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Southeast Asia's fertilizer market

African producers and blenders

Enhanced efficiency fertilizers

Potassium sulphate: a premium product

Cover: *Musa acuminata is a species of banana native to Southeast Asia. Piotr Velixar/Shutterstock.com*

Africa's blending plant boom

Primary SOP production from lake brines

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PHOSPHATES AND POTASH INSIGHT

REGULARS

Nutrients for livelihoods

"There can be no life without soil, and no soil without life." An insightful quote from Charles Kellogg, the renowned former chief of USDA's soils bureau.

Yet around one-third of the world's soils are currently degraded, a figure that could rise to more than 90 percent by 2050, according to a particularly apocalyptic UN estimate. Soil erosion on that scale would threaten global food security, given that it can reduce crop yields by as much as 50 percent.

It's unsurprising, therefore, that reversing soil degradation has become a farming priority.

There have been success stories. The widespread uptake of conservation agriculture across North and South America has helped improve soil health in those two regions. American farmers, by practicing reduced or conservation tillage and no-till systems, have done much to reduce soil erosion, conserve soil moisture and sequester carbon.

Conservation agriculture – often termed agro-ecology – is based on three clear and simple agronomic rules: firstly, minimise soil disturbance; secondly, permanently cover the soil with mulched crop residues; thirdly, practice either crop rotation or intercropping.

Conservation agriculture's initial success in tackling soil erosion in the Americas fuelled hopes that it offered a panacea for African agriculture. But a recently-published paper in the journal *Nature Food* rejects many of the claims made by agro-ecology's most ardent advocates.

The authors, led by Marc Corbeels – an expert in sustainable intensification at CIMMYT in Nairobi, Kenya – compared conservation agriculture with conventional cropping by analysing the results of 79 studies across 16 countries in sub-Saharan Africa.

They discovered that conservation agriculture did little to improve the yields of cotton, cowpea, rice, sorghum or soybean. Maize yields did show a four percent increase – but only if the herbicide glyphosate was applied pre-emergence.

Commenting on the paper, Katrien Descheemaeker, an assistant professor at Wageningen University, said: "The findings of Corbeels and colleagues refute the claims that conservation agriculture would substantially improve the food security of smallholders."

She added, "small yield increases [in Africa] are meaningless at the farm level in terms of improvements in food self-sufficiency and income, mostly because of small farm sizes", before concluding that conservation agriculture "should not be promoted on the grounds of its potential to improve crop yields and food security".

Katrien called for a shift away from conservation agriculture and a renewed focus on other options for improving the livelihoods of Africa's smallholder farmers.

Many believe the key to successful agriculture in Africa is improving fertilizer supply and distribution. They include Marie Claire Kalihangabo of the African Development Bank (AfDB). She's helping finance fertilizer projects across the continent through her role as coordinator of the African Fertilizer Financing Mechanism (AFFM).

This mechanism is currently financing a $2.2 million project aimed at improving fertilizer supply for 200,000 Nigerian smallholder farmers.

"We are confident that the project will increase access to quality and affordable fertilizer by smallholder farmers and hence contribute to the transformation of the agriculture sector in Nigeria," Marie Claire said.

By transforming its fertilizer supply and distribution in just a few short years, Nigeria has blazed a trail for the rest of sub-Saharan Africa to follow (see our report on page 15). The West African country has been at the epicentre of a remarkable expansion in African blending plant capacity.

Impressively, the number of blending plants in Nigeria increased from just eight at the start of 2017 to 34 by the beginning of this year, a total that is expected to rise to 51 by the start of 2021. This has helped Nigeria cut its NPK imports from half a million tonnes in 2017 to less than 2,000 tonnes last year.

Meanwhile, massive investment in domestic urea production capacity – much of it co-financed by the AfDB – has seen Nigeria's urea production rocket from around 280,000 tonnes in 2015 to 1.5 million tonnes last year. About half of this volume is consumed domestically by farmers.

Shuaibu Yusuf, a farmer in Nigeria's Kaduna region, spoke movingly recently about how access to locally-produced, affordable fertilizers had transformed his family's livelihood: "Low productivity brings despair. The benefits that I get from higher-yield farming are increased food, education for my children and the ability to pay our medical bills."

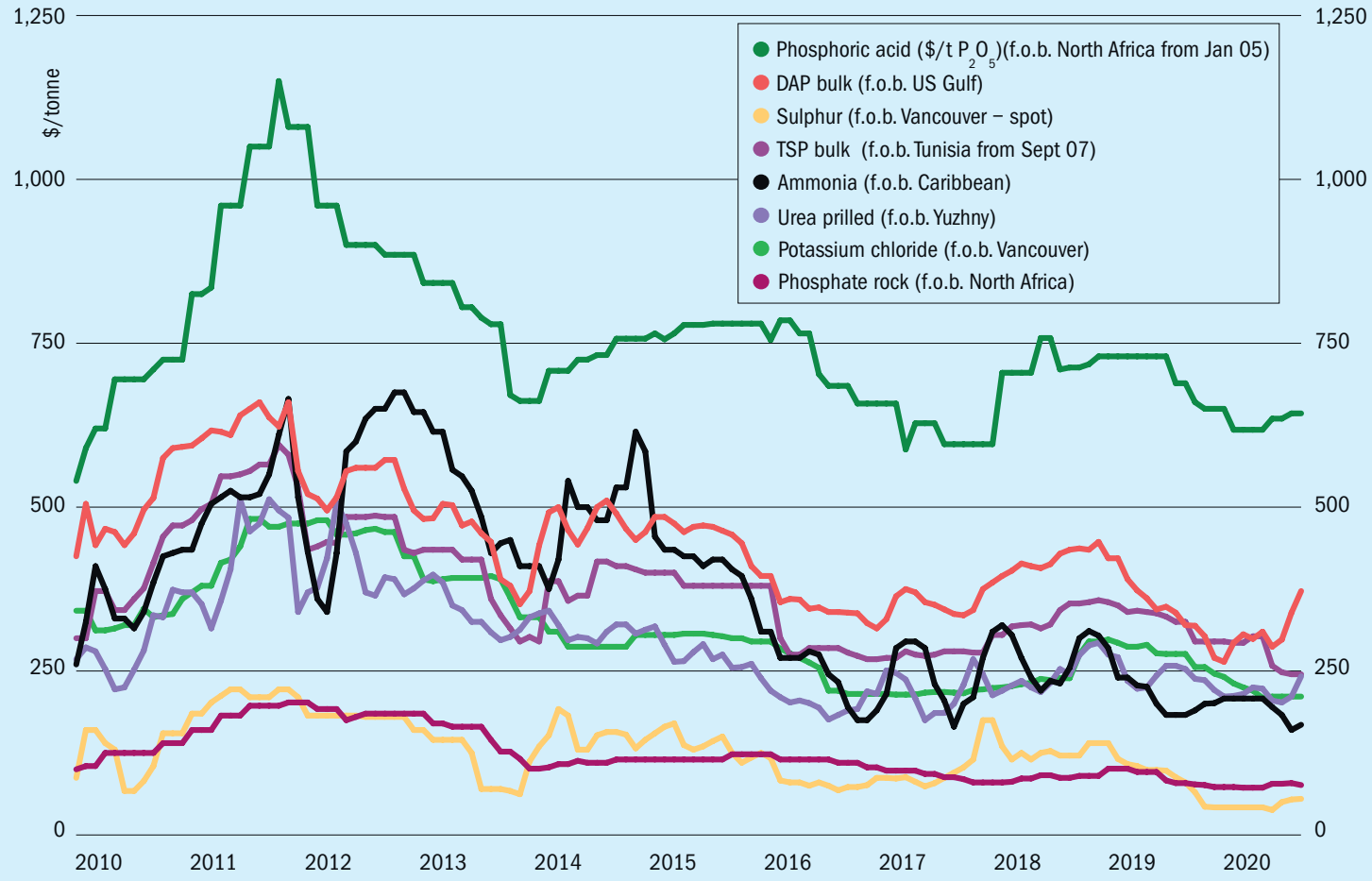
Shuaibu's farming experience brings us back to Charles Kellogg's original quote. In rural Africa, without soil – nutrient-rich soil – there can be no lives or livelihoods. ■

By transforming its fertilizer supply and distribution in just a few short years, Nigeria has blazed a trail for the rest of sub-Saharan Africa to follow.

Simon Inglethorpe, Editor

Market Insight

Historical price trends $/tonne



Source: BCInsight

Market Insight courtesy of Argus Media

PRICE TRENDS

Urea: Record Indian demand has driven up prices since May. India has issued four urea tenders in the past two months to meet a 48 percent rise in April-July sales, equivalent to 3.7 million tonnes.

The strong demand pull from India has singlehandedly lifted the whole urea market. Egyptian granular urea prices have risen from a low of $205/t in May to $280/t f.o.b. in early August, while Middle Eastern granular urea has moved up from $210/t to $270/t f.o.b. over the same period. Even third-quarter Chinese urea prices – which normally ease at the end of the domestic summer season – have instead increased to $270/t f.ob.

Prices have also moved up in Brazil. This market, which is the main focus in the west, has seen increases of $60-70/t since early June. Brazilian buyers have had few options but to pay up, given the onset of the peak period for shipments and competition for tonnages from India.

Some market buying from Egypt and Algeria has also taken place. This was to cover short positions taken by some traders for July-September shipment to Europe, these risking significant losses for those affected.

Phosphates: DAP and MAP markets have been firm since the start of June, in both the east and west, underpinned by strong demand from India and Brazil. News of Mosaic's bid to block Russian and Moroccan phosphate imports also lifted North American DAP and MAP prices.

Indian DAP demand has been boosted by near-record *kharif* season planting. Consequently, prices have risen by around $15/t since mid-June to around $330/t cfr. India's strong agricultural fundamentals, plus an above-average monsoon season, have been the main underlying factors. A private sector tender placed by neighbouring Bangladesh, meanwhile, has provided

PHOTO: PERFECT LAZYBONES/SHUTTERSTOCK.COM

Indian DAP demand has been boosted by near-record kharif season planting

Market price summary $/tonne – End August 2020

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	165-185	-	f.o.b. E. Europe	f.o.b. US Gulf	360-395	-	-
f.o.b. Yuzhny	178-205	230–250	100-120	f.o.b. N. Africa	310-330	230-260	590-695
f.o.b. Middle East	230-260	264-285**	-	cfr India	330-338	-	625*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	182-240	-	cfr US Gulf	35-50	f.o.b. Vancouver	50-60	-
f.o.b. Middle East	180-240	-	-	-	f.o.b. Arab Gulf	54-60	-
f.o.b. Western Europe	-	470-523	-	-	cfr N. Africa	63-76	-
f.o.b. Baltic	180-240	-	-	-	cfr India	67-79+	-

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.*

an outlet for 600,000 tonnes of DAP, with half of this being supplied by China.

West of Suez, Brazilian MAP prices have risen by around $25/t since mid-June to the low-$340s/t cfr. Prices have been supported by demand for September soybean planning and accompanying predictions of the second-highest ever soybean export total in 2020 (80 million tonnes). The possible lockout of Russian and Moroccan imports has pushed up US domestic prices. DAP barge prices have risen by $50/st since mid-June to $325/st f.o.b. Nola. OCP seems to be more wary of the US market already, having shipped far more DAP east of Suez so far this year compared to last.

Potash: Limited demand has left potash prices flat-to-soft in most key markets since the beginning of June. Brazil was the exception with prices there holding firm.

June brought several dips in Southeast Asian MOP prices, for example, as distributors and traders competed for sales in Malaysia, Vietnam, and Indonesia. This was followed by further price decreases in July. Oversupply and lacklustre demand saw granular MOP fall by $5/t in Thailand/Vietnam to finish July at $255-265/t cfr. Prices for standard MOP in Southeast Asia also fell by $3/t through July, ending at $230-242/t.

There were also slides in the US thanks to heavy competition. This caused f.o.b. Nola prices to fall from $198-205/st to $189-195/st during the course of June. In Europe, following falls in early July, granular MOP prices fell again at the start of August, down to €230-240/t cfr, due to buyer uncertainty. Australian and South African cfr prices for granular MOP have also softened since the end of June.

Brazilian prices for granular MOP, meanwhile, bucked the trend. These recorded consecutive rises in late June and early July, moving up to $235-240/t cfr where they have remained since.

Sulphur: An east/west divide in the market became increasingly apparent during June and July. Prices trended flat-to-soft in markets east of Suez, as there was no shortage of tonnages and buyers lacked enthusiasm for product. In the west, meanwhile, supply tightness continued as buyers looked to lock-in third-quarter cargoes.

OCP has been behind the increased availability in the east. The Moroccan phosphate giant pushed back on some of its usual contracted volumes because of healthy inventories and discharge line-ups. Appetite for these extra Middle Eastern tonnages was limited due to the approaching summer and limited demand from some regions because of the coronavirus pandemic. Across eastern markets, lacklustre demand, coupled to better-than-expected availability, pushed down prices to the low-$70s/t cfr by mid-July.

The west, in contrast, has seen f.o.b. and cfr prices hold broadly stable. With coronavirus cutting demand for refined products, US production has been reduced to just half of normal capacity in key refining and sulphur-producing regions. US supply tightness has been compounded by FSU supply reductions, most notably the extension of Kazakhstan's Opec+ compliance period to September. Despite the general supply-side tightness, elevated Middle East availability – and overall hesitancy on the buy-side – has kept a ceiling on west of Suez pricing and prevented f.o.b. and cfr price run-ups.

OUTLOOK

Urea: Indian demand will continue to support the urea market through the remainder of the third-quarter. But a correction to rapid price rises is possible, eventually, if Indian buying slackens in the fourth-quarter. Buyers in other markets are also starting to resist continually rising prices. Indeed, recent business has seen traders taking long positions in preference to making cfr sales.

Phosphates: Argus predicts a tight DAP and MAP market through the remainder of the third-quarter, with prices moving up accordingly. Supply-side issues in Tunisia will also have a short-term firming effect. The upward price impetus is only likely to slow when the market moves into surplus in the fourth-quarter.

Potash: European price levels look vulnerable currently. MOP prices in Thailand and Vietnam, in contrast, should benefit from a fertilizer demand boost in the region linked to healthy seasonal rainfall. Brazil is set to remain steady for the time being, while autumn demand in the US should spur price rises there.

Sulphur: Market prices are expected to remain broadly stable for the remainder of August, as buyers and sellers are in no hurry to trade. Shipments this month should also be absorbed by contracts and previously concluded spot deals. However, with key buyers already holding healthy inventories, some softening is widely expected when cargoes for September loading are offered to the market.

Fertilizer Industry News

BELARUS

Belarus unrest triggers share price rises

Recent protests in Belarus have triggered a wave of share price volatility, London's *Financial Times* reported on 18th August.

Shares in several major listed fertilizer companies have risen sharply on the news that workers at Belaruskali had joined a national strike called in response to the country's disputed presidential election. The state-owned company is one of the world's major potash producers. Belarus is also the second largest potash exporter globally, after Canada.

The strike is said to have forced the Belarusian Potash Company (BPC), the country's international potash trading arm, to adjust its sales plans. BPC told *Financial Times* that it was "quite hard to say as for now how quickly the situation will get back to normal".

On the back of this news, shares in The Mosaic Company, the US-headquartered phosphates and potash producer, have jumped more than one-third since the start of August, according to *Financial Times*, while shares in Israel's ICL and K+S of Germany – two other major potash producers – have also risen by 18 percent and 14 percent, respectively. Share prices in all three companies remained elevated on the 26th August, at the time of writing.

Analysts believe that any drop in shipments from BPC could provide other international potash producers with an opportunity to gain market share. The company controls more than 20 percent of the global potash market and is a key supplier to large buyers in China and India. BPC secured a major new potash supply contract with China in May (*Fertilizer International* 496, p8).

"If you have a short outage or a [production] slowdown, it can have a substantial impact on supplies in the major markets," commented CRU's senior analyst Humphrey Knight. "Other producers will be looking to fill that gap."

Disruption to Belaruskali's operations could also prove domestically damaging – given that potash exports are a key foreign revenue earner for Belarus. "The closure of the mines will be a major blow to the economy and government," commented David Riley of Argus Media.

No major or immediate impact on potash prices is currently expected, however, due to the prevalence of long-term contracts in the potash market. Overall demand for potash has also been flat this year. This has been linked to low crop prices, the Covid-19 pandemic, and reduced demand for biodiesel made from crops such as corn and palm oil.

Unusually large inventories held by major potash buyers are also dampening the market, according to CRU's Humphrey Knight. "Potash [inventories] in some key downstream markets remain high and these continue to weigh on global demand and prices," he said.

The news of possible strike disruption follows a record breaking summer production period for Belaruskali. The company set new records for both potash ore mining and potassium chloride fertilizer (MOP) production in June and July.

Belarus state news agency BelTA reported MOP production above 1,120,00 tonnes and 1,140,000 tonnes in June and July, respectively. Daily MOP shipments by the company also reached a record high of 46,000 tonnes on 3rd August. ■

MOROCCO

OCP to double EMAPHOS production capacity

OCP Group and its partners, Germany's Budenheim and Prayon of Belgium, are to begin constructing a new purified phosphoric acid (PPA) plant at Jorf Lasfar, through their jointly-owned Euro Maroc Phosphore (EMAPHOS) subsidiary.

This new plant will effectively double EMAPHOS' annual production capacity to 280,000 tonnes P_2O_5 when it enters production during the fourth-quarter of 2022.

Basic engineering was completed in March with the project currently at the detailed engineering stage. Construction is scheduled to start in the first-quarter of 2021. Equipment with long lead-in times will be ordered later this year in advance of construction commencing.

The major expansion project is part of an ambitious strategy by the three EMAPHOS partners to establish a world lead in PPA production. The development will also strengthen OCP's presence in the speciality phosphate market.

Budenheim, part of massive food conglomerate Oetker, specialises in high-value, phosphate-based food, pharmaceutical and technical products. Prayon, which is jointly owned by OCP Group and the Société Régionale d'Investissement de Wallonie (SRIW), is a world-leading phosphoric acid technology company and speciality phosphate producer.

SPAIN

Fertiberia to make green ammonia

Fertilizer producer Fertiberia and energy firm Iberdrola have teamed up to build Europe's largest green hydrogen plant.

Hydrogen generated by the new $174 million plant will be used to manufacture ammonia for industrial purposes.

The plant's 20MW water electrolysis unit will produce 720 t/a of green hydrogen. Electricity will be supplied by a 100MW solar plant linked to a 20 MWh lithium-ion battery storage system. The green hydrogen plant is scheduled to start-up in 2021.

The green hydrogen generated will supply Fertiberia's ammonia plant at Puertollano, 250 kilometres south of Madrid, reducing the plant's natural gas consumption by 10 percent. The substitution of green hydrogen will avoid an estimated 39,000 tonnes in annual CO_2 emissions.

Fertiberia will also source electrolysis-generated oxygen from the new hydrogen plant and use this to manufacture nitric acid, an intermediate used in ammonium nitrate production at Puertollano.

"We are launching the first major green hydrogen project in Europe, demonstrating that – thanks to renewables and technological innovation – it is possible to continue to meet the needs of the electrification and decarbonisation of our industry," said Ignacio Galán, the chairman of Iberdrola. "The initiative shows the opportunities offered by the energy transition to develop innovative projects as the focus for industrialisation and employment in our country."

Fertiberia president Javier Goñi added: "The partnership with Iberdrola allows Fertiberia to take a further step in its ambition to become a European reference for sustainable solutions for agriculture, and to lead the paradigm shift required for the energy transition in the chemical sector, thanks to the manufacture of green ammonia from

domestic renewable energy sources."

Spain produces an estimated 500,000 tonnes of hydrogen each year, mainly for use in the refining, chemical and fertilizer industries. Most of this is produced from natural gas and, as a consequence, generates five million tonnes of CO_2 emissions annually.

At a global scale, the annual production of hydrogen – 70 million tonnes – is associated with 830 million tonnes of CO_2, a volume that is equivalent to two percent of total global emissions. Decarbonising global hydrogen production – through the use of 100 percent renewable energy – would however increase global electricity demand by around 10 percent, some estimates suggest.

RUSSIA

Dorogobuzh completes ammonia plant upgrade

PJSC Dorogobuzh, part of Acron Group, has officially completed a five billion rouble upgrade of an ammonia plant at its nitrogen fertilizer complex in Russia's Smolensk region.

The upgrade has increased the plant's ammonia production capacity by one-fifth to 2,100 t/d. The revamp is being hailed as a landmark achievement. This is the first time in the whole of the post-Soviet era, according to Acron, that a Russian ammonia plant based on KBR technology has achieved this output level.

The Dorogobuzh ammonia plant, which dates from 1979, had an original design capacity of 450,000 t/a. Its annual ammonia output is now expected to increase by an extra 130,000 tonnes. More than 440,000 tonnes of ammonia has already been produced since the upgrade was carried out, says Acron.

Dorogobuzh is the first ammonia plant in Russian to use KBR's *KRES* heat exchange reformer technology. The resulting energy efficiency improvements have reduced the plant's natural gas consumption by seven percent (per tonne of ammonia).

LLC Novgorodsky GIAP designed the ammonia plant upgrade. The project itself was carried out by 60 Russian contractors who brought in over 1,100 specialists and 50 pieces of equipment. Dorogobuzh and Acron employees also participated.

"The upgrades to the Dorogobuzh ammonia unit are an essential part of our technology development programme," commented Vladimir Kunitsky, Acron's CEO. "The increase in the unit's capacity will give us additional ammonia to use for new projects."

Uralchem resumes production at Berezniki

Uralchem's Berezniki nitrogen fertilizer complex resumed full-scale production on 30th July, after an unplanned shutdown earlier in the month.

The Perm Krai site, the location of Uralchem's Azot Branch, ceased all operations on 7th July, following a dramatic increase in chloride content in the nearby Kama river, the source of Berezniki's process feed water. The shutdown decision was taken after Uralchem judged that the contaminated river water threatened the operational safety and integrity of its process equipment. After 10 days, the Kama River's chloride content dropped to acceptable levels at the intake point, allowing management to begin to restart production.

The resumption in output proceeded in stages. Ammonia production at Unit 1 began initially, followed by the restart of its downstream process units for granular ammonium nitrate and non-concentrated nitric acid production. Unit 2 operations resumed last, allowing the production of ammonia, concentrated nitric acid, nitrite and nitrate salts to begin once again.

The unplanned shutdown has cost Uralchem about $8 million in lost production. As a consequence, the company has asked local Russian authorities and environmental regulators to investigate and deal with the dumping of the chemicals that caused the river pollution.

