportions before being transferred to the *SmartMixer* machine. This granulates the materials in a batch process that take around six minutes in total.

The components are initially mixed together dry – this normally takes no longer than 30-60 seconds – before being dosed with water or an aqueous solution. The latter can be used to add binding agents and/or additional micronutrients. Adding nutrients in dissolved form at this stage ensures their even distribution, even at very low concentrations.

The machine is able to mix the liquid dose with the solids and so thoroughly wet the raw materials in a short space of time. The speed of the primary tool (rotor) is then reduced, with the aid of the frequency inverter, to initiate the granulation of the completely wetted particles.

The granulation stage is also rapid with the mixer becoming full of uniform granules within just a few minutes. These granules can then be coated, if required, with coating typically taking around 30 seconds. The mixer is then emptied in readiness for the next production batch.

Eirich case studies

Calcium dihydrogen phosphate (CDP): This is produced by reacting calcium carbonate with phosphoric acid in the mixer. The reaction product is then granulated without any need to transfer it to a different vessel. Eirich CDP systems are operating in:

- Slovenia: *RV15* size mixer, 750 litres
- Bulgaria: *RV24* size mixer, 3,000 litres
- Peru: *RV24* size mixer, 3,000 litres.

Projects with a *RV24* mixer are also at the planning stage in Brazil and South Africa.

Superphosphate or double superphosphate: phosphate ore is reacted with either sulphuric acid (superphosphate) or phosphoric acid (double superphosphate). Similar to CDP, reaction and granulation are carried out in a single machine, without the need to transfer materials, resulting in significantly shorter processing times.

NPK fertilizers: Eirich built a NPK fertilizer production plant – incorporating eight mixers – for a German fertilizer manufacturer in 2014. The company has subsequently supplied mixers to a large number of other NPK plants, including those located in Australia, the UK, Poland, Russia, Sweden, Switzerland and Turkey. Hauert HBG Dünger AG has been successfully operating its Eirich NPK fertilizer plant at Grossaffoltern, Switzerland, since 2017. This produces granulated NPK fertilizers marketed under the brand name *GRANUTEC Swiss Granules*.

Rhewum – high performance screening

Rhewum has been developing, designing and manufacturing screening machines for newly commissioned and operational urea granulation plants for decades. The company has supplied more than 1,800 machines to fertilizer plants located in more than 60 different countries since 1956.

Iran's Pardis Petrochemical Company (PPC) has installed Rhewum's direct excitation screening equipment at one of the world's largest urea granulation plants. PPC selected Rhewum to design, manufacture and commission the plant's extractor lines and main screens. The company's technology was able to guarantee the desired high level of process efficiency and deliver high quality urea granules – combining this with high on-stream availability and reduced energy consumption (*Nitrogen+Syngas* 358, p46).

Rhewum's extractor lines, diverters, special chutes, distribution feeders, safety and process screens all work together in concert to ensure a consistent screening process. The combination of vibrating extractors with linear motion screens maintains the level of fluidised granules in the granulator, as well as protecting the process by screening out any lumps.

High performance screening is essential for maintaining PPC's product requirements (95 percent purity) and minimising product loss to the coarse and fine fractions.

The four main screens (4 x 65 t/h capacity) are located downstream in the granulation unit where they ensure the quality of the final product. The screening process is designed to separate out lumps (>15 mm) in one outlet, the coarse particles (4 to 10 mm) in the second outlet, while the product (2 to 4 mm) and the fines (<2 mm) flow into separate inlets of the product diverter.

Efficient screening steps

Step 1: Distribution. Urea particles needs to be uniformly distributed at the inlet of the screening machine to make full use of the screening area. This is achieved using a pre-positioned vibrating distribution feeder.

Rhewum's SV feeder (Figure 1) consists of a moving inner distribution plate vibrated by two outer out-of-balance motors. These are linked to a fixed housing via a stable and dust-tight flange connection. The use of fixed flange ensures safe and dust-tight operation.

Step 2: Screen cloth. This is the most important contact part between the screening machine and urea particles. The design of the main screen cloths needs to incorporate a number of factors:

- Choosing the right mesh opening is critical when it comes to creating a high quality product.
- Keeping the screening area constantly open also increases plant capacity and reduces the costly recirculation of material.
- While easy and fast maintenance of the screen cloths leads to high on-stream availability.

An automatic cleaning cycle keeps the directly-excited screen cloths free from clogging. Each screen cloth can be changed individually, without the need to remove any of the others. This is a useful as maintenance intervals are often uneven due to unequal wear of the screen cloths. In total, there are four screen cloths installed at the PPC plant, each of which can be replaced within just ten minutes. The mesh openings for the installation were optimised during test trials at Rhewum's pilot plant in Remscheid.

Step 3: Screening technology. The WAU screening machine – with direct excitation of the screen cloth – was selected for the PPC granulation plant (Figure 2).

PPC's urea production requirements – the economic generation of granular products with reproducible qualities – were quite challenging. The overall objective was to reliably achieve high levels of granulation efficiency at the lowest operational cost.

WAU type screening machines are directly excited. Vibration is imparted into the sieve cloth by the high speed movement of a transversally mounted rocker shaft located beneath the sieve cloth. Outside the screen housing, robust out-of-balance motors rock the knocker shafts, conveying the high frequent oscillation directly into the screen mesh. This is highly effective as it means the screen mesh is vibrated directly into the urea granules. Machine energy consumption is also low – only 0.036 kW/tonne of screened urea.

The on-stream availability of each component in the urea granulation process is critical and needs to be kept as high as possible. Weak points need to be avoided as these will create bottlenecks and potentially – in the worst case – lead to the shutdown of the whole granulation plant. 100 percent availability of WAU screening machines is guaranteed by equipping these with 15 small out-of-balance motors. This allows performance stability to be maintained until the next scheduled maintenance period – even if one motor fails. The motors are coupled by flanges to vibrating axes which transmit vibrations to the urea particles via the knocker shafts and screen cloths.

The high number of motors fitted to the WAU machine also allows the screen decks to operate at different amplitudes. The ability to keep amplitude uniform over the complete width of the screen provides consistent screening quality over its entire area. Additionally, because screen housings are static and do not vibrate, WAU machines do not require a heavy steel structure, even when located at the top of the building.

Step 4: Trials and quality control. Test trials at Rhewum's laboratory help to optimise the design and ensure the screening machine will function successfully later on during production. These trials are used

Fig. 1: Rhewum SV feeder for constant and uniform distribution of screening materials.

IMAGE: RHEWUM

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Fig.2: Rhewum WAU screening machine withdirect excitation of the screen cloth.

to check if the customer's product quality guarantees can be achieved.

Rhewum's *SizeChecker* optical measurement system (0.2-20 mm) offers a cost effective alternative to standard screen analysis. Using an automatic sampler device, the system can be used in production and integrated into process monitoring and quality control. This avoids time consuming manual sampling and analysis. The system, by automatically recording measurements, allows alarms to be set and triggered when variations in particle-size distribution occur.

In summary, Rhewum's screening technology improves the overall efficiency of the whole urea granulation plant by:

- Reducing energy consumption
- Increasing availability
- Having a lighter steel structure, and
- Avoiding unnecessary maintenance.

Following its convincing performance at Rhewum's test facilities, the WAU type machine installed at PPC's granulation plant will continue to prove its high performance urea screening abilities over the coming decades. Tests conducted by Rhewum back in Remscheid have confirmed that PPC's purity and yield expectations have been exceeded at the Persian Gulf site.

Innovative low-cost ammonium sulphate granulation

Ammonium sulphate is a popular and effective dual nutrient fertilizer. It simultaneously supplies sulphur and nitrogen, boosting crop growth and yields, as well as promoting the transfer of micronutrients such as manganese, iron, and boron from soil to plants.

Among the key benefits of granular ammonium sulphate – compared to liquid or crystalline alternatives – are its improved storage, spreading, and mixing qualities. Granulated ammonium sulphate – unlike the more commonly produced crystalline product form – is also easier to incorporate into fertilizer blends.

Unfortunately, cost is a constraining factor as conventional granulation plants need to consume expensive ammonia and sulphuric acid to manufacture premium ammonium sulphate products.

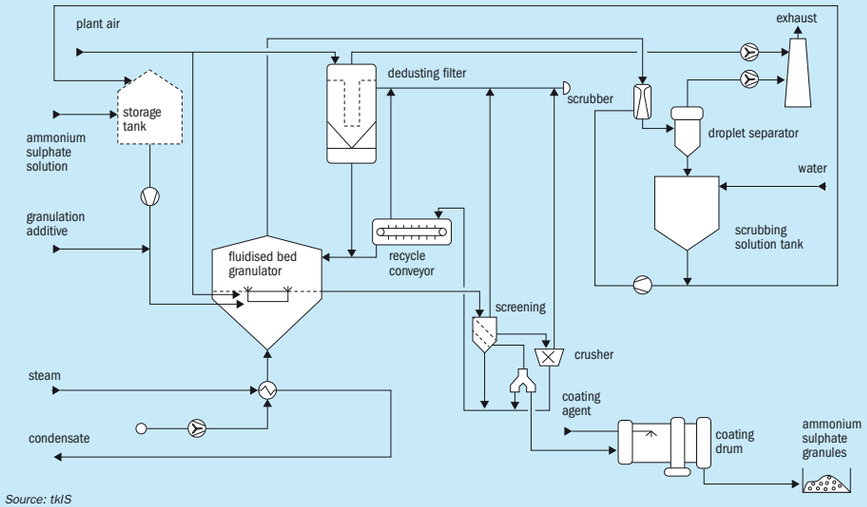
However, in a recent breakthrough, German industrial giant thyssenkrupp Industrial Solutions (tkIS) has developed a low-cost granulation process for ammonium sulphate. This innovative process converts ammonium sulphate solution – an inexpensive by-product – into premium grade granules (*Sulphur* 372, p54).

Because it is only produced by a few suppliers in small volumes currently, there is unmet demand in the market for granulated ammonium sulphate. This provides new entrants into this niche market with attractive sales opportunities, particularly as the price for premium granules, around $100 per tonne, is significantly above that of standard ammonium sulphate products.

thyssenkrupp says the new process is the outcome of "years of energy and innovative thinking" by the R&D team within its fertilizer division.

"We want to give fertilizer manufacturers the opportunity to convert an industrial

Fig. 3: **Fluidised bed granulation process for the production of ammonium sulphate**



Source: tkIS

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by-product into high-quality nitrogen fertilizers," comments tkIS, adding: "There is a worldwide demand for granular ammonium sulphate, which very few manufacturers currently make."

The patented tkIS ammonium sulphate process

thyssenkrupp's patented process (Figure 3) starts with ammonium sulphate solution – an industrial by-product generated during the manufacture of caprolactam and coal oven gas. Initially, a preventative additive is mixed with the solution. This reduce dust formation during subsequent granulation by giving the end-product a high crushing strength. The resulting liquid mixture is sprayed into a fluidised bed granulator and processed into solid granules. Materials exiting the granulator are screened. Any oversize particles are crushed and returned to the granulator alongside undersize particles. The product granules generated by the process are round, very hard, and resistant to impact and abrasion.