In a statement, Uralchem requested "urgent measures to normalize the situation, carry out appropriate inspections to establish the violation of current legislation, and to bring the perpetrators to justice." The city of Berezniki has already launched an official criminal investigation into the pollution incident.

SAUDI ARABIA

Topsoe selected for green ammonia project

Saudi Arabia has selected technology from Denmark's Haldor Topsoe for a $5 billion green hydrogen project.

The project forms part of the country's $500 billion Neom smart city development, a personal initiative of Saudi crown prince Mohammed bin Salman. This city will be built in the Tabuk region on the Red Sea near Saudi Arabia's border with Jordan.

The project involves generating 650 t/d of green hydrogen from four gigawatts of renewable electricity. This will then be converted into 3,500 t/d (1.2 million t/a) of ammonia using Topsoe technology.

Topsoe's partner Air Products will exclusively off-take all of the green ammonia produced. The company will then transport energy globally, in the form of green ammonia, before eventually converting it back into carbon-free hydrogen at local hydrogen refuelling stations.

Air Products plans to use the project to supply carbon-free hydrogen to fuel cell powered buses and trucks by 2025. Distribution to these end customers will require an additional two billion dollar investment by Air Products. Once implemented, the project will avoid the emissions generated by 700,000 cars – the equivalent of more than three million tonnes of CO_2 annually.

"We are honoured to be part of this innovative world-scale project to reduce carbon emissions. Topsoe is focused on improving energy efficiency in today's technologies while developing the solutions of the future. This is a great step ahead," said Amy Hebert, Deputy CEO and EVP, Chemicals, Haldor Topsoe.

The Neom smart city is described as "a living laboratory and a hub for innovation". It will be based on 5G technology and focus on high-technology and digital industries such as robotics and artificial intelligence (AI).

Contractor Bechtel is in charge of designing and building Neom's transport, power and water infrastructure. This include a completely renewable energy supply system based on the generation and storage of solar and wind power. Futuristic features such as an artificial moon, phosphorescent beaches and flying taxis are also planned.

CANADA

BHP delays Jansen decision

BHP is delaying the final go-ahead decision for its massive Jansen potash project until the middle of next year.

BHP – the world's largest mining company – had planned to make a final investment decision for Jansen by February 2021. But delays in shaft completion at the multi-billion dollar Canadian project have now pushed back that date by months, the company has confirmed

BHP said Jansen's progress was delayed during the second-quarter by the slower-than-expected installation of shaft

linings and the implementation of a Covid-19 response plan.

The Jansen project is 86 percent complete currently. BHP still expects to invest $2.7 billion – out of the $4 billion already set aside – to finish the excavation and lining of the project's production and service shafts. The remaining investment also covers the installation of surface infrastructure and utilities.

The Australian-based mining major has been weighing up Jansen's ultimate future for the last seven years, while continuing to invest billions of dollars in shaft sinking at the Saskatchewan project site, 140 kilometres east of Saskatoon.

Executing stage 1 of the Jansen project will require an estimated $5.3-5.7 billion. This is the capital cost of bringing the project into production and the sum BHP's board will now have to authorise – or not – in mid-2021.

If and when it enters production, the Jansen mine will produce eight million tonnes of potash annually – an estimated 15 percent of world supply – during its 70-year mine life. Jansen has the potential to be expanded in three further phases – each costing $4 billion – to reach an annual production capacity of more than 16 million tonnes. The eventual price tag of the multi-phase project could be as high as $17 billion, according to some estimates.

BHP is still bullish over Jansen's prospects. "Jansen is a tier 1 deposit, with potential to be one of the lowest cost operations in the world," commented BHP's CEO Mike Henry on 18th August.

Making an entry into the fertilizer market by becoming a major potash player has been a long-held ambition for BHP. In 2010, The Canadian government blocked BHP's $40 billion hostile takeover of Potash Corp (now Nutrien).

Other large global mining companies are making similar strategic investments. Earlier this year, for example, BHP's rival Anglo American successfully bought Sirius Minerals, the developer of the UK-based Woodsmith polyhalite mining project that is currently under-construction in Yorkshire, near England's North Sea coast (*Fertilizer International* 495, p10).

TRINIDAD

Yara to cut ammonia output

Norwegian fertilizer producer Yara took one of its two ammonia plants in Trinidad offline in August. The move is in response to weak market conditions caused by the Covid-19 pandemic.

The 1.5 million tonne capacity Tringen 1 ammonia plant will now undergo maintenance work. It will stay offline until market conditions recover, Yara said.

in recent months, Tringen 1 has been running at a lower production rate than its sister plant on the island, the 495,000 tonne capacity Tringen 2 plant. While Tringen 1 produced 156,500 tonnes in January-April this year, for example, Tringen 2 produced 175,000 tonnes over the same four-month period.

Three of Trinidad's ammonia plants are now offline due to the global slowdown in industrial ammonia demand. Yara's shutdown follows a similar decision by Nutrien to take two of its four ammonia units on the island offline until the market recovers. Yara's announcement will remove a further 40,000 tonnes of ammonia from the export market each month, according to analysts Argus.

Trinidad's ammonia industry has, in any case, been struggling to compete, being squeezed by cheaper gas in rival regions such as the US and Europe. Last year, Yara closed Yara Trinidad, its oldest and smallest plant on the island, due to its high production costs.

Caribbean/US Gulf spot prices for ammonia have fallen by over $50/t in the past three months, reports Argus, to around $150-170/t f.o.b. Several plants are said to be running at below cost at this price level. First-half ammonia exports from Point Lisas are also down 18 percent year-on-year, according to Argus.

UNITED KINGDOM

Million tonne polyhalite orders

ICL has secured international contracts totalling one million tonnes for *Polysulphate*, the polyhalite fertilizer produced at its Boulby mine in the UK.

The latest contracts include:

- A five-year agreement with a leading Ukrainian fertilizer company for a total of 350,000 tonnes
- A 12-year agreement for over 500,000 tonnes for a major customer in Poland
- An agreement with 16 regional distributors in China to sell 100,000 tonnes of *Polysulphate* and *Polysulphate*-based fertilizers in 2020.
- A three-year agreement, with an optional one-year extension, for the use of *Polysulphate* for added-value fertilizer production by a leading producer and distributor in Spain.

"As the world's first and only producer of polyhalite, we are proud to have been able to make our contribution to maintaining food production during this very challenging time," said Andrew Fulton, ICL vice president and general manager of the Boulby mine. "Recognised by the UK Government as an essential industry during the Covid-19 pandemic, everyone involved with the company has worked hard to maintain production and the news of these latest contracts show that we are well placed to continue moving forwards."

Fulton added: "It also demonstrates the increasing acceptance of *Polysulphate* as a unique high-quality multi nutrient fertilizer, demonstrated by over 600 field trials showing increases in growth, yield and quality in a wide variety of crops and conditions."

ICL is currently the world's only producer of polyhalite for the fertilizer market. The company has seen its *Polysulphate* sales volumes increase by 50 percent in each of the past three years.

PAKISTAN

Agritech urea plant restarts

Pakistan's Agritech Ltd has restarted urea production at its Tara plant, 100 kilometres southwest of Islamabad, after an eight month interruption.

The former Pak-American Fertilizers plant has been shuttered since December 19th last year due to a lack of natural gas availability. Production did, however, resume in early August after the government allocated re-gasified imported LNG to Agritech at a subsidised tariff.

The 1,300 t/d urea plant is being supplied with 28.5 million scf/d of gas at a rate of $4.48/MMBtu for three months, according to local reports. Similarly, the 300 t/d capacity urea plant operated by Fatima Fertilizers is also being supplied with gas at this concessionary rate.

The government intervention is designed to boost Pakistan's domestically-supplied urea stocks. The country's urea inventories will fall below 200,000 tonnes by the end of this year, according to production ministry estimates. The government is expecting high urea demand for several months from December 2020 onwards – due to a rise in agricultural subsidies for fertilizers, seeds, pesticides and tractors. These latest subsidy increases are designed to boost Pakistan's domestic crop production.

People

Nelson Silva was appointed to Nutrien's board of directors in the second week of August. His appointment coincided with the retirement of **David C Everitt** from Nutrien's board, where he has been a director since 2013.

"David has been a valuable member of the board of directors… and we want to express our sincere thanks for his many contributions to our success," said Mayo Schmidt, Nutrien's chairman. "The board of directors would also like to welcome Mr Silva. Nelson brings over 30 years of global business experience, and strong Brazilian experience, to the Nutrien board and we look forward to working with him to advance Nutrien's vision and strategic plans."

Mr Silva brings to Nutrien extensive experience in a variety of leadership roles at major international companies. Nelson's past roles include stints as: chief strategy and performance officer at Petroleo Brasileiro; CEO for BG Group in South America; the president of BHP Billiton's aluminium business unit; sales & marketing director at Vale; and being All Logistica's CEO. Mr Silva currently holds non-executive directorships at Compass Group, Altera Infrastructure and Cosan Limited. He is also an advisor to Appian Capital Advisory and HSB Solomon Associates.

PhosAgro has reappointed **Andrey Guryev** as company CEO, a position he has held for the last seven years. His re-appointment was unanimously confirmed at the end of July by a vote of the company's board of directors during a meeting held in absentia. The board also gave approval for Guryev's senior external positions. These include: the presidency of the Russian Association of Fertilizer Producers (RAFP); board membership of the International Fertilizer Association (IFA); membership of the Russian Federation's UNESCO Commission; board membership of the Russian Union of Industrialists and Entrepreneurs; and chairing both the Russia-Argentina and Russia-Brazil Business Councils.

Jari Ponsiluoma is Sandvik Materials Technology's new product manager for its tube business in Europe, the Middle East and Africa (EMEA). The role covers heat exchangers and fertilizer industry applications. Jari will be responsible for attracting new tube industry customers and product development, as well as promoting Sandvik's growth and profitability in the EMEA region.

Jari previously worked for Sandvik for more than a decade, becoming the company's global product manager for its automotive business unit in 2010. In 2018, he left Sandvik to work for Ovako Group for two years – as a product line manager in their powertrain division – before returning to Sandvik earlier in 2020 to take up a role within premium segments.

"It is a great opportunity to be working with Sandvik again. I look forward to reconnecting with my contacts in the industry and developing new strategies to benefit our customers in the tube industry," Ponsiluoma said.

The Sulphur Institute (TSI) has appointed **Ron Olson** as its agronomist. Ron brings to TSI 30 years of experience as an independent consulting agronomist, as well as 15 years with Cargill and The Mosaic Company as R&D manager prior to this. His consulting company works directly with farmers and agricultural retailers, offering custom soil sampling, soil analysis and crop management expertise. The company pioneered the use of precision soil sampling and the conversion of that data into computer maps. Linking these data to GPS/GIS technology allowed the development of crop management programmes capable of maximising economic yields. At Cargill and Mosaic, Ron led the team that developed *MicroEssentials*™, a product which has subsequently become the world's leading commercial sulphur-enhanced fertilizer.

"TSI is delighted with Ron Olson's eagerness to assist with the sulphur agronomy needs of our members", said John Bryant, TSI President. "Ron brings a highly applicable and successful background in sulphur fertilizers. Ron will also readily assist us with our important work on sulphur advocacy and other TSI services."

Ahmed El-Hoshy became OCI's new CEO at the start of August. He replaces **Nassef Sawiris** who has become the Executive Chairman of OCI's board, and will continue to be responsible for OCI's business strategy. El Hoshy was previously the company's chief operating officer. Prior to this, he led OCI's expansion in North America, taking the company from zero capacity in this region in

! 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

SEPTEMBER

14-16

TFI World Fertilizer Conference 2020, WASHINGTON, DC, US
Contact: Valerie Sutton
Fax: (202)-962-0577
Email: vsutton@tfi.org

14-16

CRU Africa Fertilizer Agribusiness Virtual Conference 2020, LONDON, UK
Contact: CRU Events
Chancery House, 53-64 Chancery Lane, London WC2A 1QS
Tel: +44 20 7903 2167
Email: conferences@crugroup.com

OCTOBER

20-22

IFA Crossroads Asia Pacific, SINGAPORE
Contact: IFA Conference Service
49, Avenue d'Iéna, 75116 Paris, France
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

NOVEMBER

2-4

Sulphur and Sulphuric Acid Conference 2020, THE HAGUE, Netherlands
Contact: CRU Events
Tel: +44 20 7903 2167
Email: conferences@crugroup.com

16-18

IFA Strategic Forum, KIGALI, Rwanda
Contact: IFA Conference Service
49, Avenue d'Iéna, 75116 Paris, France
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

MARCH 2021

1-3

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

APRIL

7-9

88th IFA Annual Conference, NEW DELHI, India
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

2011 to its current 5.5 million t/a of fertilizer capacity today. His various senior leadership roles at the company include CEO of OCI Partners and CEO of OCI Americas.

Nassef Sawiris said: “In my new role, I can fully focus on OCI’s strategic direction, and I look forward to working with the team to create long-term value for our shareholders, as we can see a wide array of exciting opportunities ahead that benefit the company, the market and our stakeholders. I also believe this is an opportune moment for the management change: this year marks an important inflection point for the company as we expect to achieve run-rate production across the platform, allowing us to benefit disproportionately from a recovery in the economic cycle.”

In response, Ahmed El-Hoshy said: “I am excited to take on this new role and look forward to continue working alongside Nassef, Hassan and the whole team. We have already built an industry-leading and highly efficient global platform that delivers crucial products to the world. We will continue our focus on operational and commercial excellence and recently bolstered this effort with the appointment of **Bart Voet** as VP Manufacturing to lead our global production platform. Our world-class asset base, led by exceptional employees, is well-positioned to drive value and growth within a framework of ever increasing focus on safety and sustainability.”

Sarfaraz Ahmed Rehman became the new managing director and CEO of Fauji Fertilizer Bin Qasim Ltd (FFBL) over the summer. His appointment was approved following the expiry of the contract of **Lt General Javed Iqbal**, whom he replaces. Mr Rehman is a qualified chartered accountant with senior management experience spanning three decades. He began his career with Unilever in 1983, before progressing to roles in other multinational companies such as Smithkline Beecham, Jardine Matheson/Olayan and PepsiCo.

Sarfaraz was notably CEO of Engro Foods for over six years, having launched the company in 2005. In 2012, he took a sabbatical from Engro to establish the Karachi School for Business and Leadership. Sarfaraz was contracted to Grant Thornton for 2016-17 as an executive coach. He has worked extensively as executive coach and mentor with Careem, Gatron-Novatex, Engro, ICI, Descon, PPL, UBL and City School.

On 6th August, FFBL also appointed **Mohammad Munir Malik** and **Rehan Ahmed** to the company’s board of directors, replacing Maj Gen Abid Rafique (Retd) and Brig Hamad Qadir (Retd) respectively.

John Mansanti has resigned as president and CEO of Crystal Peak Minerals, the company behind the Sevier Playa potassium sulphate (SOP) project in Utah. **Dean Pekeski**, currently vice president of project development, has been appointed interim president and CEO with effect from 31st August. Mr Pekeski has been with the Company since 2015 and has played a key role in the development of the Sevier Playa project.

Although resigning to pursue other business interests, Mr Mansanti has agreed to continue in a consulting position, acting as senior advisor to the board. This will allow Crystal Peak Minerals to still draw on his experience as it develops the Sevier Playa project. Mr Scruggs, Crystal Peak’s board chair, thanked Mr Mansanti for his contribution: “John has been instrumental in driving the development of the Sevier Playa project over the past two and half years. This culminated in the receipt of the Record of Decision in August 2019, the most significant milestone in the Company’s history. We wish John all the best in the future.”

Africa Fertilizer Agribusiness Virtual Conference 2020

Due to the Covid-19 pandemic, CRU Events is convening the 2020 Africa Fertilizer Agribusiness Conference, 14-16 September, as a ground-breaking virtual event for the first time.

The 2020 Africa Fertilizer Agribusiness Conference is the sixth in a series of similar events previously held by CRU in collaboration with the African Fertilizer Agribusiness Partnership (AFAP). These have taken place throughout Africa since 2016, having been hosted by South Africa, Tanzania, Mozambique and Ghana in past years.

A live event – on your desktop

The Covid-19 pandemic has, of course, demanded a different approach to this year's Africa Fertilizer Agribusiness Conference. CRU and AFAP have decided to take the event online for the first time, via an exciting new digital platform. This offers everything you would expect from the previous live events – delivered straight to your desktop.

With Covid-19 changing everyday lives, and the way we do business, the need for fertilizer value chains across Africa to remain connected is as important as ever. For this reason, CRU and AFAP's new online platform will offer you all the capabilities of a live conference on a virtual platform. Discussions, networking and the pursuit of business opportunities will continue to take place – all of this from your computer too.

A collaboration with AFAP

The series of Africa Fertilizer Agribusiness Conferences, which regularly attract hundreds of local and international delegates, are produced by CRU in collaboration with AFAP. Their overall purpose is to promote investment, partnerships and innovation in the African agribusiness sector. The events also offer excellent networking opportunities.

The two organisations have collaborated closely on the new virtual conference. Consequently, the 2020 event combines CRU's global perspective on fertilizer trends and detailed market data, with AFAP's deep understanding and close contact with Africa's fertilizer and agribusiness markets.

Debating the key issues

More than 500 attendees are expected at this year's new and first-of-its-kind virtual event. Debating the key issues affecting the fertilizer and agribusiness industry in Africa will be very much top of the agenda. Topics for discussion will include:

- The impact of the Covid-19 crisis on African agribusinesses and the continent's fertilizer trade
- The view of major fertilizer companies on their supply of inputs to the region
- The outlook for fertilizer production projects across Africa.

The conference provides – at the time it is most needed – insights into the impact of the coronavirus crisis on African health, politics, trade and local economies. Also on the agenda will be wider market and industry issues, in particular:

- Digital solutions for agricultural transformation in the agribusiness supply chain
- Advice for smallholder farmers and SMEs throughout the value chain on how to obtain support to grow their businesses
- An up–to-date overview of fertilizer supply and demand in key African markets.

The event's keynote session will take a deep dive into the essential role played by partnerships and development in ensuring fertilizer supply. This will provide you with unique insights into current African market issues. The session will also explore how the continent's nations can develop their natural resources to support rural development and help grow their agribusiness sectors.

Nicola Coslett, CEO of CRU Events explained: "Our attendees will have the opportunity to safely stay connected and informed, at a time when it is most important that we maintain the progress made towards improving Africa's fertilizer trade and agribusiness development."

What to expect

This year's virtual conference will bring the African fertilizer community together. As with past events, there will be plenty of opportunities to join the experts, take part in interactive panel discussions, discuss the key issues, engage in productive networking and meet with contacts, both old and new. The conference also lets you find all the content you need, flexibly and conveniently, as and when you require it. ■

Conference sessions

- Keynote Session: partnership and development to ensure fertilizer supply
- Global fertilizer leadership perspectives on boosting Africa
- Understanding the new landscape for African fertilizer and agribusiness
- Investing in African fertilizer production and distribution
- Digital solutions for agricultural transformation in the fertilizer and agribusiness supply chain
- Supporting smallholder farmers and SMEs throughout the value chain
- Understanding soil health and the need for specialty fertilizers in Africa
- Expanding African fertilizer production and processing capacity ■

African fertilizer producers and blenders

The last three years has seen a renaissance in fertilizer production and blending in sub-Saharan Africa. We highlight the expansion of capacity in Nigeria and other countries within the region.

EMT's Weighcont blending & bagging system for Glofert, Ghana.

PHOTO: EMT

Fertilizer production in sub-Saharan Africa is restricted to the manufacture of phosphate and nitrogen products – as potash is not mined in the region at present. According to the most recent survey[1], production in the region is concentrated in around 11 plants located in eight countries, excluding South Africa (Figure 1).

Phosphate mining and production

There are five main phosphate mine operators in sub-Saharan Africa, outside of South Africa:

- Industries Chimiques du Senegal (ICS), Taiba, Senegal (> two million t/a mining capacity)
- Société d'Études et de Réalisation des Phosphates (SERPM), Matam, Senegal (25,000 t/a mining capacity)
- Société Nouvelle des Phosphates du Togo (SNPT), Kpeme, Togo (> one million t/a mining capacity)
- Zimbabwe Phosphate Industries Limited (Zimphos), Mutare, Zimbabwe (150,000 t/a mining capacity)
- Minjingu Mines and Fertilizer Limited, Minjingu,Tanzania (100,000 t/a mining capacity)

Additionally, Kel Chemicals manufactures single superphosphate (SSP) using externally purchased phosphate rock at its 200,000 t/a capacity plant in Thika, Kenya. The phosphate rock mine operated by Toguna Agro Industries at Bamako, Mali (300,000 t/a mining capacity) is thought to be inactive.