Following successful lab and bench-scale tests, thyssenkrupp built a pilot plant in 2016 with an initial capacity of half a tonne per hour. "As all the tests have also been successful here, we are upping the process to industrial scale with capacities of 5-20 tonnes per hour," says tkIS. "Fertilizer manufacturers worldwide will benefit from improved cost efficiency."

The fluidised bed granulator (Figure 4) is the centre piece of the production plant, as it is where the liquid ammonium sulphate is turned into a solid product.

In the thyssenkrupp process, liquid ammonium sulphate solution is sprayed onto seed granules. These granules grow bigger in the granulator via a sequence of spraying, wetting, drying and layering (Figure 5).

PHOTO: TKIS

Fig. 4: The fluidised bed granulator is the centrepiece of the production plant.

The particles in the granulator are fluidised by a hot air stream. This stream can require steam heating. Heat integration is also possible using hot off-gases instead, if available from adjacent plants, to reduce operating costs. The air exiting the granulator is scrubbed before being discharged to the environment as clean air.

The ability to integrate the new process into existing chemical complexes will be essential for its economic success. As well as the heat integration mentioned above, there are opportunities to install the fluidised bed granulator in parallel with an existing crystalliser unit. By reducing the load to the crystalliser, this would have the added benefit of producing larger crystals.

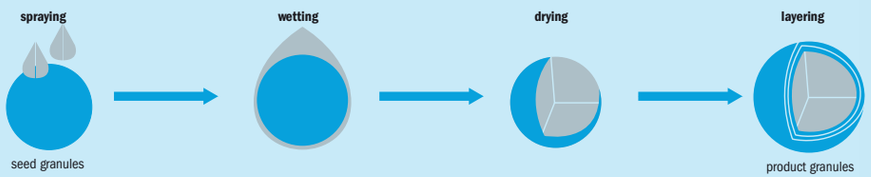
Process development

In general, the granulation of ammonium sulphate is prone to dust generation and the formation of granules with low hardness. The toughest challenge during the development of the new process was therefore finding a suitable liquid granulation additive. This is added to the liquid feedstock before spraying the solution onto the seed granules.

Process development started with small-scale, single nozzle laboratory batch tests. This enabled the main process parameters to be scoped and the selection of a suitable granulation additive. During the second phase of development, a technical-scale test facility was used to demonstrate continuous operation and to identify other granulation parameters such as the recycle ratio. Finally, the process was up-scaled and risks were mitigated by demonstration in a pilot plant with a capacity of 12 tonnes per day.

The quality of ammonium sulphate solutions generated by upstream processes can vary significantly. As the granulation process can be a sensitive to certain impurities, pilot plant trials offer a valuable way of testing feedstock quality during the feasibility phase, before deciding whether to invest in a full-scale fluidised bed granulation plant.

Fig. 5: **Conversion of liquid ammonium sulphate solution into granules**



Source: tkIS

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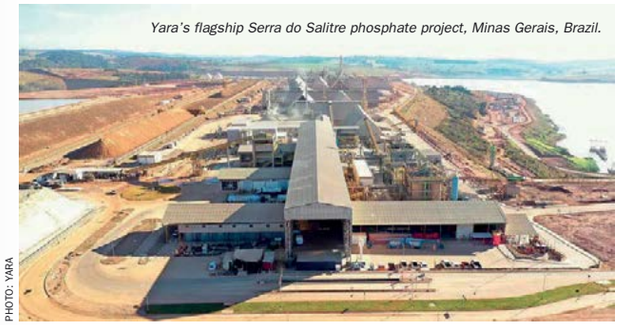
Brazil: centre of phosphates excellence



Yara's flagship Serra do Salitre phosphate project, Minas Gerais, Brazil.

PHOTO: YARA

Brazil's phosphate industry is on a growth dash to meet rising domestic demand. We report on the major acquisitions, investments and expansions by CMOC, Mosaic, Yara and Itafos.

Brazil consumes more than 16 million tonnes of nutrients each year. This makes the country the world´s fourth-largest fertilizer market, ranked behind China, India and the US. The country currently accounts for an impressive 11 percent of global fertilizer consumption.

Brazil's emergence as a global agricultural powerhouse also means fertilizer demand is continuing to grow. Total fertilizer product deliveries reached 36.2 million tonnes in 2019, a 732,000 tonne increase on the previous year. The latest fertilizer statistics show Brazilian demand accelerating, with January-May 2020 fertilizer consumption, at 12.7 million tonnes, up by more than 18 percent year-on-year.

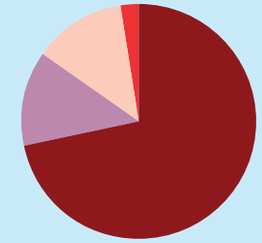
Growing import demand

Brazil's fertilizer market remains heavily import-reliant with around 80 percent of total demand being met by imports. In terms of individual nutrients, imports supply more than 95 percent of domestic potash consumption and account for roughly 83 percent of the country's nitrogen use. While Brazil is less import reliant for phosphate – having access to substantial domestic production capacity – the country still looks to the international market to supply around 60 percent of its domestic phosphate needs.

Brazil's total nameplate capacity for domestic phosphates production is around 12 million tonnes. Single superphosphate (SSP) production capacity (8.6 million tonnes capacity) predominates supplemented by significant triple superphosphate (TSP, 1.6 million tonnes) and monoammonium phosphate (MAP, 1.5 million tonnes) production assets (Figure 1). Mosaic Fertilizantes is by far the country's largest phosphates producer. Two other foreign-owned companies, Yara and CMOC, also operate major phosphate production assets in Brazil (Figure 2).

Brazil was forecast to consume 13.7 million tonnes of phosphate fertilizers in 2019, with some 5.9 million tonnes (43

Fig. 1: **Brazil's phosphate production capacity 2018, by product ('000 t)**

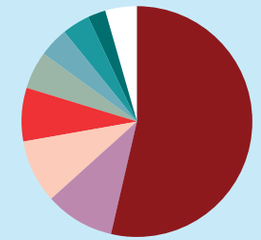


Single superphosphate (SSP) 8,620
Triple superphosphate (TSP) 1,572
Monoammonium phosphate (MAP) 1,540
Thermophosphate 280
Total capacity*: 12,012

*Does not include Yara Brazil's Serra do Salitre project.

Source: ANDA

Fig. 2: **Brazil's phosphate production capacity 2018*, by company ('000 t)**



Mosaic Fertilizantes (MAP, SSP, TSP): 6,466
CMOC (MAP, SSP, TSP): 1,160
Galvani** (SSP): 1,056
Yara Brazil* (SSP, TSP): 900
Timac Agro (SSP, TSP): 650
Itafós (SSP): 500
Fospar** (SSP): 450
Cibra (SSP): 300
Other: 530
Total capacity*: 12,012

* Does not include Yara's Serra do Salitre project.
** One of Galvani's two SSP units, the Paulinia plant, was subsequently transferred to Yara.
*** Majority owned by Mosaic.

Source: ANDA

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percent) domestically produced and 7.8 million tonnes (57 percent) imported. That contrasts with higher domestic production of 6.4 million tonnes and correspondingly lower imports of 7.2 million tonnes in 2018, a combined total of 13.6 million tonnes.

Domestic production, although focussed on SSP manufacture (Figure 1), includes significant volumes of higher analysis phosphate products. These included around 620,000 tonnes of MAP and one million tonnes of TSP in 2019, based on International Fertilizer Association (IFA) data. These production levels were down significantly from domestic deliveries for MAP and TSP of 1.2 million tonnes and 1.3 million tonnes, respectively, in 2018.

Brazilian import demand for MAP is also particularly high. The country imported 3.9 million tonnes of MAP in 2019 at a cost of $1.4 billion, according to Brazil's Comexstat agency. Latest figure for 2020 indicate MAP imports of 3.7 million tonnes in the year to date. The principal international suppliers include Morocco, Saudi Arabia, United States, China, Russia and Mexico.

Phosphate-hungry soybean

Soybean is Brazil's most widely-grown agricultural commodity. Large-scale cultivation of this potash- and phosphate-hungry crop is responsible for more than four-fifths of domestic fertilizer consumption.

The predominance of soybean farming distorts Brazil's fertilizer consumption. The country consumes much larger amounts of potash and phosphate, for example, relative to nitrogen, compared to averages in other world markets. Phosphorus (P_2O_5) is the most widely-applied nutrient in Brazil (39%), followed closely by potassium (K_2O, 35%) while – highly unusually – nitrogen (N) use is left trailing in third place (26%).

Future growth in Brazilian phosphate consumption, spurred on by rising fertilizer requirements from soybean, could result in an additional two million tonnes of annual (P_2O_5) demand by 2030, according to projections by ANDA and Yara (Figure 3) . They predict that soybean fertilization requirements will eventually capture a 50 percent share of the Brazilian fertilizer market. Demand will mainly come from large soybean farms in central regions, particularly Mato Grosso, and from soybean-growing cooperatives in Brazil's south.

China Molybdenum (CMOC)

China Molybdenum Co Ltd purchased Anglo American's substantial Brazilian niobium and phosphates business for $1.5 billion in May 2016.

The purchase transferred to China Molybdenum ownership of the 1.3 million tonne capacity Chapadao phosphate mine, the Coqueiros and Morro Preto phosphate deposits, the Ouvidor beneficiation plant and two fertilizer complexes at Catalão and Cubatão.

The Cubatão complex in São Paulo state has favourable logistics, being close to Santos Port and Mato Grosso state. It has the annual capacity to produce:

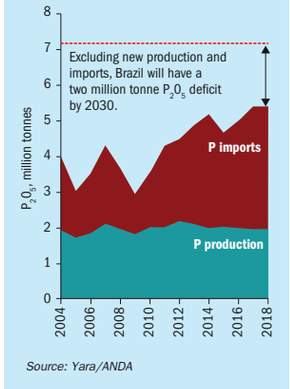
- 600,000 tonnes of SSP
- 150,000 tonnes of phosphoric acid
- 60,000 tonnes of the feed additive dicalcium phosphate (DCP).

The company's other production site at Catalão in Goiás state is located just seven kilometres away from Chapadao phosphate mine. It has the annual capacity to produce:

- 600,000 tonnes of SSP
- 200,000 tonnes of MAP/TSP
- 100,000 tonnes of DCP.

In the year prior to the sale, Anglo American's Brazilian operations produced 1.3 million tonnes of phosphate concentrate and 1.1 million tonnes of phosphate fertilizers. Combined niobium and phosphates sales generated earnings (EBITDA) of $146 million for the company in 2015 from revenues of $544 million (*Fertilizer International*, 470, p10).

Fig. 3: **Brazil's projected phosphate supply/demand gap**



Source: Yara/ANDA

Anglo American's original plan to more than double phosphate rock capacity and expand production at the Catalão site is being pursued by China Molybdenum. The main objectives of this low capex brownfield project were to provide additional capacities for:

- 1.4 million tonnes of phosphate rock
- 500,000 tonnes of phosphoric acid
- 1.1 million tonnes of sulphuric acid
- 700,000 tonnes of phosphate fertilizer.