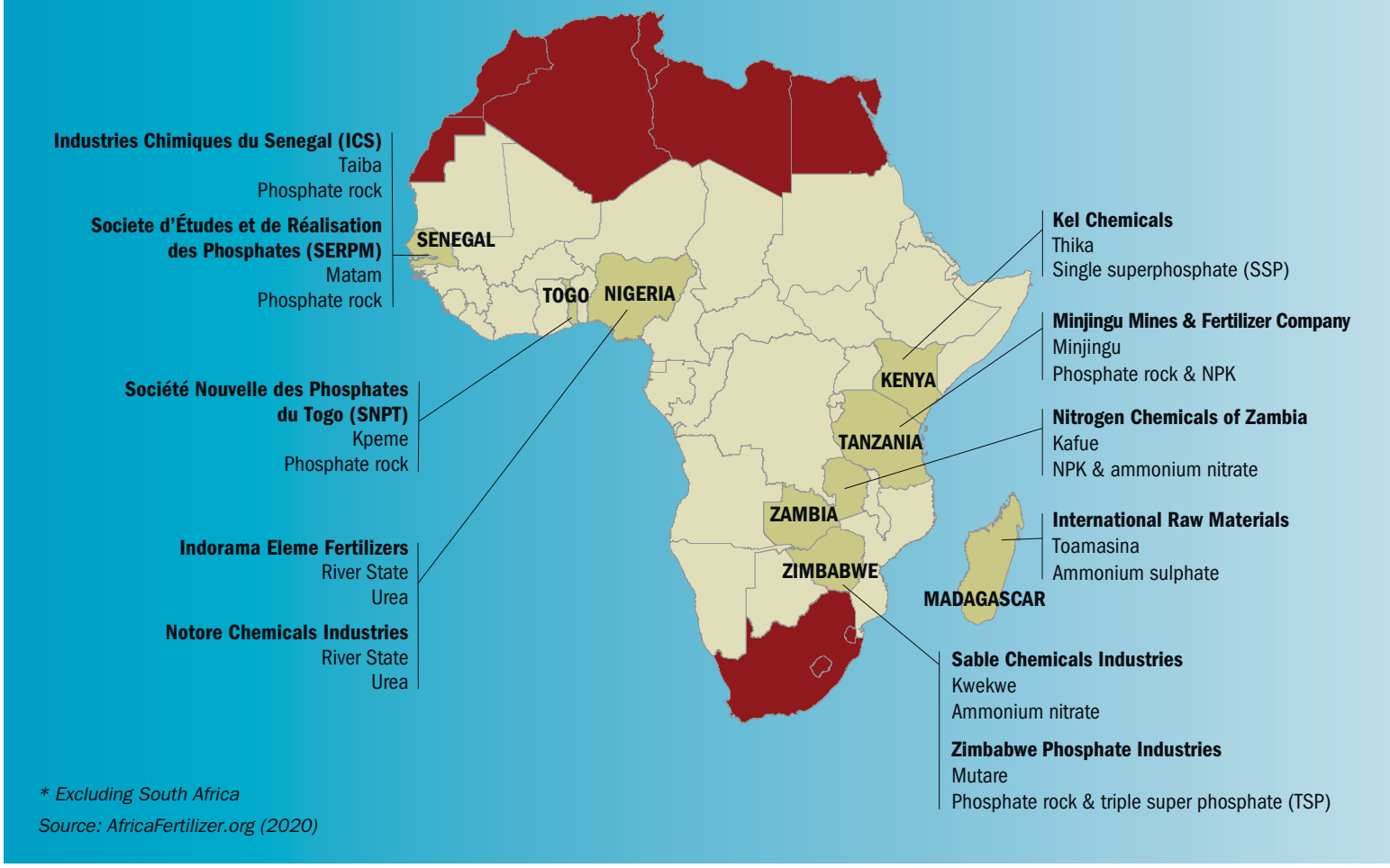
South Africa plus Senegal and Togo in West Africa are major phosphate rock producing countries. They collectively extracted more than 5.6 million tonnes of phosphate rock in 2018, exporting more than half of this amount (Figure 2). The most recent International Fertilizer Association (IFA) statistics suggest that Mali did not produce any phosphate rock in 2018, while production in both Tanzania and Zimbabwe was minor.

Senegal's phosphate reserves of 50 million tonnes are the largest in West Africa. The country produced 2.5 million tonnes of phosphate rock in 2018, one-quarter of which (almost 600,000 tonnes) went for export. The country's phosphate rock and phosphoric acid production is largely targeted at the Indian market. Senegal produced more than one million tonnes of phosphoric acid in 2018, exporting almost 80 percent of this total.

Indorama Group bought a majority stake in **Industries Chimiques du Senegal (ICS)** in August 2014, with a promise to invest $226 million in the Senegalese phosphate producer. The group currently owns 78 percent of ICS, while Indian fertilizer giant IFFCO retains a seven percent share. ICS extracts phosphate rock, manufactures phosphoric acid (600,000 t/a) and has the capacity to produce diammonium phosphate (DAP) and NPK fertilizers (250,000 t/a). A planned second plant at Mbao could eventually see annual fertilizer production capacity rise to one million tonnes.

Togo possesses world-class phosphate reserves of 30 million tonnes. Phosphate mining is of strategic importance to Togo's economy with overseas shipments generating a significant slice of the country's export earnings. Togo's phosphate mines were privatised in 2001 only to be renation-

Fig. 1: **Fertilizer production plants in sub-Saharan Africa***



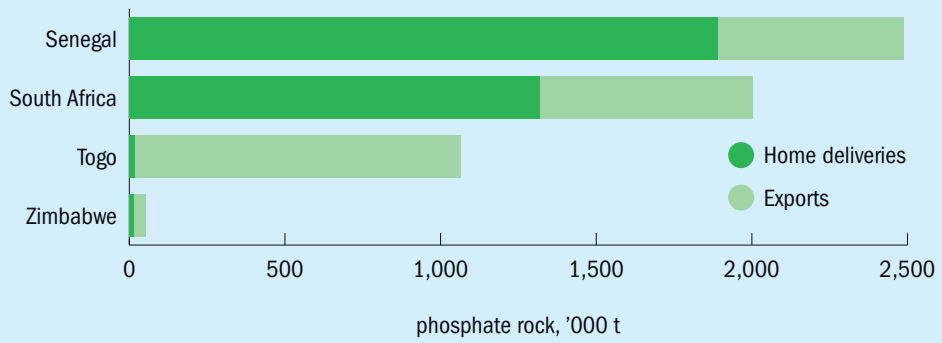
** Excluding South Africa*

Source: AfricaFertilizer.org (2020)

alised as the **Société Nouvelle des Phosphates du Togo (SNPT)** six years later. SNPT's mining and production operations, located in Hahotoe, 35 kilometres east of the capital, Lome, employ around 5,000 workers. The state-owned firm launched a $150 million investment programme in 2010.

SNPT's output has rebounded following the strikes which have seriously affected production in recent years. Togo's phosphate rock production totalled 1.1 million tonnes in 2018 (Figure 2), a 45 percent improvement on 2017. Almost all of the country's rock output is destined for export. Consequently, Togo's phosphate rock exports also recovered strongly in 2018, up by around one-third year-on-year.

Fig. 2: **Sub-Saharan Africa: phosphate rock production (home deliveries plus exports), 2018**



Source: IFA

New phosphate miners

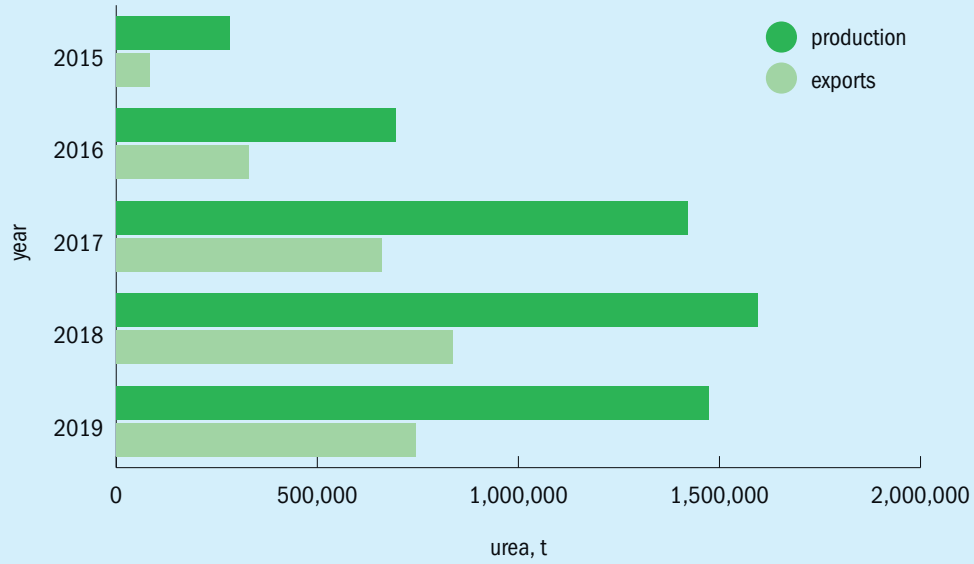
Two junior mining companies began extracting phosphate rock on a small-scale in 2017 – but have struggled to maintain production since then.

Australian developer **Avenira Ltd** made the maiden shipment from its Baboab phosphate project in Senegal in 2017. The company shipped 21,400 tonnes of phosphate rock to India from the Port of Dakar, 145 kilometres west of its Gadde Bissik mine site. However, consistent and large-scale production of high quality rock concentrate was still dependent on full commissioning, ramp-up and debottlenecking of the project's processing plant.

In March last year, Avenira published a feasibility study to increase Baobab's annual production to one million tonnes. Although Avenira had ambitious plans to expand the project, the company ultimately decided to divest from these assets, selling-off Baobab to a consortium of shareholders in July 2019. It is not clear whether the Gadde Bissik mine is producing currently.

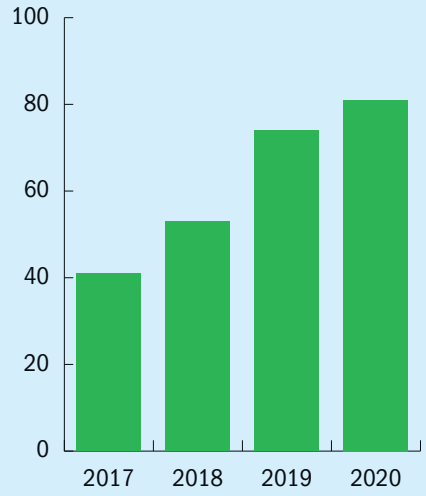
South African mining company **Kropz** is developing what is said to be South Africa's largest sedimentary phosphate deposit at a 5,000 hectare site at Elandsfontein on the country's west coast. The project's first phase involves producing 1.2-1.5 million t/a of high-grade (32% P_2O_5) rock concentrate from a total resource of 250 million tonnes.

Fig. 3: **Nigeria's urea production and exports, 2015-2019**



Source: AfricaFertilizer.org (2020)

Fig. 4: **Growth in NPK blending plants in sub-Saharan Africa*, 2017-2020**



** Excluding South Africa*

Source: AfricaFertilizer.org (2020)

The $120 million Elandsfontein project briefly entered production in 2017 but has ceased operations since. The project's highly automated processing plant, which has the capacity to deliver in excess of one million t/a of phosphate rock concentrate (>31% P_2O_5), is now nearing completion, according to Kropz. Final commissioning is, however, dependent on further test work and design modifications.

Nitrogen fertilizers

Nigeria's Notore Chemicals Industries Limited and Indorama Eleme Fertilizer & Chemicals Limited operate sub-Saharan Africa's two urea plants. Notore's 400,000 t/a capacity urea plant dates from 1988, while Indorama's 1.4 million t/a Port Harcourt urea plant was commissioned in 2016, making the company the largest urea producer in the region.

Following the start-up of Indorama's plant in June 2016, Nigeria's urea production has rocketed from around 280,000 tonnes in 2015 to 1.5 million tonnes last year. Exports over this period have also risen from around 82,000 tonnes to almost three quarters of a million tonnes (Figure 3).

About half of Indorama's urea output is consumed domestically. The remainder is exported to South America, principally Brazil, and neighbouring African countries. Some 84 percent of Nigeria's 840,000 tonnes of urea exports in 2018 was destined for Brazil.

Other plants in the region manufacture ammonium sulphate (AS) and ammonium nitrate (AN) using imported ammonia (Figure 1). These include:

- International Raw Materials' 180,000 t/a capacity AS plant in Madagascar
- Sable Chemicals Industries Limited's 240,000 t/a capacity AN plant in Kweke, Zimbabwe
- Nitrogen Chemicals of Zambia's 64,000 t/a capacity AN plant in Kafue, Zambia.

Nitrogen Chemicals of Zambia also has the capability to manufacture 100,000 t/a of NPKs.

New Nigerian nitrogen plants

Two new world-class nitrogen projects are close to completion in Nigeria, confirming the country's status as a major international production and export hub for urea.

The construction of Africa's biggest fertilizer plant in Edo state in southern Nigeria for **Dangote Group** is almost complete. The plant will comprise of two urea production lines with a capacity of 3,850 t/d each (see box). Combined, these will provide Dangote with an annual urea production capacity of 2.6 million tonnes. **Indorama**, meanwhile, is aiming to complete construction of its second world-scale ammonia-urea production line next year. This second 'Eleme II' line will effectively double urea production capacity at the Port Harcourt complex to 2.8 million t/a (see box).

NPK supply – imports vs domestic blending

Africa represents a sizable and lucrative NPK market. The continent imports more than two million tonnes of various NPK grades annually. Much of this demand is met through tenders which typically total more than 1.7 million tonnes each year.

Africa's NPK tender season usually starts in August and runs until the end of October. Benin, Burkina Faso, Ethiopia and Mali all place major tenders each year – with Ethiopia issuing the largest.

Africa is both a blend and compound NPK market. Higher quality compound NPKs – which are mostly imported – typically enjoy a price premium over blended NPKs. This should provide Africa's blended NPK producers with a cost advantage over imported products. Despite this, NPK imports have traditionally been favoured due to the general lack of in-country blending capacity throughout sub-Saharan Africa. Blending capacity within the region has also only been operating at around 20 percent of installed capacity previously, according to AfricaFertilizer.org.

As a consequence, Africa's NPK import volumes have been growing fast. The size of Ethiopia's NPK tender, for example, has increased by more than 40 percent since the 2015/16 season, reaching 670,000 tonnes in 2018/19. Even this percentage underestimates market growth as – having reduced its tender year-on-year in 2018/2019 – Ethiopia subsequently

PROJECT SPOTLIGHT

Dangote plant in pre-commissioning

Dangote Group's large-scale urea-ammonia plant in Edo State, Nigeria, has finally entered pre-commissioning, the company has confirmed.

The fertilizer plant, located near Lagos on Nigeria's Atlantic seaboard, is just one part of Dangote's massive $12 billion Lekki integrated petrochemical complex. On opening, it will be the largest fertilizer production plant in Africa. The dual-train plant has the capacity to produce 2.6 million t/a of urea and 1.5 million t/a of ammonia.

Italy's Saipem is constructing the plant, being the project's engineering, procurement and supervision contractor. Tata Consulting Engineers of India are acting as project management consultants.

The $2 billion fertilizer project is now in its final stages. Virtually every section of the urea production complex – including the central control room, ammonia and urea bulk storage, cooling tower, power generation plant and granulation plant – is now complete and are going through pre-testing.

The project, which was originally targeting completion in the first quarter of 2018, is being built to the following specification:

- Ammonia plants: 2 x 2,200 t/d based on Haldor Topsoe technology
- Urea melt plants: 2 x 3,850 t/d based on Saipem's Snamprogetti technology
- Urea granulation plants: 2 x 3,850 t/d based on Uhde Fertilizer Technology

Part of the output from Dangote's new urea plant will be dedicated to its expanding farming business. The Group is planning to increase sugar cane and rice cultivation in Nigeria to around 300,000 hectares, raising its annual fertilizer requirement to 150,000 tonnes.

returned with a 50 percent larger tender in 2019/2020. Ethiopia's strong NPK import growth is mirrored by West Africa. Benin's NPK tender, for example, increased from just 40,000 tonnes for the 2015/16 season to 230,000 tonnes in 2018/19.

This reliance on imported NPKs may be about to change, however, thanks to the boom in African fertilizer blending capacity in the last three years. The number of NPK blending plants in sub-Saharan Africa has almost doubled, from 41 at the start of 2017 to 81 by the beginning of this year (Figure 4), according to the latest annual register compiled by AfricaFertilizer.org[1]. This total excludes South Africa.

Almost 70 percent of these NPK blending plants (56) are located in West and Central Africa, the remaining 30 percent of plants (25) being distributed across East and Southern Africa. The plants vary greatly in size with installed capacities ranging from 10-200 tonnes/hour.

African compound NPK production capacity, in contrast, has remained static. The latest sub-Saharan African register includes just six NPK steam granulation plants with a combined capacity of 716,000 t/a, many of these dating from the 1950s and 1960s[1]. All six are located in East and Southern Africa:

- Optichem 2000 Ltd, Blantyre, Malawi (100,000 t/a)
- Minjingu Mines & Fertilizer Ltd, Arusha, Tanzania (100,000 t/a)
- Nitrogen Chemicals of Zambia, Kafue, Zambia (100,000 t/a)
- Zambian Fertilizers Ltd, Lusaka, Zambia (16,000 t/a)
- Windmill Pvt Ltd, Harare, Zimbabwe (200,000 t/a)
- Zimbabwe Fertilizer Co, Harare, Zimbabwe (200,000 t/a).

Nigeria's blending capacity boom

Nigeria has been at the epicentre of the expansion in African blending plant capacity. The country has seen the number of active blending plants increase from just eight at the start of 2017 to 34 by the beginning of this year. Capacity is continuing to rise. AfricaFertilizer.org expects the installation of another 16 plants during 2020 – taking Nigeria's NPK blending plant total to around 50 by the start of 2021.

Most of the 34 currently-active blending plants in Nigeria concentrate on blending NPK 20-10-10 under the country's Presidential Fertilizer Initiative (PFI). These NPK blending plants already provide Nigeria with a total installed capacity of around four million tonnes, according to a 2019 analysis by Argus, well in excess of the country's actual NPK consumption of around 700,000 tonnes each year.

The Nigerian government's ban on NPK imports in 2019 has undoubtedly boosted in-country production of blended products. The ban, which imposed foreign exchange and regulatory controls, was taken in response to oversupply and competition from imported compound NPKs. The ban is specifically designed to protect and encourage Nigeria's bulk blend industry.

The ban has proved successful, having virtually eliminated Nigeria's NPK imports. These declined from almost half a million tonnes in 2017 to less than 2,000 tonnes last year.

The NPK import ban was instigated following pressure from the Fertilizer Producers and Suppliers Association of Nigeria (Fepsan). It argued that an import ban would improve the country's foreign currency reserves, protect the domestic NPK blending industry, and encourage Nigeria's farmers to move away from generic NPK mixtures to customised soil-specific grades.

Yet – despite its apparent success to date – some analysts remain sceptical about the efficacy of Nigeria's NPK import ban and its future.

"Local Nigerian NPK blends are often adulterated, and farmers are willing to pay premia approaching 50 percent for imported NPK compounds," CRU analyst, Glen Kurokawa, commented in January. "The government has problems procuring raw materials for blends due to poor payment terms and delayed payments, leading producers being reluctant to supply."

He added: "Furthermore, blend stocks have been reduced. We expect the ban to be lifted in 2020 and that OCP-sourced NPKs will be allowed into the country once again. We forecast OCP NPK exports to Nigeria rising to nearly 200,000 tonnes in 2020."

Another 30 NPK blending plants are due to be installed in sub-Sharan African

countries by the end of this year. Some 16 of these, as stated above, will be located in Nigeria.

More than half of these new blending plants will be fitted out by just three leading equipment manufacturers: North America's AGI Fertilizer Systems, South African headquartered Bagtech International and Netherlands-based EMT. According to AfricaFertilizer.org[1], in 2020:

- AGI is installing five blending and bagging plants in Nigeria, another in Ghana, and an AGI blend system with a Nectar bagging system in Niger
- Bagtech International is installing a total of six blending and bagging systems in Nigeria
- EMT is installing four proprietary blending and bagging systems – two in Tanzania, one in Angola and another in Rwanda.

These three companies discuss their current activities in sub-Saharan Africa below.

AGI – forward-looking with a long legacy

For over 20 years Yargus Manufacturing, now AGI Fertilizer Systems, has been contributing to the development of fertilizer infrastructure in Africa. The company has been active in Nigeria for more than two decades now, as **Anne Yargus Sheehy**, AGI's director of international business development, explains:

"Yargus first sold its blending & bagging plants into Nigeria in 1997. Those three blending plants consisted of a series of load hoppers that bagged fertilizer could be dumped into – then moved with belt conveyors to a central weigh hopper and eventually fed into a tapered vertical blending systems that fed a single bagging line."

"This system would produce approximately 35 tonnes per hour of blended & bagged product. These plants were installed in three different states and were commissioned by the Nigerian Government.

"We have watched the fertilizer market in Nigeria evolve over the last 23 years. Back then, small batch systems were fulfilling the blending need. Today, there is a greater need for high-speed, automated blending and bagging facilities.

"In 2017, we started to see a strong demand for bigger, faster machines in the exact same regions in Nigeria. The private sector wanted to be in the fertilizer business and the government had made that possible. Speed, accuracy and flexibility are all key factors when designing a new blending facility.

"Three years later, in 2020, we have now sold seven new blending/bagging plants across the agriculture region in Nigeria. Four of the seven have now been installed and commissioned. By 2021, all seven will be installed and commissioned. All of these projects have high-speed, declining weight blend systems feeding into one, two or three bagging lines.

"All these systems are equipped with liquid spray systems, giving customers the ability to add liquid additives & inhibitors. Several of these new plants also have powder feeders giving them the ability to meter small quantities of powder micro nutrients into their blends, in very accurate quantities.

"We continue to receive inquiries on development in Nigeria, with two verbal orders pending final approval."

AGI Fertilizer Systems also recently commissioned a new blending and bagging facility in Ghana, and secured another order in Uganda, as Anne explains:

"This plant will also give our [Ghanaian] customer immense flexibility in their blend analysis, making it possible for them to accurately add liquids and powders to a blend. This plant is also a high speed declining weight blender. It's been fully commissioned and is now supplying the local market via custom blending technology.

"Additionally, we have sold a new plant in Uganda that will be commissioned in the coming months. This is a smaller batch system that will supply custom blends to the growers in Uganda."

Anne is proud of the company's legacy and optimistic about the future:

"AGI Fertilizer Systems has installations across the African continent in Mali, Ethiopia, Kenya, Uganda, Mozambique, South Africa, Mauritius. We can offer engineered and new production plants in many regions of Africa that did not previously have fertilizer blending available, like Ethiopia and Uganda.

Expansion of Indorama's Port Harcourt urea plant in Nigeria will double its capacity.

PHOTO: INDORAMA

PROJECT SPOTLIGHT

Port Harcourt expansion targets 2021

Indorama Eleme Fertiliser and Chemicals Ltd is aiming to complete construction of its second world-scale ammonia-urea production line next year. The second line will effectively double Indorama's urea capacity to 2.8 million t/a at its Port Harcourt complex by duplicating the 1.4 million t/a capacity of the existing line production line.

Indorama secured the $1 billion finance package for the 'Eleme II' project in 2018 from a consortium of banks led by the International Finance Corporation, the investment arm of the World Bank (*Fertilizer International* 485, p10).

The project has been under construction for two years. Bukola Saraki, the president of Nigeria's senate, laid the foundation stone at an official groundbreaking ceremony in July 2018.

Toyo (TEC) was awarded the contract to build the second urea-ammonia line at Port Harcourt, replicating its work on the original production line. Toyo is also the urea technology licensor (*ACES21®) for* Eleme II, as well as being responsible for the project's basic design, detail engineering, procurement and commissioning services. KBR will provide the technology licensing, basic engineering design, proprietary equipment and the catalyst for Port Harcourt's second ammonia plant. ■

The AGI/Yargus declining weight blender is a popular choice in Nigerian projects.

"We can provide a complete fertilizer handling solution that will help diagnose fertilizer requirements for various regions and improve fertilizer blend formulations specific for the soil and crops."

EMT's Africa-wide projects

Netherlands-based fertilizer blending and bagging equipment, manufacturer EMT has been heavily involved in the development of the African fertilizer industry. The Netherlands-based company has a long list of references, as managing director, **Gustaaf Zeeman**, explains:

"In total we have installed more than 460 projects in over 70 countries worldwide. The company has exported to more than 20 African countries in previous years.