The project is reportedly on-track to deliver 440,000 t/a (P_2O_5) of extra MAP/TSP capacity during the second-half of 2020.

Mosaic Fertilizantes

The Mosaic Company purchased Vale Fertilizantes, the fertilizer arm of Vale S.A., for $2.5 billion in January 2018.

As part of this major deal, Mosaic acquired five Brazilian phosphate rock mines, four chemical and fertilizer production sites and one potash plant. Outside of Brazil, Mosaic also gained ownership of Vale's 40 percent interest in the Miski Mayo phosphate mine in Peru and its potash project at Kronau, Saskatchewan, as part of the deal.

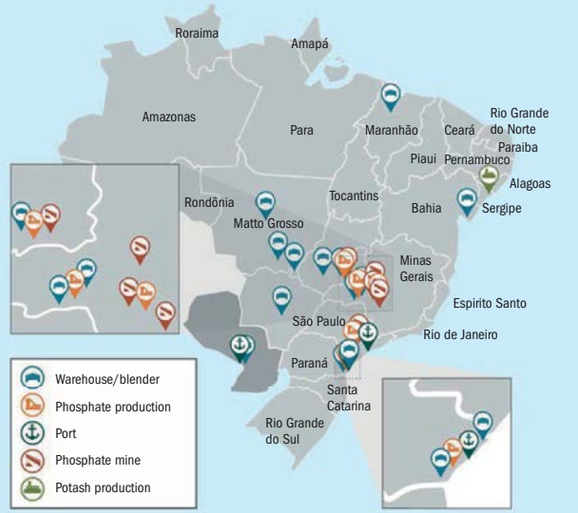
The newly-formed subsidiary company, Mosaic Fertilizantes, has the capacity to produce 4.8 million tonnes of finished phosphates (SSP, TSP and MAP) and 500,000 tonnes of potash in Brazil, making it Brazil's leading fertilizer producer and distributor (Figure 4). Mosaic also holds a majority interest in Fospar which owns and operates a 450,000 t/a capacity SSP granulation plant in Brazil.

Mosaic's agreement with Vale excluded the nitrogen and non-integrated phosphate business in Cubatão. These assets were acquired separately by Norway's Yara International (see below).

Most of Vale's fertilizer assets and distribution network in Brazil were originally acquired through its purchase of Fosfertil in 2010.

Domestic phosphate rock production took a major hit in 2019 after Mosaic Fertilizantes was forced to idle three of its Brazilian phosphate mines for a large part of the year, as it worked to comply with new tailings dam legislation. The Araxá and Tapira mines in Minas Gerais subsequently reopened at full capacity in September 2019, following the full resumption of operations at the Catalão mine in June

Fig. 4: **Mosaic Fertilizantes is one of Brazil's largest fertilizer companies, operating production, blending and storage assets throughout the country**



Source: Mosaic

that year. Despite these prolonged mine closures, the company still produced 2.6 million tonnes of finished phosphates in 2019, down nine percent on 2018 production levels. In total, The Mosaic Company sold 9.2 million tonnes of fertilizer products in Brazil in 2019, equivalent to a 25 percent market share.

In March 2020, Mosaic Fertilizantes unveiled plans to increase its annual fertilizer output in Brazil by 800,000 tonnes to 4.5 million tonnes. Floris Bielders, the company's commercial VP, said he expected Brazilian fertilizer consumption to climb by up to three percent in 2020 in response to rising demand from local farmers. "Mosaic is already receiving orders for fertilizer deliveries in the first quarter 2021," Bielders said. By March time, Brazil's farmers had reportedly already sold about 20 percent of next season's soybean crop. This had netted higher export market revenues due to the US dollar's climb against the local currency.

Looking ahead, Mosaic says its main priorities in Brazil will be:

- Normalising operations having resolved its tailings dam issues
- A second round of supply chain efficiencies
- Reducing phosphate rock costs and ramping-up output at its Patrocinio mine
- Continuing to grow premium product sales
- Growing its co-product sales – gypsum and excess sulphuric acid.

Yara Brazil

Brazil is Yara International's single largest market, accounting for one-third of the company's global employees and operations. Yara's cash generating units in Brazil cover fertilizer production – including phosphate mining and SSP production – together with fertilizer blending and distribution. The Norwegian-headquartered company is capable of delivering around nine million tonnes of fertilizers to the Brazilian market, covering roughly one-quarter of domestic demand.

Yara expanded its presence in Brazil by purchasing the Cubatão fertilizer complex from Vale in May 2018 for $255 million. The purchase was expected to double Yara's annual fertilizer production capacity in Brazil to three million tonnes.

The company has embarked on a Brazilian asset-buying spree in recent years. Notable acquisitions include the purchase of Fertibras in 2006, Bunge's fertilizer business in 2013, and the part-purchase of Galvani in 2014.

The large-scale Cubatão complex has the capacity to produce around 200,000 tonnes of ammonia, 600,000 tonnes of nitrates and 980,000 tonnes of phosphate fertilizers annually. A nearby import terminal supplies the complex with ammonia, phosphate rock and sulphur raw materials. Locally-sourced natural gas is also used in ammonia production.

Cubatão sold 1.3 million tonnes of nitrogen and phosphate products in 2016, generating revenues of $413 million and earnings of $30 million. The complex, which employs 970 permanent and 930 contract staff, is notable for supplying Brazil's huge sugarcane industry – the world's largest – with nitrogen fertilizers such as ammonium nitrate.

Yara pledged to invest $80 million in upgrades at the complex in the period up to 2020. It expects this investment to generate $25 million in annual savings by optimising the site's costs, assets and product portfolio.

Yara is also due to complete the expansion of its fertilizer granulation, blending and bagging complex in the southern state of Rio Grande do Sul by the end of 2020. The $400 million investment should increase the production capacity of the Rio Grande unit by around 60 percent. Granulation capacity for NPKs and SSP will increase from 750,000 t/a to 1.2 million t/a, while fertilizer mixing and bagging capacity is expected to climb from 1.5 million t/a to 2.2 million t/a. The expanded complex has two phosphate and NPK production plants, an acidulation plant, a granulation plant and a fertilizer blender.

Yara buys Galvani assets

Following the acquisition of the Cubatão complex, Yara further cemented its Brazilian market position by purchasing outright a number of assets from Galvani (Galvani Indústria, Comércio e Serviços) in October 2018. Yara initially took a 60 percent stake in the major Brazilian producer in 2014.

Galvani's main business is phosphate rock mining, SSP production and fertilizer distribution. The company employed around 1,250 staff and generated revenues of $220 million in 2017 from ferti-

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lizer sales of one million tonnes. It markets powdered and granulated SSP in Brazil, with incorporated micronutrients, under the *Phosagro* brand. Galvani also sells fertilizer blends under the *Phosmix* moniker and granulated NPKs.

Prior to the 2018 buy-out and division of assets, Galvani operated a total of around one million tonnes of SSP production capacity through its Paulínia, Sao Paulo, and Luis Eduardo Magalhães, Bahia, plants. Both plants sourced phosphate rock from two company-owned mines, Lagamar in Minas Gerais and Angico dos Dias in Bahia, and the leased Irecê mine.

The 2018 deal with Yara saw the outright transfer to Yara Brazil of the Paulínia SSP plant and bulk blending unit, together with the under-construction Serra do Salitre phosphate project.

Yara's purchase agreement with the Galvani family included a cash payment of $70 million over a three-year period on closure of the deal, and a future payment conditional on project success. The full integration of Galvani into Yara Brazil should unlock annual savings (synergies) of $15 million after tax from 2020 onwards.

The Galvani family retains ownership and control of the Bahia-based Luis Eduardo Magalhães production plant and the Angico dos Dias and Irecê mines, as well as the Santa Quitéria greenfield phosphate project. These assets now make up a new company worth around $90 million.

Serra do Salitre project

Yara's flagship Serra do Salitre project is ranked as Brazil's foremost investment in greenfield fertilizer capacity, due to its scale and imminent start-up (*Fertilizer International* 488, p45). The project is also ideally located in Minas Gerais state, close to key fertilizer-consuming markets.

The Salitre project represents a major commitment by Yara to the Brazilian market, and a significant expansion of its in-country operations. It is also one of only a handful of priority investments Yara is making in production capacity. The company is investing $229 million in the project in 2020 following similar substantial investments in 2018 and 2019.

The project was originally a joint venture between Yara International and Brazilian producer Galvani. However, the project is now 100 percent Yara-owned (see above).

Serra do Salitre is divided into two phases. The initial phase involved the completion of a 1.2 million tonne capacity phosphate rock mine. This delivered its first 150,000 tonnes of mined rock in early 2018. The second phase, a one million tonne capacity production plant for finished phosphate products, is now scheduled for completion during the second-half of 2021.

Building a fully-integrated fertilizer production plant in Brazil is a costly, complex and highly ambitious venture. The scale of the project is such that it will increase national P_2O_5 production by around 20 percent. Importantly, Salitre will ensure that Yara's Paulínia production plant is self-sufficient in P_2O_5 by providing a dedicated supply of phosphate rock.

Once operational, Serra do Salitre will generate:

- 900,000 tonnes of sulphuric acid
- 1.2 million tonnes of phosphate rock
- 250,000 tonnes of phosphoric acid
- One million tonnes of granulated finished phosphate products
- More than 1.2 million tonnes of gypsum
- 1,500 jobs during the operational phase
- Around 29 MW of energy.

The project's product mix will include diammonium phosphate (DAP), MAP, nitrophosphate (NP), SSP and TSP.

Itafos

Itafos, formerly MBAC Fertilizer Corp, is the owner and developer of the vertically-integrated Arraias SSP project in Brazil. The Toronto stock exchange listed company is also the owner-operator of the Conda, Idaho, phosphate mine and plant in the US, having bought this from Agrium in 2017.

Itafos supplies the Brazilian market via the recently recommissioned 500,000 t/a capacity Arraias SSP production complex at Tocantins in central Brazil. This complex includes a mill, a beneficiation plant, a sulphuric acid plant, an SSP plant and a granulation plant. The complex consumes phosphate rock extracted from an Itafos-owned open pit mine located around 10 miles away from the production site.

The Arraias plant occupies a strategic position in one of the world's fastest growing fertilizer markets, according to Itafos. Its SSP sales are targeted at eight Cerrado states – Bahia, Goiás, Mato Grosso, Piauí, Maranhão, Tocantins, Pará and Minas Gerais. These states are collectively responsible for around half of Brazil's annual SSP demand of 5 million tonnes, although Itafos is targeting sales within a sub-region that consumes 1.1 million tonnes.

Itafos has other phosphate projects under development in South America including the Santana project – a vertically-integrated phosphate mining and fertilizer project located in Pará, Brazil – and the Mantaro phosphate rock mining project in Peru. The company is also developing the 1.34 million t/a capacity Farim phosphate rock mining project in Guinea Bissau, West Africa. This had been expected to enter commercial production as early as the second-half of 2020.