"One of the most recent larger installations on the continent has been a *Weighcont Continuous Blender Line* with small bag bagging lines. The company Glofert has invested in a machine line with a capacity of 80 tons per hour (see photo). With its machine installation, Glofert can continuously produce blends and bag the fertilizer through two bagging lines, each of 40 tonnes per hour.

"The company is a local Ghanaian business that is directly selling fertilizer to their local distributors. Ghana has a strong presence of fertilizer blenders with EMT equipment, including LDC-Chemico and Yara. In fact, we recently expanded Yara's blending facility with a new machine installation."

EMT has been very active across Africa, Gustaaf adds:

"Analysing the African market as a whole, we can see Ethiopia as a big investor, with EMT blender and bagging lines installed at four different locations. But, of all the sub-Saharan countries, South Africa has the highest number of companies running EMT equipment. Having said that, Angola, Botswana, Cameroon, Ivory Coast, Malawi, Nigeria, Togo and Zimbabwe also have local companies running our blending and bagging equipment.

"In the African market, there's a constant need to develop the agricultural sector further. We are incredibly busy right now. Currently, we have EMT installation projects in Rwanda, Burkina Faso, Mali and Nigeria – all running at the same time!"

EMT's equipment has the ability to coat fertilizers. This is becoming a valuable requirement, both in the African market and elsewhere, concludes Gustaaf:

"A new and upcoming development, both inside and outside Africa, is the coating of urea and/or blended fertilizers. Almost all of EMT's blending equipment can add liquids to impregnate urea, for example, within the same machine line. We've also developed standalone coating units which focus solely on coating one type of fertilizer – usually urea with an inhibitor."

Shamrock drum blender installed for a customer in Angola.

Bagtech International – Africa's local leader

Bagtech International is a highly successful bagging and blending equipment supplier and bulk material processing service provider based in Durban, South African

In 2018, the company installed the highest capacity continuous fertiliser blending plant in Africa, capable of blending at up to 200 tonnes per hour and bagging out at up to 240 tonnes per hour. The project was commissioned by Hoopstad-based fertilizer company Westfert in South Africa's Free State. Hoopstad is at the heart of country's richest maize producing region. Bagtech completed this installation in collaboration with automation specialists Festo.

The company is extremely active throughout Africa, currently, as **Fred Coelho**, Bagtech's CEO and founder, explains:

"As well as selling the largest blending plant in Africa to Westfert, we have sold 15 to 20 complete NPK blending plants in Southern Africa. That includes sales to leading companies such as Yara, Gavilon, Omnia Fertilizers and TWK.

"Outside of South Africa, we've sold a plant to Angola, our first plant there, one for Tanzania and another one for Zimbabwe. Earlier this year, we also commissioned two large blending plants in Nigeria for major companies – one in Lagos and another one in Kaduna. On top of that, we have two very large plants waiting to be installed for another big company in Nigeria.

"We also have a plant in Nigeria running in Kebbi near Abuja. This was our first plant in Nigeria. We now have a very strong infrastructure in Nigeria, with 100 percent local support – and our people there will be key in expanding in West Africa as well.

"In East Africa, we sold a plant to Toyota Tsusho about three years ago, after they visited our competitors in Europe and the United States."

Bagtech is expanding outside of Africa too – into Latin America and other international markets, as Fred makes clear:

"We have just sold our first NPK blender in Brazil. We are also about to close a deal for a very special blender to Thailand and are seriously looking to expand into Southeast Asia."

References

1. AfricaFertilizer.org, 2020. *Register of Fertilizer Manufacturing & Processing Facilities in Sub-Saharan Africa*. AfricaFertilizer.org, February 2020.

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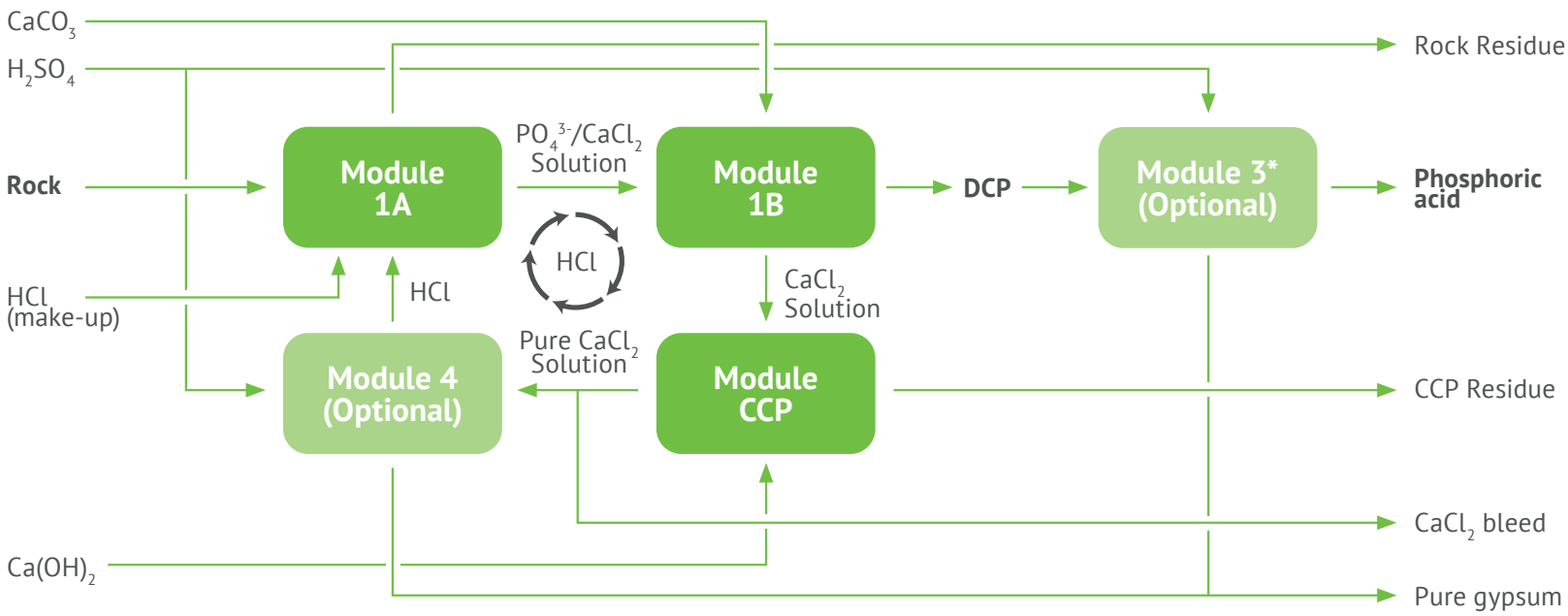
PHOSPHATE PRODUCTION PROCESS

LOW-GRADE RAW-MATERIALS | **HIGH QUALITY PRODUCTS** | **ENVIRONMENTAL FRIENDLY** PROCESS | **MODULAR** TECHNOLOGY



Calcium phosphate and/or phosphoric acid production through HCl route
** Prayon phosphoric acid technology*

USE OF LOW GRADE ROCK

Low P_2O_5

High organics content

High heavy metals content

High Al/Fe content

FLEXIBILITY OF ACIDIC SOURCES

Hydrochloric acid

Sulfuric acid

PRODUCING HIGH QUALITY PRODUCTS

Pure DCP that can be converted in various phosphate products (phosphoric acid and derivates) and address different markets: animal feed, fertilizer, technical...

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Medical cannabis cultivation

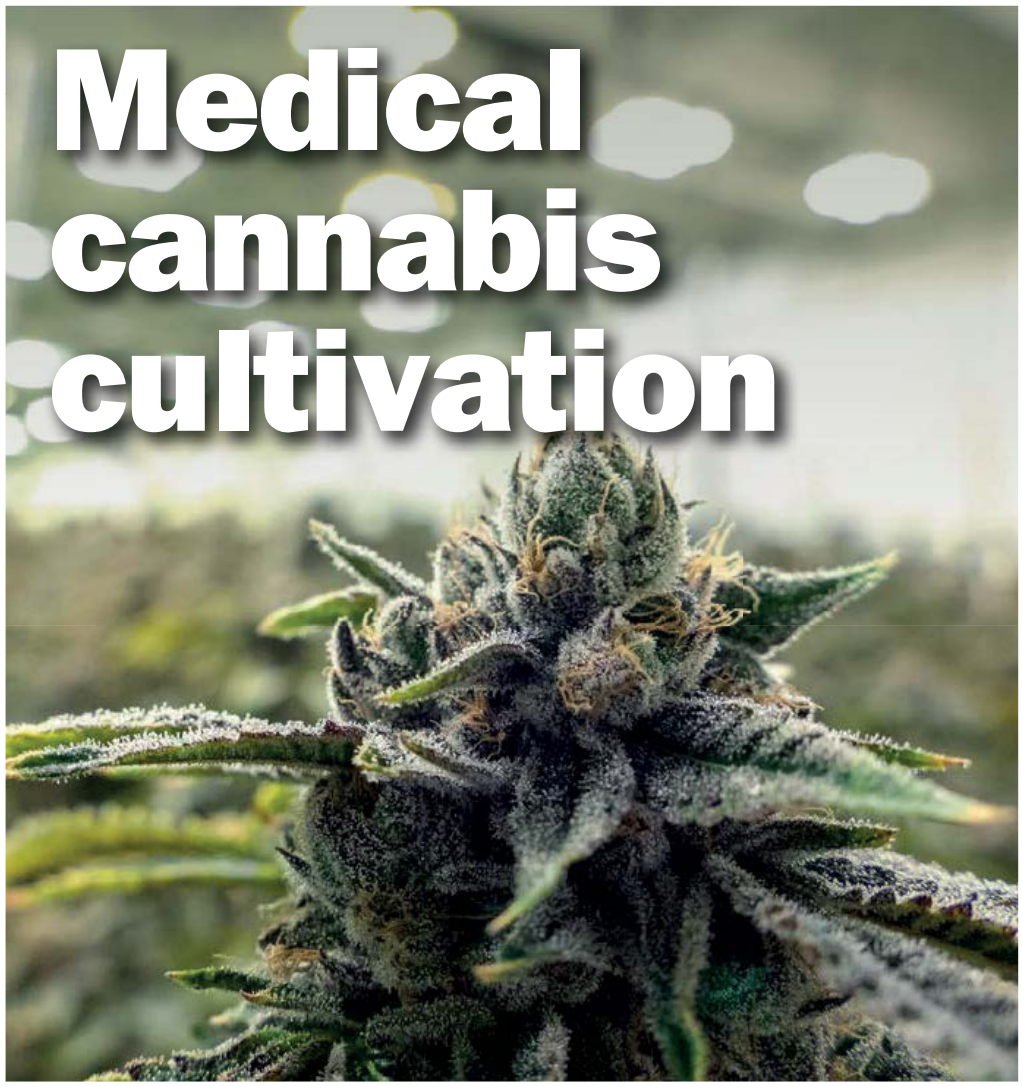


PHOTO: DEPOSITPHOTOS

Left: Commercially-grown cannabis plant cultivated for the medicinal market.

The commercial production of cannabis for medicinal purposes is expanding rapidly. This burgeoning market is opening up new opportunities for growers and fertilizer producers alike. **Avishai Schneider**, market development agronomist at Haifa Group, offers his advice for successful fertilization of this sensitive and difficult to grow crop.

The commercial cultivation of medical cannabis (*Cannabis sativa L.*) is a fast developing farming niche. The crop is cultivated mainly for its female flowers. These are rich in commercially-valuable cannabinoid compounds – mainly cannabidiol (CBD) and tetrahydrocannabinol (THC) – with desirable therapeutic properties.

Large-scale commercial production of medical cannabis generally requires supervised cultivation in a regulated, closely-controlled environment – typically in greenhouses and soil-less systems. Balanced crop nutrition is also a prerequisite for successful cultivation. In cannabis growing, a carefully calibrated supply of plant nutrients is essential if the desired crop yield and crop quality are to be achieved. The use of high-quality fertilizers is also a must – as part of the precision fertilization programme needed to achieve high yields.

Plant nutrition and cannabinoids content

The amount of academic research with hard scientific evidence on the best growing conditions for medical cannabis is still limited. This has meant that – out of necessity – most protocols for crop cultivation are based on growers' experience. Only recently has reliable evidence and useful publicly-available information started to emerge and accumulate.

Nevertheless, recent studies have begun to shed light on how different plant nutrient (fertilization) regimes can influence the content of commercially-valuable compounds found in cannabis flower buds and leaves. Initial studies suggest that these desirable active compounds are, in fact, secondary metabolites produced when the plant is under stress.

Some preliminary research, for example, has shown that potassium deficiency increases cannabinoid concentration in cannabis flower buds. Similarly, it has been discovered that excess nitrogen levels can lead to a reduction in THC content, and therefore should be avoided during the latter stages of crop development.

Despite such improvements in agronomic knowledge, the scientific understanding of the relationship between nutrient availability and the levels of active compounds found in cannabis plants is still in its infancy. The evidence that is available therefore requires cautious and careful consideration when planning nutrition programmes for cannabis.

In growers practice, the underlying assumption is that it is desirable to maximize flower bud yield – as long as THC and CBD contents stay within their regulatory limits. Overall, therefore, the aim of a nutritional programme for cannabis is to achieve maximum yield, while at the same time ensuring appropriate concentrations of THC and CBD.

When designing a fertilization programme, the following key points need to be considered:

- Crop requirements
- The efficient and accurate supply of nutrients
- Knowing your hybrid
- Choosing the right fertilizers.

Each one of these vital points is discussed in turn below.

Crop requirements

The growth cycle of the cannabis plant is divided into two main stages – an initial vegetative growth phase followed by a flowering phase when the plant develops flower buds. Each of these two main stages can be further divided into sub-stages.

The **vegetative growth stage** starts after the establishment of rooted cuttings in the growing substrate. During this stage, by cultivating in a controlled environment, plants are given exposure to long daylight hours (16-24 hours) to induce vigorous vegetative growth.

The vegetative stage is critical because it determines the plant's strength and health, subsequently affecting its ability to produce flower buds and, importantly, the quality of these buds. Nutrient requirements at this stage are high – especially for nitrogen and potassium – as good supply is necessary to support rapid plant growth.

The **flowering stage** is induced when daylight time shortens to 10-12 hours. This phase is divided into three physiological sub-stages, namely:

- Bud formation
- Bud sizing
- The finishing stage – the time when the flower buds reach maturity and are ready for harvesting.

The flowering stage is critical in determining both crop quantity (yield) and quality. Nutrient supply during flowering directly influences both bud formation and development. At this stage, the nitrogen-to-potassium ratio should favour potassium (N:K < 1). Phosphorus should also be supplied carefully, as excess phosphorus in the feeding solution may induce iron, magnesium and calcium deficiencies.

To maintain optimal conditions for nutrient uptake, nutrient solutions must be maintained at pH 5-6.5. Around 20-30 percent of the drainage of irrigation water should also be kept within the system to prevent the high build-up of salinity. It is also important to continuously monitor both electrical conductivity (EC) and pH of the irrigation water and drainage water.

While cannabis plants are heavy consumers of nitrogen during the early stages of their vegetative development, excessive nitrogen levels – as mentioned above – can lead to an undesirable reduction in THC content and should therefore be avoided during later plant development stages.

During continuous fertilization, the target concentration of phosphorus (P) is between 25-35 ppm. Lower P levels will result in retarded growth, while the minor benefit from higher P levels does not justify the extra cost incurred.

Potassium (K), calcium (Ca) and magnesium (Mg) are all nutrients consumed by cannabis plants in large quantities. A nutrition solution that keeps to a K:Ca:Mg ratio of 4:2:1 is recommended to avoid antagonisms. The application concentration for these three nutrients should be around 200 ppm K, 100 ppm Ca and 50 ppm Mg.

Efficient and accurate supply of nutrients

A typical A, B and C tank system should be employed to apply the fertilization programme. This system includes two tanks for the fertilization formulae – the A tank for the fertilizers containing phosphorus, the B tank for the calcium and magnesium fertilizers – and a C tank for the acids used to adjust the pH of the irrigation water.

Dividing the water-soluble fertilizers between separate tanks overcomes nutrient incompatibility problems. Nutrient availability and solubility are negatively affected when solutions of two incompatible products are mixed and react to form insoluble compounds. This is to be avoided.

One example of an incompatibility happens when sulphur-containing fertilizers are co-dissolved with phosphoric fertilizers in the same tank. The resulting precipitation of insoluble gypsum (calcium sulphate) can clog drip lines and emitters, as well as making nutrients unavailable for plant uptake. However, the concentration of dissolved nutrients determines whether this precipitation reaction takes place and the severity of its effects. It may not occur or be a major issue, for example, in dilute liquid feeds.

Generally in a tank mix, the compositional formula for calcium and magnesium needs to kept constant throughout, while the N:P:K composition needs to be adjusted during the course of cultivation, according to the growth stage and cannabis crop demands.

Know your hybrid

A large variety of cannabis hybrids are grown commercially for medical purposes, with each hybrid potentially having different nutritional requirements. The nutritional programme must therefore be adjusted and tailored to match the hybrid's specific nutrient needs.

Additionally, with each cannabis hybrid, nutrient deficiency symptoms may not develop in quite the same way and can also look slightly different. Leaf tissue analyses and systematic tests – such as monitoring and comparing the nutrient content in irrigation and drainage water – are therefore necessary to adjust the nutrient programme for a specific cannabis plant variety. Such adjustments must be supervised and carried out with great care. Because of this, Haifa generally recommends that growers consult a crop nutrition specialist before making before any changes to the fertilization programme.

Choosing the right fertilizers

Only compositionally pure, high-quality and specially-formulated fertilizers are recommended for cannabis cultivation to ensure a proper and adequate supply of plant nutrients. Fertilizer product quality is important as the introduction of potentially harmful elements such as heavy metals needs to be avoided.

The high-quality water-soluble fertilizers offered to medical cannabis growers by Haifa Group ensure that the nutrient levels needed by the crop are precisely maintained. It is particularly crucial to supply a well-balanced and complete range of plant nutrients. This should include adequate amounts of micronutrients, in addition to the supply of major elements at a precise N:P:K ratio.

Importantly, unlike standard fertilizers used in traditional agriculture, the fertilizers applied to medical cannabis must be fully water-soluble, extremely low in heavy metals, and virtually free of chloride, sodium and other elements that are detrimental for plants.

Haifa Group, a leading and expert provider of specialty fertilizers, has taken cannabis crop nutrition to the next level by developing a precise methodology and crop nutrition solutions for cannabis cultivation. Haifa's overall approach to cannabis crop nutrient management builds on the company's extensive global experience in horticultural crop nutrition. Analysing and meeting the plant's nutrient requirements, in the most efficient and accurate method, is always the prime objective.

Haifa *Nutrient*™, a sophisticated online software package developed by Haifa Group, offers growers a powerful tool for planning irrigation schemes and fertigation (nutrigation) programmes for medical cannabis and many other crops. The software is available free of charge on the company's website. ■

Southeast Asia's fertilizer market

PHOTO: DOLPHFYN/SHUTTERSTOCK.COM

Left: Oil palm fruit is harvested extensively in Indonesia and Malaysia.

The two agricultural products most strongly associated with the economies of Southeast Asia are the food staple rice and export commodity palm oil. We explore the link between the region's agricultural productivity and its fertilizer consumption.

Southeast Asia is a dynamic and diverse region, economically, culturally and geographically. This cluster of mainland and island nations is strategically located at the crossroads between Asia's two competing giants, China to the east and India to the west.

To enhance their economic clout and international influence, 10 regional countries – Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam – form the Association of Southeast Asian Nations (ASEAN), an intergovernmental alliance that dates back to 1967.

Southeast Asia has been a rising star of the world economy over the last two decades, establishing itself as an economic stalwart that contributes six percent to global GDP. Since the start of the millennium, the region has powered ahead with robust annual economic growth averaging almost five percent.

While the rise of 'Factory Asia' has made Southeast Asia an influential player in world manufacturing, the region is also responsible for nine percent of global agricultural production.

Rice cultivation remains the region's central farming activity – its production in Southeast Asia delivering more value than any other agricultural commodity. The importance of rice revenues for the region is on the wane, however, declining from 40 percent of total agricultural production value in the early 1990s to close to 30 percent by the early part of the last decade.

The relative decline in rice revenues has been driven by the increasing contribution that palm oil – a much higher value product – makes to agricultural production in the region. This shift towards palm oil – which has crowded out rice and other types of crop production – has been most pronounced in Malaysia. The Philippines, meanwhile, has bucked this trend, being the only Southeast Asian country where rice's production value has increased.

In the following article, we concentrate on the fertilizer market in five leading Southeast Asian nations – Indonesia, Malaysia, Philippines Thailand and Vietnam. These countries collectively provide a lucrative 35 million tonne market for fertilizer products annually – with more than 60 percent of this requirement coming from imports (Figure 1).

Agricultural overview

Rice remains Southeast Asia's main crop, in terms of both cultivated area and production (Figures 2 and 3). The region produced well in excess of 150 million tonnes of rice in 2017. With the exception of Malaysia, maize is the other most commonly cultivated cereal. The starchy root vegetable cassava is also widely grown regionally as a carbohydrate food staple.

Oil palm plantations are central to both Malaysia's and Indonesia's agricultural economies and the global production of crude palm oil (CPO). Together, the two countries have a pre-eminent market position, collectively producing 85-90 percent of the world's palm oil. The scale of the industry is enormous. Plantations in Indonesia and Malaysia – covering 10.6 million hectares and 5.8 million hectares, respectively – produced 63 million tonnes of palm oil in 2017.

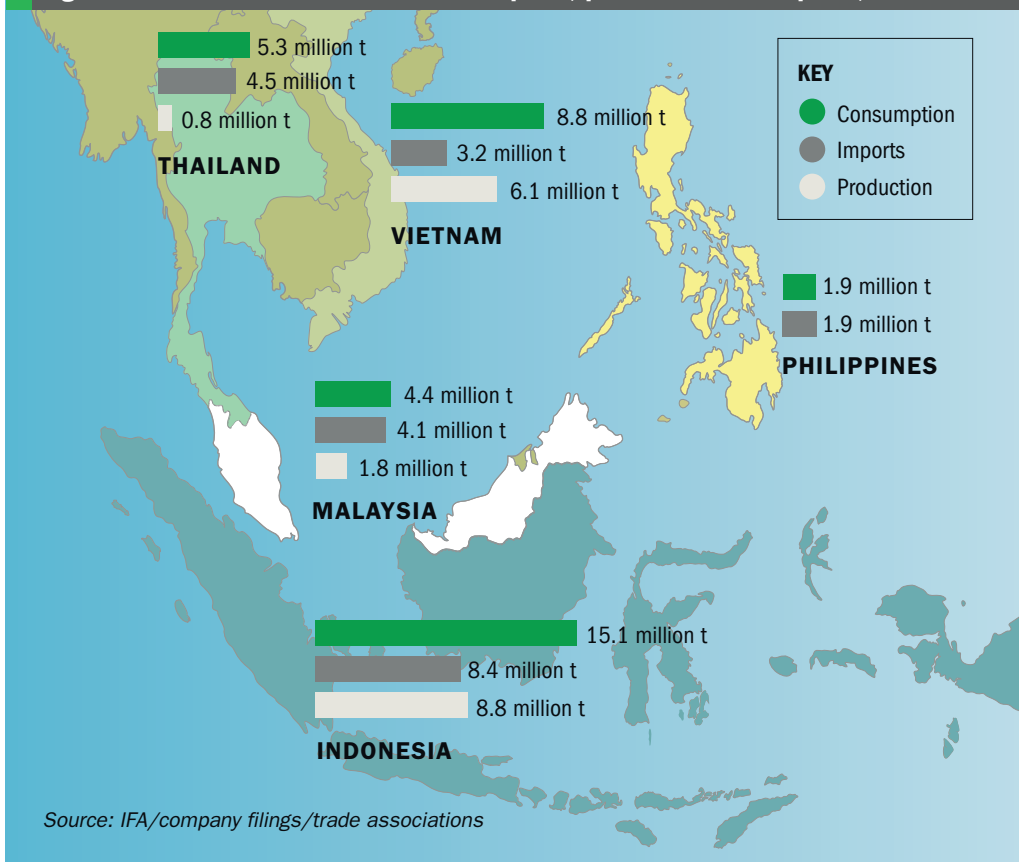
Around 70 percent of Indonesia's oil palm plantations are located on the island of Sumatra, while the remaining 30 percent are situated in Kalimantan on the island of Borneo. The 26.4 million tonnes of COP exported by Indonesia in 2014, generated a massive $15.4 billion in export revenues. China, India, Pakistan, Malaysia and the Netherlands were the main export destinations.

The scale of oil palm cultivation makes plantation owners key end-users in the Southeast Asian fertilizer market, given that consumption by oil palm accounts for two-fifths of Indonesian fertilizer use and four-fifths of Malaysian fertilizer consumption. Urea, superphosphate, rock phosphate, ammonium sulphate (AS), muriate of potash (MOP) and kieserite are the main fertilizers used on oil palm plantations. Compound or blended NPK, NP, and PK fertilizers are also applied (*Fertilizer International* 479, p14). Oil palm fertilizer applications are heavily skewed towards potash, making both countries key destinations for major European and Canadian MOP exporters.

Both Thailand and Indonesia are world-leading producers of natural rubber, producing 4.9 million tonnes and 3.6 million tonnes respectively in 2017 (Figure 3). Large rubber plantations covering some 3-4 million hectares are a notable feature of both countries (Figure 2). Indonesia and the Philippines, meanwhile, both grow bananas – another plantation crop – on a large scale, producing 7.3 million tonnes and 9.2 million tonnes, respectively, in 2017.

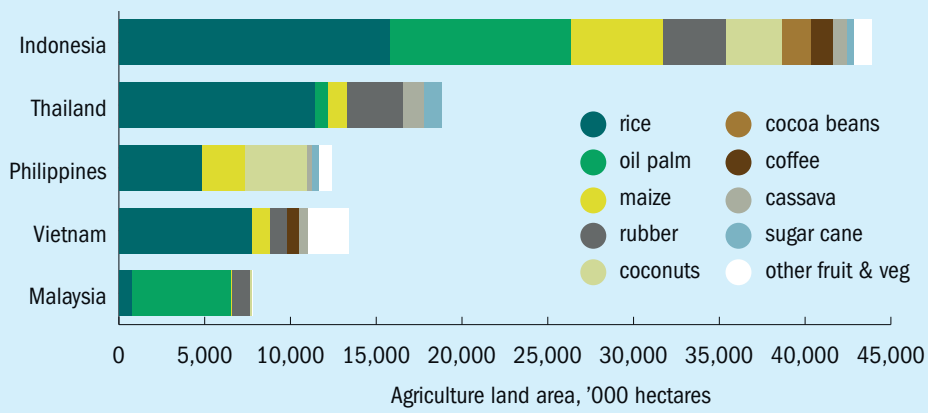
Commercial coconut production is also highly concentrated in Southeast Asia, with the Philippines and Indonesia combined accounting for around three-quarters of global copra production. Indonesia is the world's top coconut producer, while the Philippines is the largest coconut exporting country globally. Both countries dedicate more than three million hectares of their land area to this major tree crop (Figure 2).

Fig. 1: **Southeast Asia: fertilizer consumption, production and imports, 2018**



Source: IFA/company filings/trade associations

Fig. 2: **Southeast Asia: cultivated area of main cash crops, 2017**



Source: FAOSTAT/government agencies

Indonesia – with almost 44 million hectares devoted to growing crops – is Southeast Asia's agricultural powerhouse. The scale of cultivation on this vast archipelago allows Indonesia to easily out-produce its regional neighbours when it comes to rice, palm oil and maize. It is the most agriculturally diverse country in the region too, growing and producing cassava, bananas, coconuts, mangoes, oranges and sugarcane at scale. Malaysia – due to a dominance of rice growing and plantation crops (oil palm and rubber) – arguably has the region's least diversified agricultural sector (Figures 2 and 3).

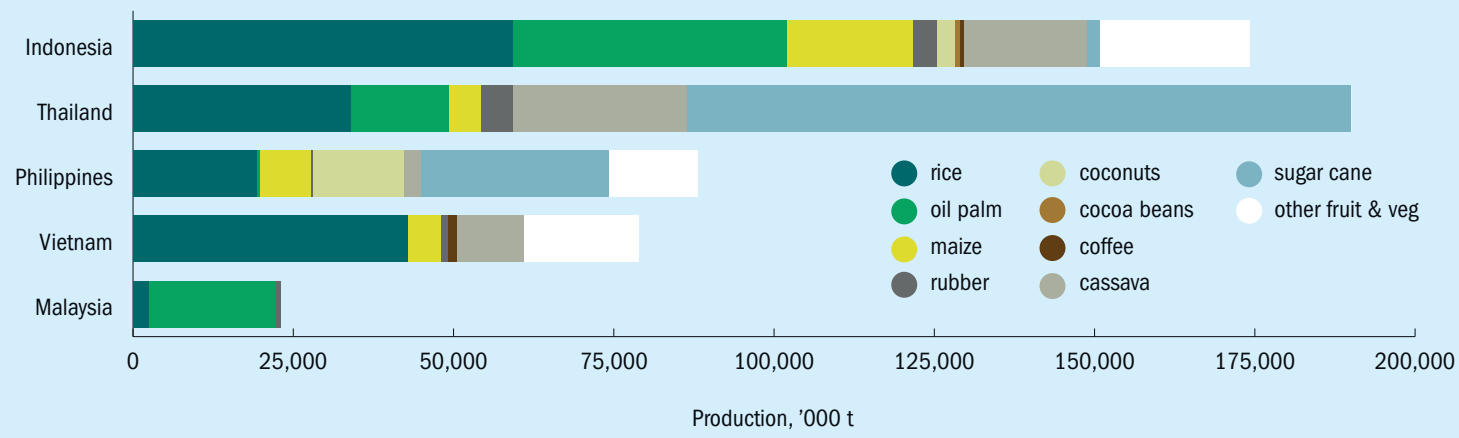
Indonesia

Indonesia is the world's largest producer of cloves and cinnamon, as well as being among the world's top producers of natural rubber, cassava, coconut oil and nutmeg. Additionally, the country is a major producer of coffee, cocoa, rice, tobacco and tea.

Indonesia is the world's fifth-largest fertilizer market, according to the International Fertilizer Association (IFA), accounting for around three percent of total global consumption. The country's domestic fertilizer demand more than doubled between 2000 and 2012 and currently stands at around 15-16 million tonnes (Figure 4).

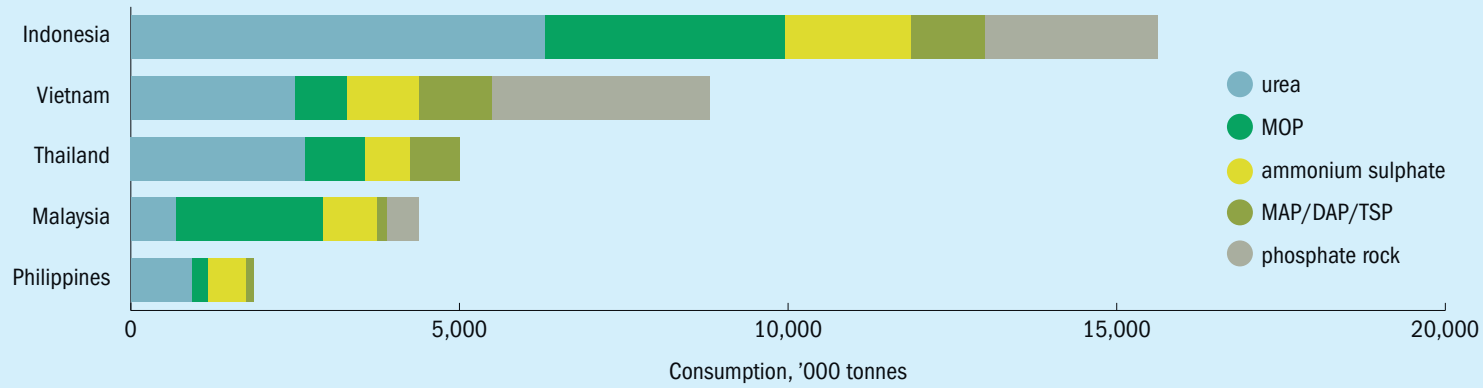
Oil palm is the country's main fertilizer-consuming crop, accounting for two-fifths of Indonesia's total fertilizer consumption – this share having risen quickly in tandem with the fast expansion of oil palm plantations. Cereals, mostly rice supplemented by maize, are responsible for another two-fifths of domestic fertilizer applications (Figure 5). Applications rates for major crops are shown in Table 1.

Fig. 3: **Southeast Asia: production of main cash crops, 2017**



Source: FAOSTAT/government agencies

Fig. 4: **Southeast Asia: fertilizer consumption, 2018**



Source: IFA/company filings/trade associations

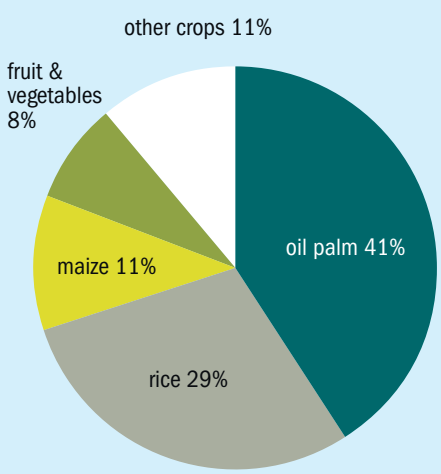
Indonesia consumes 15-16 million tonnes of fertilizer annually. Urea, NPKs and potash are preferred products, accounting for around three-quarters of total consumption (Figure 6). Phosphorus requirements are met through the use of direct application phosphate rock (DAPR) and superphosphate. DAPR is valued by Indonesian (and Malaysian) oil palm growers as a soluble phosphorus source, particularly during the establishment of younger palms. The country's high demand for DAPR is met through the import of 2.6 million tonnes of phosphate rock annually (Figure 7). Rock is also used as a raw material in NPK blends.

Table 1: **Indonesia: straight fertilizer applications rates for major crops**

	Application rate (kg/ha)			
Crop	**Urea**	**Superphosphate (SP-36)**	**Potash**	**Kieserite**
Sugar cane	800	200	200	
Maize	400	150	75	
Paddy rice	300	125	75	
Rubber	165	125	145	
Oil palm	0.9	2.3	2.4	1

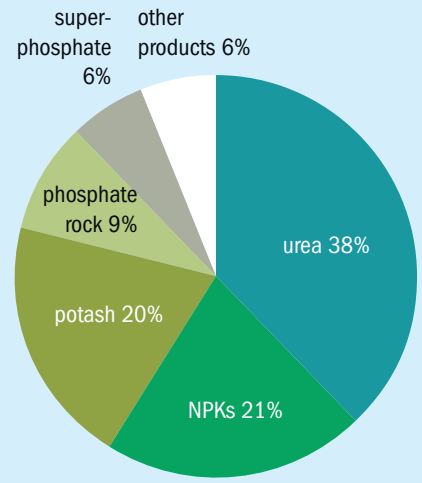
Source: Pupuk Indonesia

Fig. 5: **Indonesia: fertilizer use by crop, 2014**



Source: IFA

Fig. 6: **Indonesia: fertilizer use by product, 2016**



Source: IFA

Domestic product consumption in 2018 (15.1 million tonnes) was as follows, based on Pupuk Indonesia estimates:

- Urea: 6.7 million tonnes
- NPKs: 2.9 million tonnes
- Ammonium sulphate (AS): 1.1 million tonnes
- Superphosphate (*SP-36*): 0.9 million tonnes.

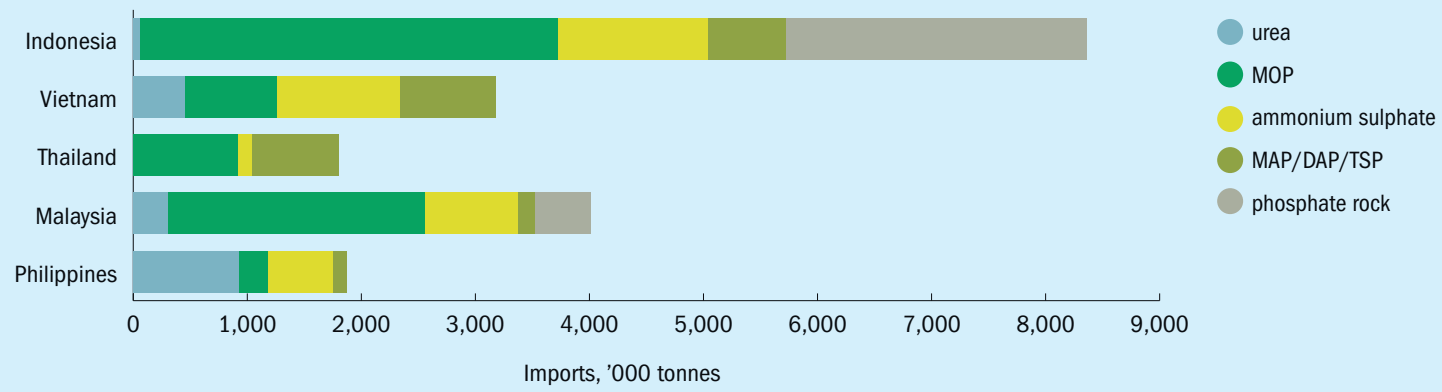
Indonesia consumes more than six million tonnes of urea annually almost half of regional urea demand, and is far and away Southeast Asia's largest urea consumer. Thailand and Vietnam are also significant urea consumers, each having annual requirements in excess of two million tonnes, while more moderate consumption levels are typical of Malaysia and the Philippines (Figure 4).

Indonesia is a major fertilizer producer (Figure 8). The country's nitrogen industry is the largest in the region by some margin – an unsurprising fact given the size and maturity of its oil and gas industry. State-owned holding company Pupuk Indonesia is a large-scale manufacturer of ammonia, urea, NPKs and superphosphate. Its production base is distributed across five main sites on Sumatra, Java, and on the east coast of Kalimantan, Borneo (*Fertilizer International* 486, p34):

- PT Pupuk Kalimantan Timur (Kaltim), Borneo
- PT Petrokimia Gresik, East Java
- PT Pupuk Kujang, West Java
- PT Pupuk Sriwidjaja Palembang (Pusri), south Sumatra
- PT Pupuk Iskandar Muda (PIM), north Sumatra.

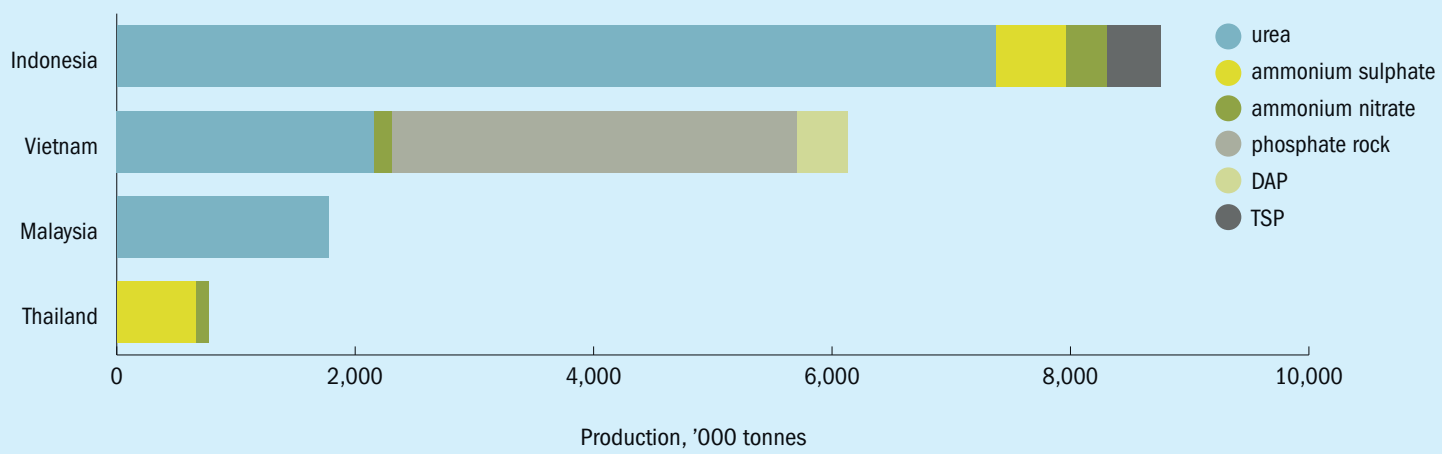
In 2018, Indonesia manufactured 9.3 million tonnes of urea – for both fertilizer and industrial use – together with 3.1 million tonnes of NPKs, according to Pupuk Indonesia. Indone-

Fig. 7: **Southeast Asia: fertilizer imports, 2018**



Source: IFA/company filings/trade associations

Fig. 8: **Southeast Asia: fertilizer production, 2018**



Source: IFA/company filings/trade associations

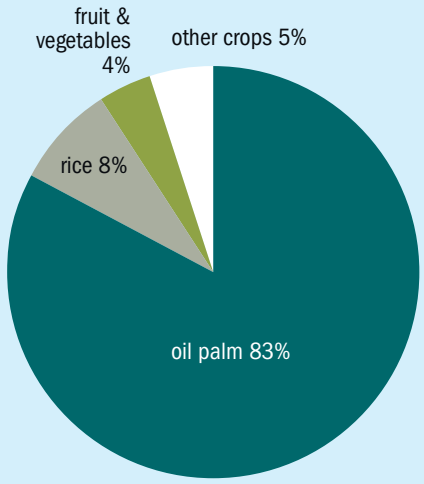
sia is more than self-sufficient in urea, exporting a 1.1 million tonne surplus in 2018.

The country does, however, rely entirely on imports to fulfil its potash requirements. These totalled 3.7 million tonnes in 2018. Muriate of potash (MOP, KCl) imports have expanded nearly three-fold since 2005, making the country the world's fifth largest MOP importer.

Malaysia

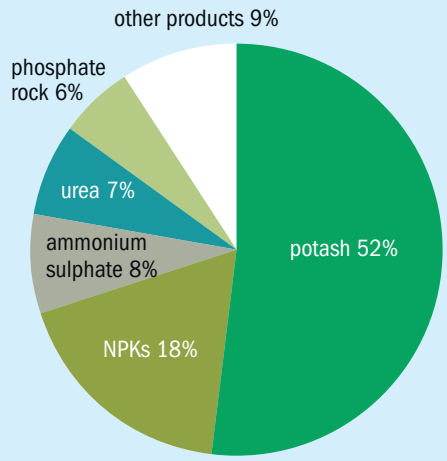
Malaysia cultivates crops over a land area of around eight million hectares. Malaysian agriculture is less diverse than in neighbouring countries with large tracts of land devoted to oil palm and rubber plantations (Figure 2). Rice is the country's main cereal crop and is also grown at scale. Agricultural output is focussed on these three principal crops with Malaysia producing 20.0 million tonnes, 2.4 million tonnes and 0.7 million

Fig. 9: **Malaysia: fertilizer use by crop, 2014**



Source: IFA

Fig. 10: **Malaysia: fertilizer use by product, 2016**



Source: IFA

tonnes of palm oil, rice and rubber, respectively, in 2018 (Figure 3). Coconut, banana, cocoa, pepper, mango coffee, sugarcane and tobacco are also grown commercially, although cultivation of many of these has declined over the last decade.

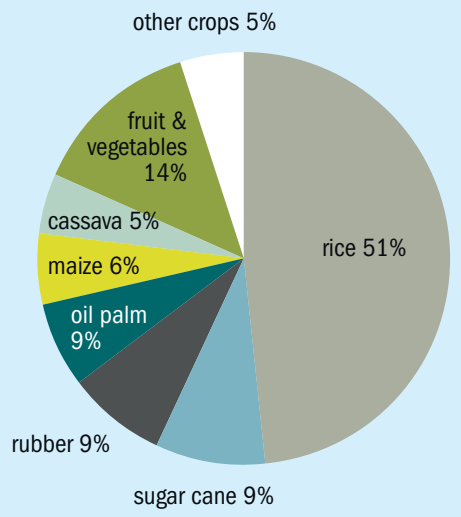
Oil palm accounts for more than fourth-fifths of fertilizer use in Malaysia – unsurprising, given the predominance of oil palm plantations – with rice consuming another eight percent of domestically-applied fertilizers (Figure 9). Potash alone accounts for more than 50 percent of Malaysian fertilizer consumption, making MOP the country's main product preference. NPKs, ammonium sulphate and urea are also popular products with Malaysian farmers (Figure 10).

The Malaysia fertilizer market has varied between 5.0-5.5 million tonnes in recent years (Figure 4). Fertilizer consumption is highly import dependent with the country importing, on average, around four million tonnes of fertilizers annually (Figure 7). MOP is imported in large volumes (2.2 million tonnes), as is ammonium sulphate (0.8 million tonnes) and phosphate rock (0.5 million tonnes).