Foreign ownership, consolidation and vertical integration

Brazil's phosphate production industry underwent a wholesale change of ownership in 2018. In the previous year, production assets were overwhelmingly domestically-owned with Anglo American the only foreign market player. Yet by 2018 industry ownership had been divided up between US-, Chinese- and Norwegian-headquartered companies, following a buying spree by Mosaic, China Molybdenum and Yara.

These changes in production ownership are part of the wider, rapid trend for vertical integration within the Brazilian fertilizer market. In distribution and blending, notable consolidations include:

- Yara's compete acquisition of Bunge's fertilizer blending plants, brands and warehouse in 2013
- Mosaic's purchase of Archer Daniels Midlands Brazilian fertilizer distribution business in 2014
- OCP's and Nutrien each taking a 10 percent stake in Fertilizantes Heringer in 2014 and 2015
- EuroChem taking a controlling interest in Fertilizantes Tocantins in 2016.

These moves have left fertilizer distribution highly consolidated and vertically integrated, with 80 percent of the Brazilian market now in the hands of just four key players – Mosaic, Yara, Fertipar and Fertilizantes Heringer.

Brazil – being a massive agricultural economy with a major fertilizer supply deficit – has become highly important strategically to international fertilizer producers with expansion plans. Gaining market share and being able to control logistics in Brazil, a key demand market, has become an increasing priority for major market players such as EuroChem, Mosaic, OCP, PhosAgro and Yara. ■

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Potash project listing 2020

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

Plant/project	Type	Company	EPC/EPCM contractor(s)	Equipment/ technology	Location	Product	Capacity '000 t	Status	Start-up date
AUSTRALIA									
Lake Way	G, LBE	Salt Lakes Potash			West. Australia	SOP	245	UC	2021
Beyondie	G, LBE	Kalium Lakes	DRA Global	Ebner/K-UTEC/Köppern	West. Australia	SOP	82	UC	2021
Lake Wells	G, LBE	Australian Potash			West. Australia	SOP	150	FS	2023
BELARUS									
Petrikov	G, CM	Belaruskali			Gomel	MOP	1,500	UC	2020
Nezhinsky GOK	G, CM	Slavkaliy	China State Engineering Corp/Deilmann-Haniel	Herrenknecht Shaft Boring Roadheader (SBR) system	Lyuban	MOP	2,000	UC	2023
BRAZIL									
Cerrado Verde	G*, CM	Verde AgriTech			Minas Gerais	SG	300	UC	N/A
CANADA									
Esterhazy K3	B, CM	Mosaic	Hatch/AMC	DCM Group	Saskatchewan	MOP	1,800	UC	2024
Bethune	G*, SM	K+S Canada			Saskatchewan	MOP	400	UC	2019/20
Bethune	G*, SM	K+S Canada			Saskatchewan	MOP	200	UC	2022
Jansen	G, CM	BHP	DMC Mining	Herrenknecht Shaft Boring Roadheader (SBR) system	Saskatchewan	MOP	2,000	UC	N/A
Milestone	G, SM	Western Potash	Artisan Consulting/ AKITA Drilling		Saskatchewan	MOP	146	UC	2020
Wynyard	G, SM	Kamalyte Resources/ GSFC	Amec FW (Wood)		Saskatchewan	MOP	625	FS, P	N/A
Southey project	G, SM	Yancoal			Saskatchewan	MOP	2,800	P	2022
ERITREA									
Colluli	G, CM	Colluli Mining Share Company (CMSC)	DRA Global		Danakil Depression	SOP	472	FS, P	2021/22
ETHIOPIA									
Yara Dallol	G	Yara/Liberty Metals and Mining/XLR Capital	SNC-Lavalin		Afar	SOP	600	FS, P	N/A
Danakil Potash	G	Circum Minerals			Danakil	MOP/SOP	2,000/750	FS, P	N/A
ISRAEL									
Dead Sea Works	B, LBE	ICL			Dead Sea	MOP	400	UC	2020/22
MOROCCO									
Khemisset	G, CM	Emmerson			Khemisset	MOP	735	FS	N/A
PERU									
SalSud**	G, LBE	Salmuras Sudamericanas			Sechura desert	SOP	100	P	On hold
RUSSIA									
Volgakaliy I	G, CM	Eurochem			Volgograd	MOP	2,300	UC	2019
Volgakaliy II	G*, CM	Eurochem			Volgograd	MOP	2,000	UC	2023
Usolskiy II	G*, CM	Eurochem			Perm	MOP	1,400	UC	2022
Talitsky	G, CM	Acron (Verkhnekamsk Potash Company)			Perm	MOP	2,000	UC	2022/23
SPAIN									
Muga	G, CM	Highfield Resources/ Geoalcali			Navarra & Aragón	MOP	1,100	FS, P	N/A
UNITED KINGDOM									
Woodsmith Mine	G, CM	Anglo American	DMC Mining/ STRABAG AG/Jacobs	Herrenknecht Shaft Boring Roadheader (SBR) system	North Yorkshire	Polyhalite	10,000	UC	2021/22
UNITED STATES									
Sevier Playa**	G, LBE	Cystal Peak Minerals			Utah	SOP	27.5	FS, P	On hold

NOTES: * *Ramp-up/expansion* ** *Project under review*

- Greenfield projects (G): generally, these must have reached the detailed/bankable feasibility study (FS) stage for inclusion.
- Brownfield expansions (BE): capacity indicates incremental additions, not total capacity.
- The following projects have not been listed as their current status is unknown: ThaiKali, Thailand; SinoAgri, Laos; Kalium Mineracao, Brazil; Ochoa, New Mexico.
- Bolivia's CAMC (Uyuni) 350,000 t/a capacity MOP plant commissioned in 2018 has yet to fully ramp-up
- Production at the Turkmenkhimiya (Garlyk) MOP plant in Turkmenistan commissioned in 2017/18 was forecast at 100,000 tonnes in 2020.
- A final investment decision in BHP's Jansen mega project in Saskatchewan is expected in mid-2021.