Malaysia does, however, benefit from a large export-oriented nitrogen industry. The country produced 1.8 million tonnes of urea in 2018 (Figure 8) – exporting almost 80 percent of this volume, mainly to Asia-Pacific region countries.

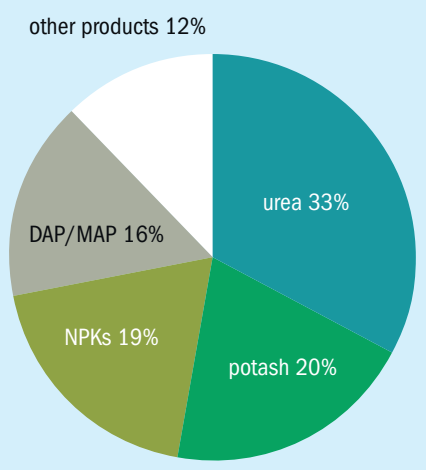
The ASEAN Bintulu urea plant on the northwest coast of Borneo has a capacity of 540,000 t/a, while Malaysian state oil company Petronas operates the 595,000 t/a capacity Gurun, Kedah, urea plant. Petronas also commissioned the 1.2 million t/a capacity SAMUR urea plant at the Sipitang Oil & Gas Industrial Park, Sabah, in 2017 (*Fertilizer International* 486, p34).

Fig. 11: **Thailand: fertilizer use by crop, 2017**



Source: Thai government

Fig. 12: **Thailand: fertilizer use by product, 2016**



Source: IFA

Thailand

Thailand has a diverse and productive agricultural sector. The country devotes around 20 million hectares to agriculture with 60 percent of this area (11.4 million ha) being dedicated to rice cultivation (Figure 2). Paddy production is important and around 4.5 million hectares of agricultural land in Thailand is irrigated currently.

Thai agriculture produced around 190 million tonnes of food commodities in 2018. Its main commercial crops include rice, cassava, palm oil, maize, rubber, banana and sugar cane (Figure 3). The country is one of the largest rice producers globally – producing 34 million tonnes in 2018. Rice is a major export earner for Thailand and the country competes, alongside India and Vietnam, for the position of world's top rice exporter.

More than half of the fertilizers used in Thailand are applied in rice cultivation, a reflection of its importance to the country's agricultural sector. Fertilizer applications to fruit and vegetables, sugarcane, rubber, oil palm, maize and cassava make up much of the remaining consumption (Figure 11). Urea, MOP, NPKs and ammonium phosphates (DAP/MAP) are the main product preferences in Thailand, these collectively accounting for almost 90 percent of the country's fertilizer usage (Figure 12).

Thailand consumed 5.3 million tonnes of fertilizers in 2018 (Figure 4). The country is almost completely import dependent for its fertilizer supply. Urea requirements – around 2.6 million t/a in 2018 – have

expanded by more than 70 percent since the mid-2000s. MOP and diammonium phosphate (DAP) import volumes are also significant (Figure 7).

NPK imports are supplemented by locally produced products. Thailand has the capacity to manufacture 1.7 million t/a of compound NPKs, using imported fertilizers and fertilizer raw materials. These are also used to prepare NPK bulk blends. Thailand also possesses 540,000 t/a of domestic ammonium sulphate (AS) capacity. AS is used both as straight fertilizer in Thailand and as a raw material for compound NPKs and NPK bulk blends.

Vietnam

Vietnam cultivates crops on around 13-14 million hectares of land. Two-thirds of this are is dedicated to growing the cereal crops rice (7.7 million ha) and maize (1.1 million ha). Fruit and vegetables, rubber, coffee and cassava – as well as cashew, pepper and tea – are other important commercial crops (Figure 2).

Vietnam, similar to Thailand, is a leading global producer and exporter of rice. Unsurprisingly, therefore, rice production – 42.8 million tonnes in 2018 – is Vietnam's main agricultural commodity and a major export earner. The country's diverse ag sector also produced large quantities of cassava (10.3 million tonnes) and maize (5.1 million tonnes) in 2018 together with coffee, rubber and tea (Figure 3).

Vietnam consumed 8.8 million tonnes of fertilizers in 2018, making it the second largest fertilizer market in Southeast Asia after Indonesia (Figure 4). The country is less import reliant than neighbouring countries, but still imported 3.2 million tonnes of fertilizers in 2018 – around one-third of its total needs.

Table 2: **Vietnam's fertilizer producers**

Product	Production plant
Urea	Phu My
	Ca Mau
	Ha Bac
	Ninh Binh
Diammonium phosphate (DAP)	DAP Dinh Vu
	DAP Lao Cai
Superphosphate	Lamthao Fertilizers & Chemicals
	Southern Fertilizer
NPKs	Lamthao Fertilizers & Chemicals
	Ninh Binh Phosphate Fertilizer
	Southern Fertilizer
	Phu My NPK

Source: AgroMonitor viettraders

Vietnam's main import requirements are for AS, MOP, DAP and urea (Figure 7). Import demand for fertilizers – including NPKs – has varied between 3.8-4.7 million t/a over the last decade. In recent times, urea imports have shifted away from China, being mostly sourced from Indonesia, Malaysia, the UAE and Russia instead. DAP imports have largely been sourced from China, South Korea, Morocco and Jordan, while domestic demand for AS continues to be met by supplies from China and Japan.

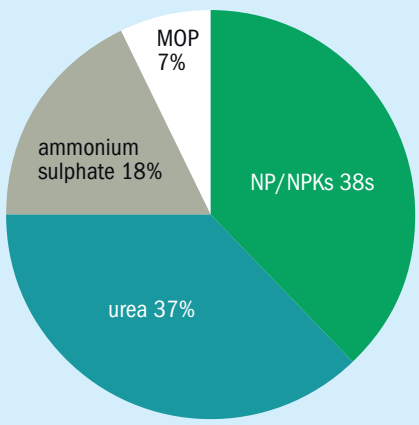
Vietnam's domestic fertilizer industry (Table 2) is one of the largest in the region with around 12 plants providing significant capacity for the production of:

- Urea: 2.6 million tonnes
- DAP: 0.5 million tonnes
- NPKs: 2.6 million tonnes.

Vietnam has four nitrogen plants. On paper – with a potential combined urea output of 2.6 million t/a – these plants should meet domestic demand and provide a potential surplus for export.

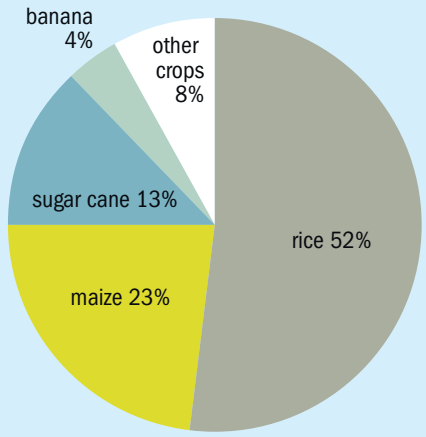
The country's two relatively modern gas-based ammonia-urea plants – Phu My and Ca Mau – operate reliably. Both are supplied with gas feedstock from the Nam Con Son basin, developed by BP, PetroVietnam and Conoco. Vietnam's two other ammonia-urea plants – Ninh Binh and Ha Bac – are

Fig. 13: **Philippines: fertilizer use by product, 2017**



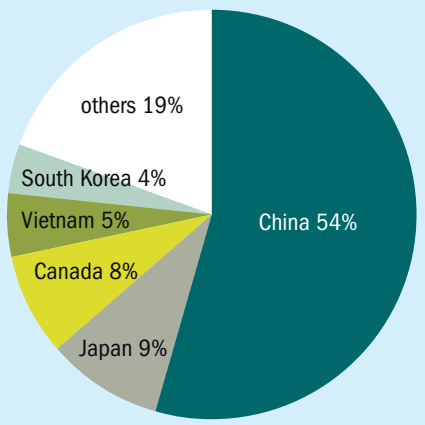
Source: Atlas Fertilizer Corporation (AFC)

Fig. 14: **Philippines: fertilizer use by crop, 2017**



Source: Atlas Fertilizer Corporation (AFC)

Fig. 15: **Philippines: imports of manufactured (finished) fertilizers by country of origin, 2018**



Source: Philippines Statistics Authority (PSA)

based on coal gasification. Located in the north of the country, both plants have been plagued by production problems, serious financial difficulties and poor market conditions (*Fertilizer International* 486, p34).

Philippines

More than 12 million hectares of land is devoted to agriculture in the Philippines, a vast and varied archipelago set in the South China Seas. Much of this area is given over to growing rice (39%), coconut (30%), maize (21%) and sugar cane (4%). Banana and pineapple are also commercially-important crops.

The Philippines is a two million tonne fertilizer market. The country's most popular products are NP/NPKs and urea, together with AS and MOP (Figure 13). The most frequently applied NPK and NK grades are 14-14-14 ('complete') and 16-20-0 ('ammophos'). Similar to Thailand, fertilizer applications to rice make up more than half of total consumption in the Philippines. Additionally, fertilizers applied to maize account for almost one-quarter of total usage (Figure 14).

Using imported raw materials, the Philippines manufactures compound fertilizers to supply the domestic market, producing 0.52 million tonnes in 2018, according to the latest government statistics. Founded in 1957, Atlas Fertilizer Corporation (AFC), now a subsidiary of Japan's Sojitz Corporation, is a long-established local manufacturer of compound fertilizers (NP/NPK/NK products) with a 42 percent share of the domestic NPK market.

AFC's production plant is located at Toldeo City on the island of Cebu. The company also has an extensive country-wide storage network, owning and operating seven satellite storage warehouses across the Philippines. These are capable of storing more than one million standard-size fertilizer bags.

Luzon-based Soiltech Agricultural Products is another major domestic NP/NPK fertilizer producer (14-14-14, 16-20-0, 6-9-15). Other fertilizer companies in the Philippines include:

- International Chemical industries: SOP
- Philippine Phosphate Fertilizer Corporation: AS, DAP, NP/NPKs
- Tierra Agri Technologies: Blended fertilizers
- Universal Harvester Incorporated: SOP.

Official estimates of fertilizer supply by the Philippines Statistics Authority (PSA) – 2.5-2.8 million tonnes between 2014 and 2018 – are significantly higher than domestic fertilizer consumption figures reported by the AFC (1.9-2.0 million tonnes), based on the company's own market research and PSA data.

The PSA reported the following fertilizer market statistics for 2018:

- Production: 517,754 tonnes
- Imports: 2,300,757 tonnes
- Total supply: 2,818,511 tonnes

It is unclear, however, whether the PSA has subtracted imports that end up in domestically-produced NPK fertilizers from total supply to avoid double counting. The PSA separately reported that the Philippines imported 1.5 million tonnes of manufactured (finished) fertilizers in 2018, with more than half of these being sourced from China (Figure 15).

AFC is forecasting that the Philippines fertilizer market will grow modestly to 2.06 million tonnes by 2022, a seven percent increase on 2018. ■

PHOTO: PURSELL AGRI-TECH

Efficient fertilizers: helping profits and the planet

Enhanced efficiency fertilizers (EEFs) occupy a small but high-value segment of the overall fertilizer market, although their production and use is accelerating. This trend is unsurprising given that their higher costs are usually more than offset by better efficiency and lower application rates.

Enhanced efficiency fertilizers (EEFs) are a niche but fast-growing and high-value group of plant nutrient products. They include slow- and controlled-release and stabilised fertilizers – hence the label SCRSFs, the other widely-used term for these products.

The Association of American Plant Food Control Officials (AAFPCO) defines EEFs as: "Fertilizer products with characteristics that allow increased plant nutrient availability and reduce potential of nutrient losses to the environment when compared to an appropriate reference product."

Previously, their relatively high cost/benefit ratio has largely restricted the use of EEFs to turf and ornamental applications, horticulture and high-value cash crops. This is now beginning to change. EEFs are increasingly being applied to broad acre crops, as higher market volumes bring down production costs and understanding of their benefits becomes more widely understood (*Fertilizer International* 480, p30).

Overall, the main drivers of growth for EEFs are the desire to increase crop yields, nutrient use efficiency (NUE) and farm profitability, alongside environmental concerns. New environmental protection legislation, regulations designed to combat climate change, as well as 4R nutrient stewardship programmes, are also supporting market growth.

The main types of EEFs, their mode of action and relative costs are summarised in Table 1. Production and consumption of these products is accelerating. This trend

Table 1: **Main types of SCRSF: mode of action, technology and cost**

Types	Mode of action	Technology	Cost in use
Slow release fertilizer (SRF)	Microbial	Urea-aldehyde	$$$$
	Physical	Sulphur coated urea (SCU)	$$
Controlled release fertilizer (CRF)	Physical	Polymer coated urea	$$$$$
Stabilised nitrogen fertilizer (SNF)	Biological	Treated with urease and nitrification inhibitors	$$

Source: Solvay

Above: Pursell Agri-tech's innovative CRF coating plant in Alabama.

Table 2: **List of selected stabilised nitrogen fertilizer (SNF) products and producers**

Company	Product name	Technology	Uses
BASF	Limus	NBPT, NPPT	Urea/UAN
Corteva	PinnitMax	NBPT	Urea/UAN
Corteva	Instinct	Nitrapyrin	Urea/UAN
Corteva	N Serve	Nitrapyrin	Anydrous ammonia
Eurochem	ENTEC	DMPP	Urea/UAN/ ammonium fertilizer
Koch	Agrotain	NBPT	Urea/UAN
Koch	Super U	NBPT+DCD+urea	Urea
Koch	Centuro	Pronitridine	Anydrous ammonia
Koch	Anvol	Duromide	Urea/UAN
SKW Piesteritz	Alzon	DCD and 1,2,4-triazole	Urea/UAN
Solvay	AgRho N Protect	NBPT	Urea/UAN
Solvay	AgRho NH4 Protect	DCD	Urea/UAN/ anydrous ammonia
Solvay	AgRho N Dual Protect	NBPT+DCD	Urea/UAN

Key:
NBPT: N-Butyl thiophosphoric triamide (urease inhibitor) DCD: Dicyandiamide (nitrification inhibitor)
DMPP: Dimethylpyrazole phosphate (nitrification inhibitor) UAN: Urea ammonium nitrate
NPPT: N-propyl thiophosphoric triamide (urease inhibitor)

Source: Company information

Table 3: **List of selected controlled-release fertilizer (CRF) products and producers**

Company	Product name	Technology
Haifa	Multikote, CoteN	Polymer
ICL	Osmocote	Polymer
Kingenta	Ekote	Polymer
Koch	Polyon, Duration	Polymer
Nutrien	ESN	Polymer
Sumitomo Chemical	SR Coat	Polymer

Source: Company information

Table 4: **List of selected slow release fertilizer (SRF) products and producers**

Company	Product name	Technology
Compo Expert (Grupa Azoty)	Floranid	IBDU
ICL	Sierraform GT	Methylene urea
ICL	Ekote	PSCU
Kingenta	Polyon, Duration	SCU
Koch	ESN	Methylene urea
Koch	SR Coat	SCU
Koch	Nitamin/NFusion	Methylene urea+Triazone
Nutrien (Loveland)	N-Pact	Triazone
Sadepan Chimica (Italy)	Sazolene	Methylene urea
Tessenderlo kerley	N Sure	Triazone

Key:
IBDU: Isobutylidine diurea SCU: Sulphur coated urea PSCU: Polymer sulphur coated urea
Source: Company information

is unsurprising given that their higher costs can be offset by better use efficiency and lower application rates.

Market value, volume and growth

Enhanced efficiency fertilizers are used as value-added substitutes for standard commodity fertilizers such as urea, anhydrous ammonia and urea ammonium nitrate (UAN). While stabilised nitrogen fertilizers (SNFs) have developed a strong foothold in broad acre agriculture, the use of controlled-release fertilizers (CRFs) and slow-release fertilizers (SRFs) on broad acre crops generally requires evidence that their cost premium is justified.

An increasingly wide range of enhanced efficiency products are becoming available on the global market. A selection of leading SNF, CRF and SRF products and their producers are listed in Tables 2, 3 and 4, respectively.

For enhanced efficiency products, the value proposition – and environmental benefits – can be delivered in two ways:

- Substitution of an untreated nitrogen fertilizer with an enhanced efficiency product at the same standard application rate to deliver a yield improvement (typically 5-15 percent); or
- Substitution of an untreated nitrogen fertilizer with an enhanced efficiency product at a lower application rate to obtain the same or better yield.

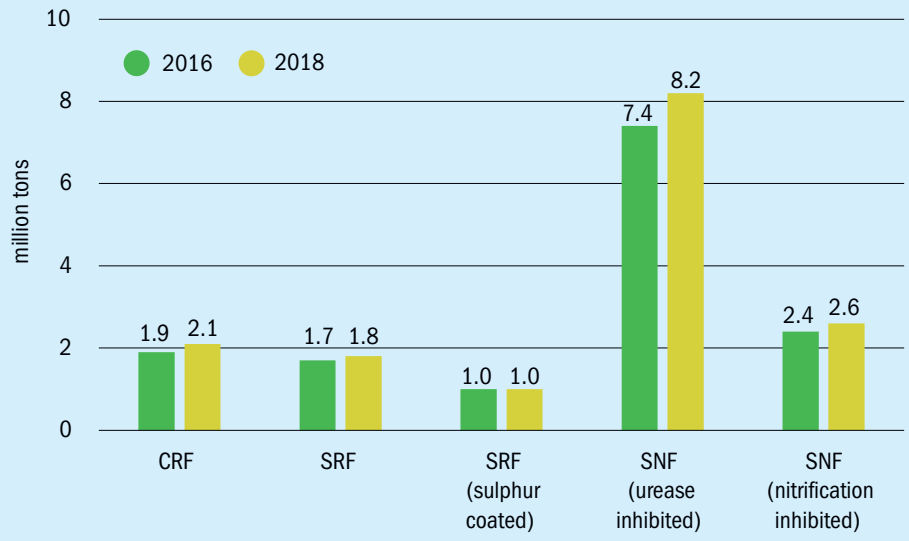
On the regulatory front, SNF market growth has been strongly supported by:

- China's zero fertilizer growth policy
- Biofuels regulation in Brazil
- Regulations in Germany making treatment of nitrogen fertilizers with inhibitors mandatory, or requiring their incorporation into the ground.

Complex and lengthy fertilizer registration processes, on the other hand, can hinder the adoption and sale of SNFs. The introduction of a new EU regulation on polymer biodegradability is also likely to limit European CRF demand in the medium-term. Several CRF producers are, however, fast-tracking the development of lower-cost biodegradable coatings to comply with the regulation.

The value of the global EEF market was estimated at $4.7 billion in 2018, and looks set to grow at nine percent p.a. to exceed $10 billion by 2028. The consumption of EEFs reached 15.7 million tonnes

Fig. 1: **World consumption of SCRSFs: 2018 vs 2016**



Source: Rams & Co for IFA, 2019.

in 2018, up from 14.4 million tonnes in 2016 (*Fertilizer International* 492, p34). Market growth was mainly due to the rising popularity of SNFs, particularly urea stabilised with urease inhibitors (Figure 1).

SNFs occupy a dominant position in the SCRSF market with a market share of more than 50 percent. The nitrification inhibitor market is mainly in the US where consumption is highest in the anhydrous ammonia segment.

SCRF segment

China, the United States, Western Europe and Japan are the leading global markets for slow- and controlled-release fertilizers (SCRFs). World demand is expected to grow a rate of nearly six percent p.a. during the period 2017 to 2022, according to IHS Markit (*Fertilizer International* 486, p25).

China's increasing consumption of SCRFs has been particularly significant in recent years, and is projected to grow at nearly 10 percent p.a. between 2017 and 2022. An analysis by IHS Markit suggests that China currently consumes 700,000 tonnes of these products annually, nearly 46 percent of the world market, while the US consumes 560,000, close to 37 percent of the global total (*Fertilizer International* 486, p25).

Western Europe is the next largest SCRF market, at more than 10 percent of global demand, followed by Japan at roughly eight percent of global demand. China is also the world's leading SCRF producer, having aggressively expanded its production during the past five years, to reach nearly 3.7 million tonnes annually (*Fertilizer International* 486, p25).

Production overview

Demand for EEFs is accelerating rapidly globally, albeit from a relatively low starting position. Production is fairly concentrated, both geographically and commercially. Four companies, Koch and Agrium in North America and Kingenta and Hanfeng Evergreen in China, have led the way in terms of production scale and output. Other large global players include ICL and Haifa Group in Israel, COMPO Expert in Germany, and SQM Vitas, the latter a joint venture between France's Roullier Group and SQM of Chile (*Fertilizer International* 480, p30).

Large global chemical manufacturers have also been instrumental in the development of innovative nitrogen stabilisation agents. These include Belgium's Solvay, BASF and SKW Piesterlitz in Germany, Japan's Chisso-asahi and Dow Agrosciences in the US.

Leading global urease inhibitor brands, such as Koch's *Agrotain*, Solvay's *Agrho N-Protect* and BASF's *Limus* products are based on the stabilisation agent NBPT (N-(N-butyl)thiophosphoric triamide) – although *Limus* also contains another urease inhibitor, NPPT (N-(2-nitrophenyl) phosphoric triamide). Solvay's *N-Protect* and Koch's *SuperU* are innovative in that they both incorporate a nitrification inhibitor (DCD) and urease inhibitor together in a single stabilised fertilizer product (*Fertilizer International* 480, p30).

Solvay

Solvay has developed the eco-friendly *AgRho® N Protect™* range of nitrogen stabilisers. These incorporate both urease (NBPT) and nitrification inhibitors (DCD). The *AgRho® N Protect™* range benefits from Solvay's expertise in green solvent technology and agrochemical formulations, delivering active ingredients at a load capacity of up to 50 percent in a non-toxic solvent formulation (*Nitrogen+Syngas* 362, p36).

Solvay has shown that the use of formulations containing a nitrification inhibitor such as DCD can reduce nitrate leaching by more than 60 percent. The use of urease inhibitor such as NBPT, meanwhile, is one of the most effective management tools for preventing ammonia loss from surface applications of urea or UAN. Reductions in ammonia volatilisation of more than 80 percent have been observed with the use of NBPT.

Excess nitrogen fertilizer application is responsible for unnecessary nitrogen losses to the environment. Through the use of nitrogen stabilisation formulation, such *as AgRho® N Protect™*, Solvay has also shown that N_2O emissions can be reduced by 50 percent, when compared to untreated fertilizer.

Furthermore, based on extensive field trials in different regions, *AgRho® N Protect™* can deliver crop yield increases of up to 20 percent – or nitrogen fertilizer savings of up to 20 percent.

AgRho® N Protect™ works particularly well in no-till systems. This is because, normally, if urea is left on the surface then much of the applied nitrogen will be lost as ammonia into the atmosphere due to high enzyme activity. *AgRho® N Protect™* stops this enzyme activity for up to two weeks. Additionally, treatment of urea with *AgRho® N Protect™* improves options for fertilizer timings and the number of split applications required, potentially helping growers to save on costs and labour.

The risk of nitrogen losses through ammonia volatilisation or nitrate leaching depends on a variety of different parameters, including:

- Environmental factors such as weather and soil conditions
- The types of fertilizer(s) used
- The nitrogen programme, particularly the number of split applications.

One size does not fit all, in Solvay's view. The company therefore recommends the

Koch Agronomic Services: pioneer and innovator

Stabilised fertilizers (SFs) are the largest segment of the speciality product market globally, according to a recent analysis by Rams & Co for the International Fertilizer Association (IFA). Indeed, urease inhibitor (UI) and nitrification inhibitor (NI) products combined now represent a 10.8 million tonne market globally. SFs are mostly applied in broad acre agriculture. North America, in particular, has been a pathfinder region for stabilised fertilizers and innovation in the development of urease and nitrification inhibitors.

We talk to **Greg Schwab**, Vice President, Technology and Innovation at Koch Agronomic Services (Koch), pictured left, about the current state of the market. Koch has been a pioneer in the SF market and continues to innovate.

The nitrogen stabiliser *AGROTAIN*® is the original and most proven urease inhibitor product on the market, being backed up by more than 25 years of trial results and the successful application on millions of acres of crops worldwide. Koch subsequently introduced *ANVOL*® nitrogen stabilizer in January 2019. This new product combines NBPT, the urease inhibitor found in *AGROTAIN*®, with Duromide to deliver longest-lasting protection against ammonia volatilisation.

Koch also launched *CENTURO*® nitrogen stabilizer in 2018, its next-generation nitrification inhibitor for use with anhydrous ammonia and urea ammonium nitrate (UAN). Featuring Pronitridine, *CENTURO*® is the first new nitrification inhibitor to receive US Environmental Protection Agency (EPA) registration in more than 40 years.

Additionally, Koch manufactures *SUPERU*® fertilizer, a stabilised granular urea product that contains urease and nitrification inhibitors to guard crops from denitrification, leaching and volatilisation.

What particular conditions and factors have driven the successful uptake of stabilised fertilizers in North America?

The initial adoption of urease inhibitors revolved around the desire to prevent soil erosion with reduced and no-till cropping systems. Urease inhibitors eliminated the need to incorporate the fertilizer into the soil to prevent ammonia volatilization loss. They increased in popularity as farmers began shifting to more in-season nitrogen applications to further improve fertilizer use efficiency and limit environmental impact.

While in-season nitrogen applications are very efficient, the continued growth in US farm size can make it challenging to apply all of the nitrogen fertilizer after crop emergence. Nitrification inhibitors can stabilize pre-season ammonia and urea nitrogen applications and minimize losses from leaching and denitrification.

In fact, our research has shown nitrification inhibitors like *CENTURO*® are equally efficient, comparing pre-season applications with a nitrification inhibitor and in-season applications without. With in-season nitrogen applications, nitrification inhibitors also play a role in protecting the nitrogen from spring rains which can allow the grower greater flexibility for when and how they apply their nitrogen.

Has Koch been pleased with the take-up of *ANVOL*® since its launch, with customers switching over from *AGROTAIN*®?

AGROTAIN® is one of the few agricultural products that has been in use for more than 25 years – which is a testament to the value it brings to farmers. After discovering Duromide, we realised that its performance could surpass NBPT, the active ingredient in *AGROTAIN*®. Like any new product there is an adoption curve. However, some of our customers have already fully transitioned to *ANVOL*® and we are very pleased with the product's progress in the market.

How much of a milestone and landmark moment has the launch of *CENTURO*® been – both for the company and the wider stabilised fertilizer market?

Developed in the US in 2010 by a team of chemists at Koch, our goal was to create a single nitrification inhibitor compatible with anhydrous ammonia and UAN. After listening to retailers and growers, we focused on designing a product that was first and foremost agronomically effective and secondarily, had improved operational benefits like being noncorrosive to the metals used in anhydrous ammonia and UAN equipment.

Over the course of the 10-year development process, we worked with several land grant universities to conduct in-field research on the impact *CENTURO*® could have – on improving nutrient use efficiency, optimising yield and minimising nitrogen losses to leaching. This strong body of university research, coupled with the operational efficiencies gained from the storage and handling characteristics, has created excitement in the industry for this product, and we look forward to its continued growth and adoption.

What are the main markets for *SUPERU*® and where is it currently manufactured and on what scale?

SUPERU® fertilizer is unique because it is the only ready-to-use incorporated urea product that protects from all three forms of loss – volatilisation, leaching and denitrification – without sacrificing nitrogen concentration [46 percent nitrogen].

Weather variability means that farmers are often uncertain which form of loss to expect. In drier years, ammonia volatilisation is the main concern, but in wetter years leaching and denitrification are the biggest problems. *SUPERU*® allows farmers a way to minimise loss, regardless, in one easy-to-apply product. *SUPERU*® is produced at our world-scale production facilities in Enid, Oklahoma in the US and at Brandon, Manitoba, Canada.

Koch is offering to license the process technology for *SUPERU*® fertilizer to third-party urea producers. Could this play an important part in the wider roll-out and adoption of SFs across the world?

As countries like Germany begin to require urease inhibitors for all surface-applied urea fertilizers, we believe adding inhibitors at the time of manufacturing is an efficient alternative for retailers to deliver stabilised nitrogen to the farmer. This process removes the need for local blending and allows the retailer to apply other products like micronutrients, biologicals, or crop protection products to the granule.

In fact, we've added the ability to make *SUPERU*® to all our North American urea production facilities. Globally, we are engaging with other manufacturers to license Koch's proprietary *N-TEGRATION*™ technology that integrates the active ingredients evenly and homogenously into every granule. ■

selection of a tailored nitrogen stabiliser formulation that matches the grower's specific environmental factors and nitrogen fertilization programme. To help find the right nitrogen stabiliser, Solvay has developed a web-based tool (nprotect-solvay.com). This allows the grower to select the nitrogen stabiliser formulation that best fits their needs.

Koch Agronomic Services

Koch Agronomic Services (Koch) helped pioneer the enhanced efficiency fertilizer (EEF) market and continues to innovate (see box). Working with leading universities and third-party researchers, the company has commissioned extensive and rigorous trials to demonstrate the efficacy of EEFs and their benefits for growers (*Nitrogen+Syngas* 362, p36).

Koch is well known for its market leading *SUPERU®* fertilizer and *AGROTAIN®* nitrogen stabiliser. Both are based on easy-to-implement technologies and are designed to work seamlessly in the urea manufacturing process.

Koch's long-standing *AGROTAIN®* nitrogen stabiliser incorporates the urease inhibitor NBPT as an active ingredient. While its *SUPERU®* fertilizer incorporates two types of stabilisers, NBPT and DCD. These dual inhibitors protect fertilizer from all three forms of nitrogen loss – volatilisation, denitrification and leaching. This enables *SUPERU®* to deliver protection, productivity and efficiency in one homogenous urea granule, according to Koch.

A summary of the reductions in nitrogen losses delivered by *AGROTAIN®* and the maize and wheat yield benefits from using *SUPERU®* are shown in Figures 2, 3, 4 and 5.

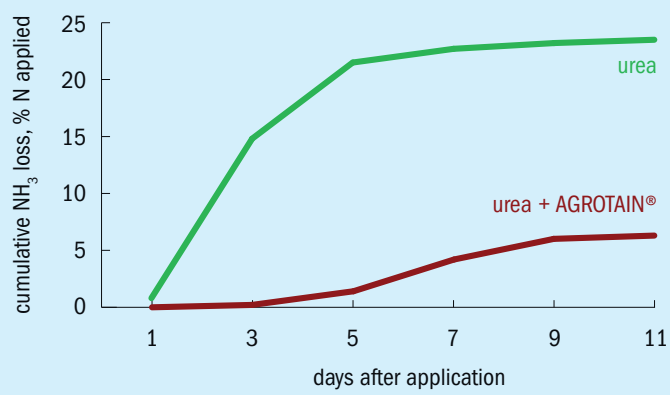
EEFs can be produced at various points in the supply chain, including at the manufacturer, distributor and retailer level, or at the farm gate. Each of these options vary in cost and the value they offer to growers.

Koch's *N-TEGRATION®* technology allows inhibitors to be incorporated during urea manufacturing. It offers nitrogen fertilizer producers a simple, cost effective, and reliable way of creating value for their end users, as well as capturing some of that value for themselves.

N-TEGRATION® technology is currently in use at Koch's fertilizer production plants in Enid, Oklahoma, US, and Brandon, Manitoba, Canada, where it is used to produce *SUPERU®* fertilizer. The technology offers the following benefits:

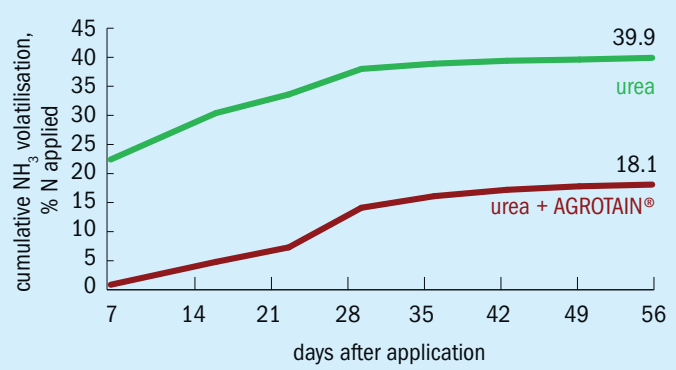
- **Minimal scope/impact:** It can be bolted on to existing urea plants or incorporated in new ones

Fig. 2: **The reduction of nitrogen loss with AGROTAIN®**



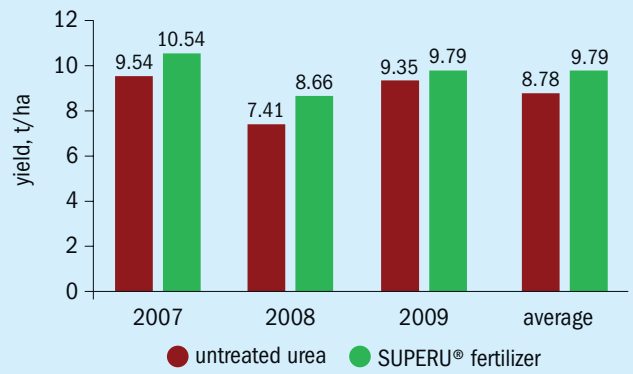
Source: Harrell, 2014. Louisiana State University. The underlying data was provided by Louisiana State University under a Research Trial Financial Support Agreement with Koch Agronomic Services, LLC and neither Louisiana State University, nor the individual researchers referenced, endorse or recommend any product or service.

Fig. 3: **The reduction of nitrogen loss with AGROTAIN® in cold weather**



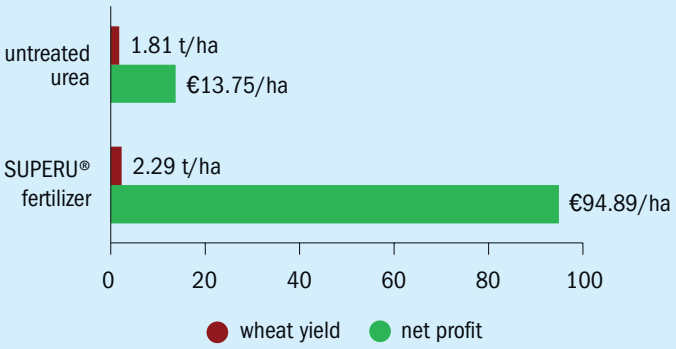
Source: Engel et al., 2011. Montana State University. The underlying data was provided by Montana State University under a Research Trial Financial Support Agreement with Koch Agronomic Services, LLC and neither Montana State University, nor the individual researchers referenced, endorse or recommend any product or service.

Fig. 4: **Three-year study demonstrating the maize yield benefit when using SUPERU®**



Source: Murdock, 2009. University of Kentucky. The underlying data was provided by the University of Kentucky under a Research Trial Financial Support Agreement and neither the University of Kentucky, nor the individual researchers referenced, endorse or recommend any product or service.

Fig. 5: **Wheat yield benefit with SUPERU® and profit benefit**



Source: Adams, C. B., S. B. Thapa, Y. Fan, and S. Park. 2018. Agronomic and Economic Effects of Two Enhanced-Efficiency Urea Fertilizer Technologies on Southern Great Plains Winter Wheat. Agron. J. 110:1097-1102. doi:10.2134/agronj2017.08.048. Neither Texas A&M University, nor the individual researchers referenced, endorse or recommend any product or service.

- **Short installation schedule:** It only takes around 10 months from the beginning of the design process to plant start up
- **Operational flexibility:** *N-TEGRATION*® technology can be easily switched on or off – allowing batch runs or continuous EEF production
- **Minimal capex investment:** Approximately $3-$12 million.
- **Ability to capture higher margins:** It delivers premium margins over commodity urea
- **Differentiation = liquidity:** The production of a differentiated product improves urea plant liquidity and/or net-backs in a long commodity urea market
- **Sustainability:** Differentiated products help operators meet growing regulations and achieve corporate sustainability goals.

Koch continues to innovate. Because urea remains the largest nitrogen source used in agriculture, the company has sought to improve on NBPT, one of the most widely recognised and used urease inhibitors on the market. This resulted in the development of *DUROMIDE*™, the patented active ingredient in Koch's new *ANVOL*™ nitrogen stabiliser.

Koch made its *ANVOL*™ nitrogen stabiliser available to US growers in in 2019. This next-generation stabiliser, compared to other urease inhibitor technologies, provides longer-lasting protection against ammonia volatilisation. It does this by providing dual active ingredients – *DUROMIDE*™ and NBPT – in optimal amounts. *DUROMIDE*™ offers a number of distinct benefits:

- A patented chemical structure
- More stable over a wider range of soil environments
- Slows down urea hydrolysis in the soil over a longer window
- More effective than NBPT alone
- Buys more time for rainfall incorporation
- Reduces ammonia loss.

Stamicarbon/Pursell Agri-Tech

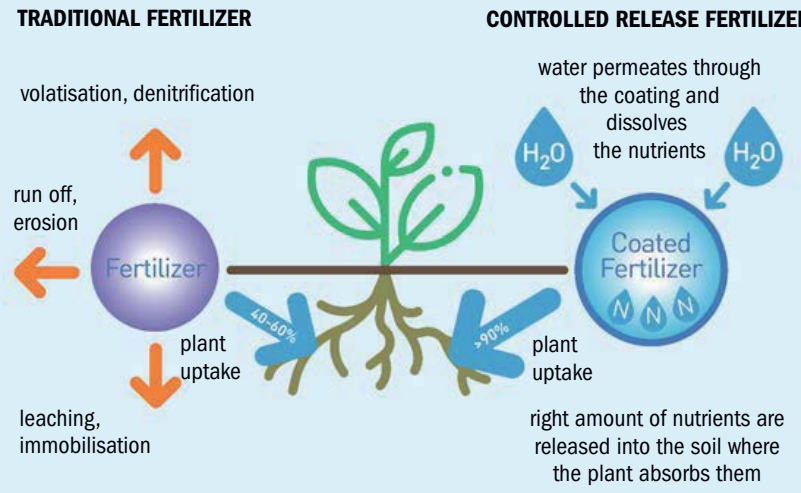
Stamicarbon in cooperation with Pursell Agri-Tech is offering a complete package for controlled-release fertilizer (CRF) production – one that is based on a novel coating technology exclusively developed for this purpose (*Fertilizer International* 492, p38). This production package, based on a batch coating process in a high intensity mixer, is able to encapsulate a wide variety of different fertilizer products with a new kind of polymer coating. This coats fertilizer granules within an extremely thin and durable membrane. The controlled release of nutrients can be adjusted over a time span of between one and 12 months, depending on the weight of the applied coating.

The novel polymer used in the production process is exclusively supplied by a major global polymer producer. The equipment manufacturer, also working in exclusive cooperation, is able to supply customers with complete production installations on a lump sum, turnkey basis.

The guarantees provided by these exclusive arrangements eliminate investment risks in new plant capacity, and provide a solid foundation for a major expansion in CRF production. This production package makes it possible for fertilizer producers, importers and distributors to access CRF production technology and manufacture products for their domestic customers. The production units are designed to be located close to the end-user (farmers) so as to avoid the unnecessary handling of the coated product.

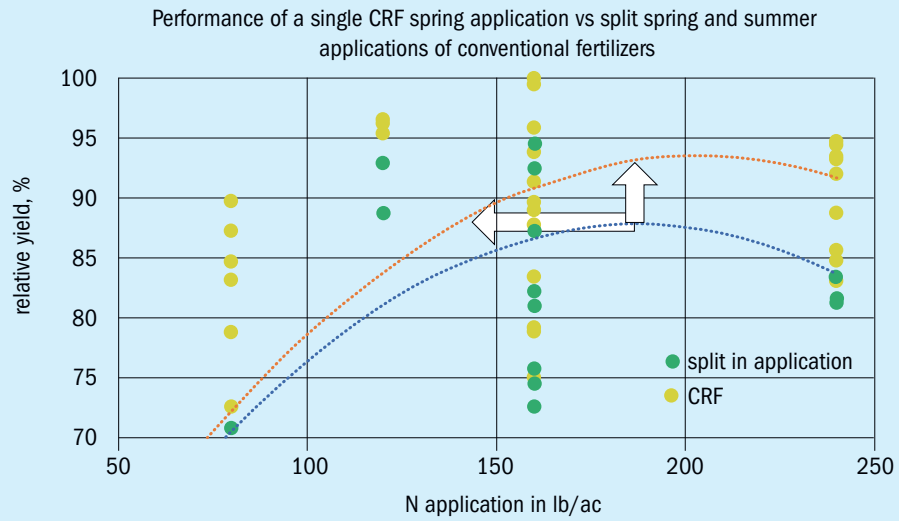
The first CRF demonstration plant, operated by Pursell Agri-Tech in Sylacauga, Alabama (pictured), has been performing successfully since spring 2018. The plant is currently running 24 hours a day, in five days a week operation, providing just under 100,000 t/a of coated product capacity. The current coating line can coat nearly all fertilizer grades, including granular and prilled urea, DAP, MAP, NPK, etc.

Fig. 6: **Comparison between traditional and controlled-release fertilizers (CRFs)**



Source: Stamicarbon

Fig. 7: **US corn trials, 2017-2018**



Source: Stamicarbon

CRFs – better farm economics

Typically, the high solubility of conventional fertilizers means that the nutrients provided dissolve quickly in the soil and are only available for the plant a short time after their application. Controlled-release fertilizers, in contrast, offer the timed release of nutrients, in-sync with the continuous crop demand for these, during the whole growing season (Figure 6).

Numerous field studies over the last decade have compared the performance of controlled-release fertilizers with conventional split-application fertilizers. The analysis shown in Figure 7 is based on US field trials with corn in 2017 and 2018. It compares a single spring application of a CRF to split applications with conventional fertilizers in spring and early summer. For each individual test site and test year, the highest yield obtained is recorded as 100 percent and used as a yardstick. All other results were then measured against this maximum reference point.

The results revealed that, in general, CRFs offer a steady yield improvement over conventional split applications. They also confirmed that CRFs improve nutrient use efficiency, delivering either higher yields, or lower application rates, due to a reduction in volatility and leaching losses.

Based on these field trial results, the following observations on cost have been made for a single CRF application versus split applications of conventional fertilizers, assuming $400/t for the urea price and $4/bushel for the corn price:

- At similar application rates: the 6-7% yield improvement achieved means CRFs are still cost competitive with conventional fertilizers even when sold at a premium of more than $200/t.
- At 25% lower application rates: the similar yield achieved by a lower amount of CRF allows for a price premium of $130/t.

The above calculations are conservative estimates as they do not include additional savings to the farmer such as the fuel saved from the single application of CRFs. In general, the business case for CRFs is always positive, providing a sound financial incentive for their increased adoption and use.

Stamicarbon and Pursell Agri-Tech have concluded that, for broad-acre agriculture in North America, targeting a $100/t price premium over urea for CRFs could provide significant financial incentives for farmers to switch from commodity to coated fertilizers.

ICL's *E-Max Release Technology*

ICL Specialty Fertilizers is a long-standing and major player in the controlled-release fertilizer (CRF) market. The company's *Osmocote* range – targeted at nursery stock, perennials, and pot & bedding plants – pioneered CRFs some 48 years ago.

CRFs are an important speciality product category for ICL, and the company expects their use to grow rapidly worldwide. Although originally targeted at the ornamental and turf market, as well as speciality crops, CRFs are increasingly being applied to a wide range of other crops, such as field vegetables, soft and hard fruit, maize, potatoes, rice and sugarcane, according to ICL.

In 2016, ICL responded to rising agriculture demand by starting CRF production at its Heerlen plant in the Netherlands using new *E-Max Release Technology*. The CRF products manufactured at Heerlen's 25,000 t/a capacity production line are marketed under the brand names *Agromaster*© and *Agrocote Max*©.

Production in the Netherlands added to existing production using the same technology at ICL's Summerville plant in the United States. This has been producing CRF's with *E-Max Release Technology* since 2014. ICL also has advanced plans for new CRF production lines in Asia and Latin America – key markets for these products.

E-Max Release Technology is a relatively new CRF technology that precisely releases nutrients, such as nitrogen, potassium and phosphorus, to exactly match crops needs, while limiting nutrient leaching. The technology was developed at ICL's Netherlands-based R&D section over several years. It was specifically designed for use in agriculture and has been tested worldwide.

The basis of *E-Max release Technology* is a polymer coating that improves nutrient use efficiency. This semi-permeable coating regulates the supply of nutrients by releasing these over a predictable timescale. Release is influenced by both soil moisture and temperature. Nutrient release is faster at higher temperature, while at lower temperatures release is slower, mirroring the nutritional needs of the plant.

> **"We have developed a unique process and technology for adding a very thin coating to a fertilizer granule.**

Leon Terlingen, ICL's R&D director, explains more: "We have developed a unique process and technology for adding a very thin coating to a fertilizer granule. The new thin coating allows us to keep the nutrient level very high, while also assuring a very good release curve for the crops. A new production process enables us to produce the controlled release fertilizer in a faster way than with previous technologies. We have tested and developed this new technology in our laboratories on a special pilot installation over a number of years in order to exactly formulate and tailor the desired products to fit specific crop needs."