KEY

PROJECT TYPE:
G Greenfield
B Brownfield expansion
CM Conventional mine
SM Solution mine
LBE Lake brine extraction

STATUS:
N/A Not available or provided

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

PROJECT STAGE:
S Scoping
FS Feasibility study
P Permitted
UC Under construction
C Completed

Woodsmith project update

One mile down beneath the North York Moors National Park lies a 260 million-year-old polyhalite deposit. This is the world's largest, highest grade resource of this nutrient-rich mineral – a fact which helped convince Anglo American to purchase Sirius Minerals and its Woodsmith project in March this year (*Fertilizer International* 494, p8; *Fertilizer International* 495, p10).

Polyhalite is a potassium-bearing mineral which also contains sulphur, magnesium and calcium, together with numerous micronutrients such as iron, boron, zinc and selenium. It is therefore able to provide several key plant nutrients in just one product. This is being marketed by Anglo American under the name *POLY4*.

Unlike other fertilizer products, *POLY4* does not require any chemical processing. It is simply crushed and granulated, making it suitable for organic farming. This relatively simple production process, together with its 1:1 ore-to-product ratio, also gives *POLY4* a low carbon footprint compared to other conventional chemical fertilizers. Anglo American believes that these properties – allied to the ability of the calcium present in *POLY4* to strengthen soils – will help drive more sustainable fertiliser practices. Indeed, sustainability and low environmental impact are central themes which run through the entire Woodsmith project.

The mine itself – nestled on a hilltop above the picturesque town of Whitby – will be barely visible. It has been specifically designed to blend into the North York Moors landscape, with all the key infrastructure hidden beneath the surface. The number and size of the buildings have also been reduced to a minimum, while extensive landscaping and planting ensures the site is screened from view.

Most importantly, a 360 metre-deep mineral transportation tunnel will eliminate the need for any surface transport of the product. Instead, from the Woodsmith mine, just south of Whitby, the polyhalite will travel via an underground conveyor belt to a processing plant and harbour on Teesside, 37 kilometres away. From there it will be transported around the world and sold as a bulk speciality fertilizer.

Mine construction began in spring 2017. Two 35 metre-wide and 60 metre-deep foreshafts were initially excavated and constructed. The headframes for the service shaft and production shaft will be emplaced in these, enabling them to be sunk underground and hidden from view. The service shaft foreshaft was completed in late 2019, with the production shaft following a few months later. Preparations for main shaft sinking operations have advanced at pace since then.

The shaft sinking method is in keeping with the innovative approach to the whole project – with the company choosing to use Shaft Boring Roadheader (SBR) technology over traditional drill-and-blast methods. Adapted from tunnel boring machine technology, SBR machines mechanically cut, remove spoil and line the shaft simultaneously, allowing safer, faster progress. As of October 2020, the first SBR machine is fully constructed and undergoing commissioning, ahead of the start of shaft sinking operations this winter, with the second SBR machine for the production shaft not far behind. Shaft sinking operations are expected to last around two years.

PHOTO: ANGLO AMERICAN

Woodsmith project team at the tunnel boring machine launch on Teesside.

37 kilometres to the north, a factory to process the polyhalite ore into soluble, slow-release granules will be built in the heavily industrialised Teesside area. Excavation of the transportation tunnel to link the two sites began in April 2019, using a tunnel boring machine launched from the Teesside end (see photo). Since then, progress has been quick, with the tunnel passing the 10 kilometre mark, as of October 2020. Another tunnel boring machine will begin tunnelling northwards from the mine end, once a shallow access shaft has been sunk with a cavern constructed at the bottom. Shaft sinking operations for this access shaft will begin in the coming months.

Once those operations are complete, the next stage will be the completion of the mine, tunnel, processing and shipping facilities needed to bring the mine into production. ■

Lake Wells SOP project at engineering design stage

Australian Potash Limited's flagship Lake Wells sulphate of potash (SOP) is currently at the front-end engineering design (FEED) stage. Six engineering procurement and construction (EPC) contracts have also been issued for the project's SOP processing plant, borefield fit-out, high voltage (HV) network, power station, communications infrastructure and village accommodation.

Additionally, the company is concluding offtake agreement discussions and securing finance to develop the project. This included successfully raising $7 million through a share issue in early November.

The Lake Wells project is located in the Eastern Goldfields region of Western Australia, 500 kilometres northeast of Kalgoorlie. The project – alongside the Woodsmith project in the UK, the Slavkaliy project in Belarus and EuroChem's VolgaKaliy project in Russia – is one of only four greenfield projects globally that the International Fertilizer Association expects to be commissioned out to 2023.

Highlights of the project's definitive feasibility study (DFS) published in 2019 include:

- Estimated reserves of 3.6 million tonnes and measured resources of 18.1 million tonnes
- A 30-year mine life based on the production of 150,000 t/a of premium grade SOP (*K-Brite*)
- Pre-tax Net Present Value (NPV) – a measure of profitability – of AUD 665 million and an Internal Rate of Return (IRR) of 25 percent
- Capex requirement of AUD 208 million with a capital intensity of AUD 1,387/t
- First-quartile industry opex of $262/t that delivers high cash operating margins.

The project has binding offtake agreements in place with four trading partners – Helm, Migao, Mitsui and Redox – covering 130,000 t/a of SOP production output in total. In September, Western Australia's Environmental Protection Agency recommended that government ministers approve the project, although this decision is still pending. ■

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