CRFs have been shown to significantly increase nutrient use efficiency during agronomic trials – improving crop yields and quality as a result. Indeed, CRF products such as *Agromaster*© and *Agrocote Max*© can offer "tremendous benefits for growers", according to ICL, as they allow the cultivation of higher yielding and better quality crops from fewer fertilizer applications.

"Our agronomists are able to design and offer the right *Agromaster*© NPK with the desired release pattern and longevity," comments ICL. "We know, for example, that potatoes need nitrogen in a specific period of the growth cycle and we are able to design a product that has a nitrogen release that suits the potato crop and creates balanced NPK fertilization."

Agromaster© and *Agrocote Max*© function particularly well on sandy and loamy soils, and/or in regions where there is substantial rainfall during the growing season. They can also deliver carbon savings. ICL calculates, for example, that for every 10,000 hectares of cultivated land, substituting urea [check] with *Agromaster*© reduces the CO_2 footprint of fertilizer use by an amount equal to:

- Almost 1,500 circuits around the world in an average family car
- Planting 390,000 trees
- The annual CO_2 emission of more 1,100 average EU citizens.

The key benefits of *Agromaster*© relative to standard urea include:

- Higher or equal crop yields – with less mineral fertilizer input – thanks to the continuous nutrient release pattern
- Fewer applications = lower costs
- Reduced leaching, volatilisation and denitrification.

PHOTOS: ICL

Forestry fertilization: two-year old spruce seedlings after standard (left) and Agroblen© controlled-release fertilizer (right) treatments.

ICL trials have shown that *Agromaster©* outperformed commodity fertilizers and standard growing practices for rice and potato growing:

- **Rice:** *Agromaster©* can substantially improve yield and nutrient use efficiency in rice. Using this product as a controlled-release base fertilizer for nitrogen was found to significantly increase yields – at application rates that are similar to (and sometimes lower than) those used in conventional practice.
- **Potatoes:** on average, an eight percent yield increase could be obtained from *Agromaster©* versus standard grower practice.

Another of ICL's controlled-release fertilizer products, *Agroblen©*, contains polymer coated NPK granules that release nutrients over a pre-determined length of time. These CRF products are used in open-field agriculture, in plant hole applications and in pots.

Agroblen© is a less labour intensive and environmentally-friendly product, compared to conventional compound NPKs, and delivers higher plant yields while reducing soil compaction. Trials have shown it to be an effective fertilizer for young fruit trees (years 1-3) when used in combination with *Agromaster©*:

- **At planting:** *Agroblen©* allowed a 50 percent reduction in nitrogen input and the number of applications, while improving total annual shoot growth and trunk diameter by six percent and 24 percent, respectively, in the first two years.
- **Subsequent years:** Compared to the control, *Agromaster©* provided the best results, in terms of the number of inflorescences and final yield, from a 20 percent reduction in nitrogen delivered in a single application.

Trial results published last year by ICL also demonstrated the benefits of *Agroblen©* for establishing newly-planted forestry seedlings, such as spruce and pine. The results of an *Agroblen©* trial by Sweden's SLU university showed significant improvements in seedling growth during the first three years after planting, as measured by stem collar diameter, tree height and root volume (see photos). The trial used a 100 percent coated NPK+Mg+B compound *Agroblen©* fertilizer that gradually releases nutrients over 1.5-2 seasons.

InnoSolve 45N™ from Innovar Ag

InnoSolve 45N™ is the latest enhanced efficiency fertilizer from the specialist US fertilizer producer Innovar Ag, first entering the market towards the end of last year. This new urea-based, high analysis (45-0-0) fertilizer has multiple capabilities. Importantly, the product:

- Incorporates four different mechanisms for reducing nitrogen losses from volatilisation, immobilisation, denitrification, and leaching
- Has the ability to increase microbial populations by acting as a long-lasting food source
- Enables crops to better utilise phosphorus, potash, secondary nutrients and micronutrients.

The product's active components are well-researched, both by universities and extension services. These components are all thoroughly proven and provide predictable results, according to Innovar, being backed by 1,000 cumulative studies.

InnoSolve 45N™ is manufactured by Innovar using a proprietary 'Encapsulated Infused Fertilizer' (EIF) process. This completely infuses each granule during granulation, but without excessive heat, ensuring superior agronomic results, says Innovar.

"In our view, *InnoSolve 45N™* is the most cost effective, broad spectrum fertilizer technology on the market," comments Carrie Garcia, Innovar Ag's managing director. "Our revolutionary Encapsulated Infused Technology allows four different efficiency technologies to be included into a nitrogen or phosphate fertilizer."

The thinking behind the EIF process came out of the Innovar team's many years of experience and market development work – stretching back more than two decades – with a range of polymer-coated, urea-formaldehyde, stabilised and organic fertilizers. Innovar's link-up with a polymer manufacturing company and a state-of-the-art manufacturing plant (formerly devoted to oil and gas sector products) has also made the EIF process and the production of *InnoSolve 45N™* a reality.

The company's precision EIF manufacturing site in the US has the capacity to produce up to 500,000 tons of *InnoSolve* products annually. Innovar is also seeking to expand production internationally at other manufacturing sites in regions with important markets.

"Even with the best growing season predictions, mother nature has a habit of throwing a wrench into the works – leaving growers without the best fertilizer technology for the change in conditions," comments Andrew Semple, Innovar Ag's CEO. "A fertilizer product that combines multiple technologies has long been desired, yet operational, manufacturing and economic challenges have precluded the chances of such a development. Until now!"

Semple is proud of the new product and what's been achieved by his colleagues: "The Innovar Ag team has introduced a new all-star fertilizer that combines multiple, proven technologies in one nutrient substrate. We now have a world where nutrient management challenges are all answered by a single fertilizer source that's a proven compilation of nutrient efficiency technologies."

He concludes: "It is truly exciting to see *InnoSolve 45N™* at the forefront of nutrient plans being devised by agronomic managers. We see this new product as providing a 'one stop shop of tools' in a single fertilizer." ■

September-October 2020

phosphates & potash INSIGHT

PRAYON

Prayon Technologies

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EXPERTS TEAM

PROCESSES & **TECHNIQUES**

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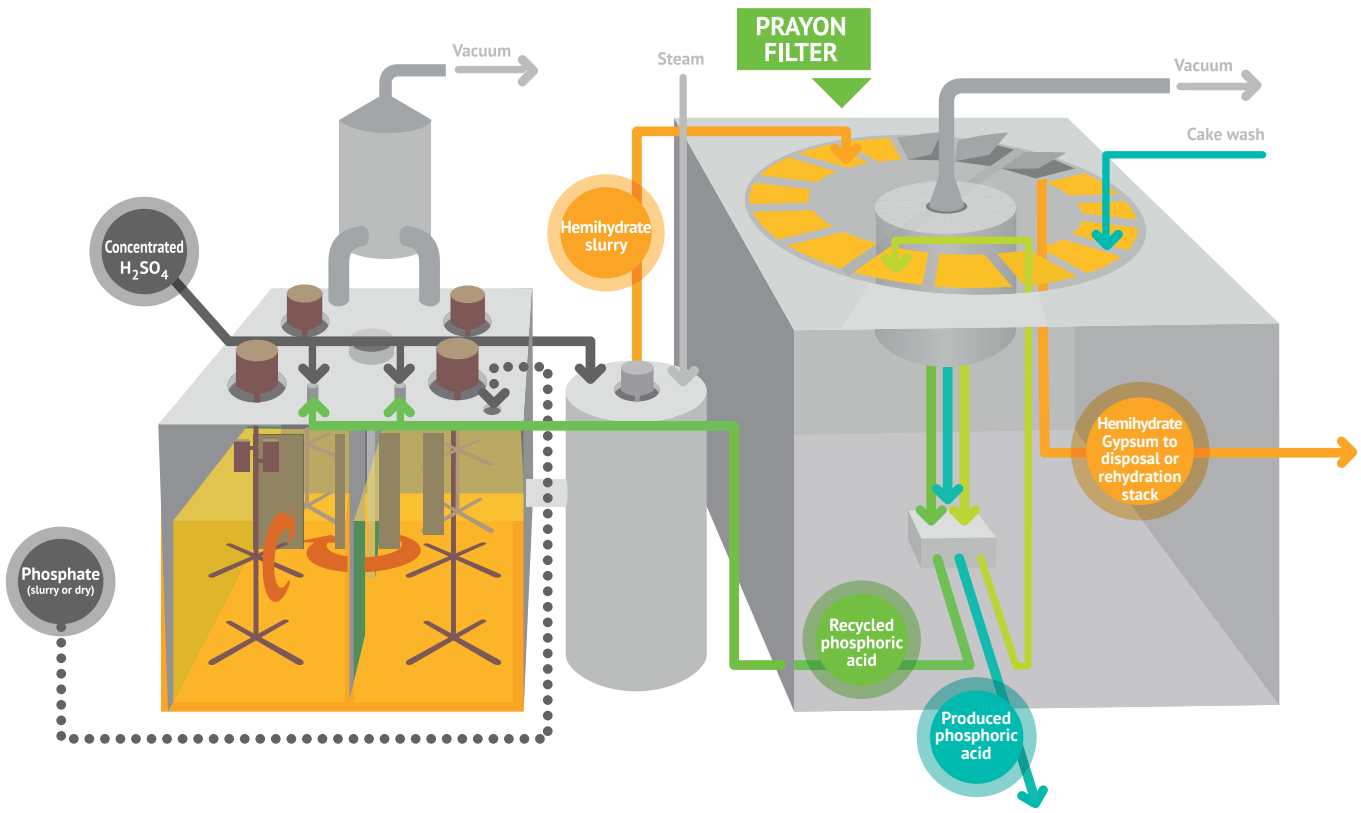

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Middle Eastern Geoscan PGNAA installation on an external conveyor analysing raw feed to plant.

PHOTO: SCANTECH

Phosphate process analysers

Sophisticated control of phosphates production is now possible thanks to the availability of real-time process analysers. We assess the range of technologies currently on the market and their key advantages.

It's been a challenging 12 months for phosphate fertilizer production, particularly in North America. At a market low point towards the end of last year, high inventories and weak prices in the region led to production cuts of 650,000 tonnes a month. Some producers were still reporting significant operating losses in the second-quarter of 2020. While gross margins per tonne – a crude measure of phosphate production economics – have recovered, they had fallen into negative territory earlier in the year.

Realised prices on products have been depressed too. The current diammonium phosphate (DAP) price is flat year-on-year at $329/t (Tampa f.o.b.), and down about one-fifth on the start of 2019, a recent highpoint.

Driving down production costs

This challenging environment means that there is more pressure than ever – and an economic imperative – for phosphate producers to cut their operating costs. This, in turn, requires a much greater degree of process control.

But fine tuning the phosphates production process remains problematic. Traditional laboratory methods for analysing the grade (P_2O_5 content) of mined phosphate rock, concentrates and chemical plant feed materials are time-consuming and labour intensive. The length of time taken between sample collection and the delivery of results also limits their usefulness in process control at phosphate mines and plants. Infrequent and intermittent sampling also means that lab test results are not always representative. Because of this, lab-based analysis is only able to provide a fragmented, incomplete picture of the production process.

Typically, phosphate fertilizer producers can only rely on getting lab results every 4-6 hours, meaning that process stages such as phosphate rock mining, froth flotation and phosphoric acid reactors are effectively flying blind when it comes to P_2O_5 feed control.

It is therefore unsurprising that phosphate plant operators are increasingly adopting automated on-line technologies for process and feed control These generate results rapidly, often in near real-time, and deliver tangible benefits in terms of improved phosphate plant efficiency and yield.

They can also deliver surprisingly quick returns on investment. For a typical beneficiation plant, an improvement in P_2O_5 recovery of just two percent, for example, can deliver annual savings of half a million dollars, according to some calculations.

Three proven types of automated analytical systems for process control in the phosphates industry are reviewed below.

Nuclear magnetic resonance

Massachusetts-headquartered **LexMar Global** is the world's leading provider of Nuclear Magnetic Resonance (NMR) analysers for process control. Within the industry, these installations are commonly called Industrial Magnetic Resonance (IMR) systems.

The company has installed more than 400 analysers globally in 45 countries, and operates regional service centres in Belgium, Texas, Morocco, Abu Dhabi, and China. Phosphate industry customers

include major players Ma'aden, Mosaic, Nutrien and OCP, as well as chemical and oil giants such as ExxonMobil, Dow and Borealis. The company supplies other markets including polyolefin resin manufacturing and mining.

LexMar Global produces the *MagModule II* IMR analyser for on-line process measurements on phosphate slurries. These are supplied with either multiplexer or metallurgical sampling systems. The advantages of NMR technology include:

- Direct analysis of phosphate content – as either weight percentage $Ca_3(PO_4)_2$ (BPL, bone phosphate of lime) or P_2O_5
- Powders, pellets, slurries and liquids can all be measured
- Non-destructive, rapid analysis with results in less than five minutes
- Stable calibration – no routine re-calibration required
- No sample preparation necessary
- Analysis is independent of particle size
- Robust instrumentation with rugged industrial design and construction
- Avoids use of radioactive materials.

MagModule II on-line phosphate analysers can be installed at different process stages. Units can be placed at the beneficiation stage, to monitor and help regulate froth flotation, further downstream in acid reactor feed control, or upstream in mining operations. The benefits of this include:

- Greater P_2O_5 recovery with consequently better usage of phosphate rock reserves and less wastage
- Increased plant efficiency and higher production rates
- Lower production costs
- Avoidance of contract penalties.

LexMar Global's MagModule II IMR analyser.

Samples are collected for analysis using either a metallurgical sampler or a multiplexer. Coupling the analyser to an automated multiplexer is advantageous as it allows a single analyser to take routine measurement from multiple sample points without interrupting operations.

IMR technology is capable of delivering comparable, consistent results. Analysers are calibrated for P_2O_5 content by comparing IMR results with laboratory reference measurements over a range of different phosphate compositions. According to LexMar Global, IMR calibrations are intrinsically more stable than those required for alternative techniques such as X-Ray fluorescence (XRF) or prompt gamma neutron activation analysis (PGNAA).

One of the main benefits of on-line IMR analysis is that it allows more timely process decisions to be made which, in turn, leads to more consistent product quality. The resulting process improvements can deliver large annual savings and rapid payback.

"Improved process control is the primary benefit of incorporating on-line analysers into your plant," explains Dr Olaf Kohlmann, LexMar Global's NMR product manager and strategist. "On-line magnetic resonance will give you phosphate concentration readings within a few minutes. Having real-time information about the process status 24/7 allows the engineers to optimize production for a plant."

He adds: "Even if you could only improve P_2O_5 recovery by one single percent, the payback is significant, and the lifespan of your reserve is improved. The amount of material moving through your process decreases. Efficiency, production costs, opex, will all start to go in the right direction."

IMR analysis of conveyor belt feeds provides continuous real-time information on the grade (BPL) of phosphate rock, enabling precise quality control at the very start of the process. It also helps reduce rock waste.

In froth flotation, IMR analysis again provides real-time BPL data for flotation feeds, concentrates and tailings, improving P_2O_5 recovery during beneficiation and preventing the over- or under-application of flotation chemicals. When combined with an automatic multiplexer, *MagModule II* has the ability to sequentially sample from and analyse up to four different process streams.

IMR on-line analysers can also be installed further downstream at the reactor stage in the phosphate production process. Using the technology to monitor feedstock helps optimise reactor control and improves P_2O_5 recovery and efficiency. Other tangible benefits include reduced production costs and improved product quality and consistency.

The installation of IMR on-line analysers provides rapid payback on investment and delivers long-term profits, according to LexMar Global, even if P_2O_5 recovery is improved by just a small percentage, due to the operating cost reductions achieved and longer mine life.

The growing need for mining industry automation will open up even greater opportunities for on-line analysis in future, in Dr Kohlmann's view. "As limited global reserves are expended, but demand increases, innovative process optimisation techniques and refinement efficiencies will become increasingly necessary to compete in the global market," he concludes.

Prompt gamma neutron activation analysis

Prompt gamma neutron activation analysis (PGNAA) is a proven on-belt technology used for the real-time monitoring, bulk sorting and blending of ore materials on conveyors.

The *Geoscan* range of on-belt PGNAA analysers developed by Australia's **Scantech International** have been widely-used for the monitoring of bulk industrial materials such as cement, coal and minerals for more than two decades. The *Geoscan-M* analyser is suitable for ore and concentrate analysis in the minerals industry, and enables operators to measure and control feed and product quality. There are more than 100 *Geoscan* analysers installed and working in mining and processing plants worldwide, including iron ore, manganese, zinc-lead, bauxite and copper operations, with more than 20 units operating in the phosphate sector.

The *Geoscan-M* is installed directly on the conveyor system, with the belt passing through the instrument's analysis tunnel (see photo). Its compact design uses only one metre of belt space, enabling it to be fitted between standard idlers. One of three different frame sizes can be selected to suit any conveyor with belt widths up to 2.4 metres and bed depths up to 0.53 metres. All material that passes through the analysis tunnel is continuously analysed and reported for a truly representative analysis. Being a fully penetrative analysis technique, it avoids the issues associated with surface analysis methods.

Geoscan-M installations emit neutrons from a californium-252 source located below the conveyor. These are absorbed by elements present in the material being conveyed, with each element emitting a unique gamma ray spectrum. The resulting spectra are monitored by proprietary detector array located above the conveyor, and processed to provide independent multi-elemental analyses (Si, Al, Fe, Ti, K, Mn etc.). The *Geoscan* unit then reports these to the plant – typically every two minutes – where they are interpreted to make process decisions. Results are combined with microwave measurements which detect and report moisture content.

The main applications and benefits of PGNAA in phosphate mining and processing include:

- Measuring beneficiation feed quality for plant control
- Sorting phosphate rock received at chemical plant stockpiles
- Blending to improve feed quality and meet specification
- Blending acid reactor feed
- Controlling sulphuric acid additions to the acid reactor, based on phosphate rock feed chemistry, to maximise P_2O_5 recovery, recover Ca to gypsum, and optimise acid consumption.

PHOTO SCANTECH

North American Geoscan-M installation for monitoring beneficiated phosphate – with a TBM moisture analyser in the foreground.

"After notching up numerous successful installations in a variety of sectors of the minerals industry, we turned our hand towards the phosphates sector in the early 2010s," comments Scantech's Dr Luke Balzan. "After testing in our factory in Adelaide, Australia, we deployed our first *Geoscan* in the phosphate industry in 2014. Consequently, we were the first supplier to successfully yield positive process control outcomes and deliver excellent and reliable analysis results. From there, we've been able to work in all the major phosphate markets globally, with more than 20 phosphate installations contributing to our total of more than 1,200 analysers worldwide"

He continues: "One of our Middle Eastern customers, as a result of having a *Geoscan* installed close to the front end of their process, has been able to obtain greater plant stability – and reduce the costs and delays associated with laboratory analysis. The delivery of results every two minutes has enabled the site to make process control decisions in real time.

"One of our American customers has an installation on the feed to their chemical plant – so they've been able to use *Geoscan* data to increase their yield by actively controlling their acid reactor process, as well as controlling what gets fed to the plant. *Geoscan* has therefore enabled them to make some very significant gains in production."

Such process improvements and production cost reductions are not widely publicised.

"Obviously, our customers like to keep what they're doing close to their chest!," comments Dr Balzan. "But they really do see a competitive advantage with PGNAA. We're simply pleased that our extensive past experience in minerals, as well as our focus on customer service and support, has enabled the phosphate sector to make such gains."

PGNAA offers a number of advantages for on-belt analysis, suggests Scantech, relative to other on-line methods:

- **Comprehensive measurement:** across the full cross section of the belt continuously, 6 monthly standard calibration checks, accuracy improves as more material is measured
- **Deep penetration:** through the entire bed depth
- **Large-scale sampling**: tonnages limited only by belt size and depth (~17,000 t/h)
- **Reliable analysis**: no mineralogy or matrix effects (Ca, Fe), unaffected by layering, particle-size, dust and belt speed
- **Low maintenance**: solid state components, low cost, non-contact, remote units.

PGNAA technology has also been developed for slurry analysis by San Diego-headquartered **SABIA, Inc**. The company manufactures two types of on-line analysers. 'On-belt' analysers continuously measure the elemental composition of bulk material on a conveyor, while 'on-pipe' analysers are mounted around a slurry pipe to continuously measure the complete slurry stream.

Both types of PGNAA analyser have been installed by major North America phosphate producers (see box). Two of the SABIA's *Model X1-XP Slurry Analysers*, for example, have been successfully installed at JR Simplot's Vernal phosphate beneficiation plant in Utah (*Fertilizer International* 477, p52).

Both PGNAA analyser types perform full stream, continuous, on-line multi-elemental analysis. This penetrates the material flow for a completely representative analysis without the need for frequent sampling or multiplexing. This non-intrusive multi-elemental analysis allows operators to simultaneously monitor elements of interest and see percentage composition changes/trends in essentially real-time.

The technology is uniquely suitable for high throughput (t/h or kg/m^3 volumes) and fast flowing (m/s) bulk materials. SABIA analysers have no moving parts and are easy to install. Their integrated electronics only require two cables – for power and network access.

North American conveyor belt installation of a SABIA PGNAA analyser.

PHOTO: SABIA

Spotlight on PGNAA applications

Major phosphate producers in North America have installed SABIA's PGNAA analysers in the following applications:

Beneficiation feed tuning

The analyser is located on 12-inch slurry pipe discharging into a flotation feed surge tank ahead of the primary flotation de-sliming circuit. Continuous measurement of P_2O_5 and MgO allows incoming feed grade monitoring and quick validation of downstream control decisions. Operators can adjust the primary flotation circuit to increase grade by slowing down the incoming feed rate and fine-tuning reagent control.

Final product validation

The analyser is located on an 8-inch slurry pipe after sizing and thickening. The MgO content of the final concentrate is continuously monitored and compared with quality targets. The challenge for this specific ore body is liberating P_2O_5, but without over grinding as this liberates MgO-containing dolomite and contaminates the phosphate concentrate. Continuous online analysis allows quick validation of upstream process decisions to keep the concentrate on target. PGNAA measurement reduces control response validation to 90 minutes, down from 12 hours for conventional sampling and lab analysis. Maintaining a final product target for MgO (<0.80%) eliminates the reaction and filtration issues associated with high MgO content at the final product processing plant.

Run of mine (ROM) pebble sorting, first example

The analyser is placed, after the mechanical sampling system and before the shuttle belt feeding bins, for diverting waste. The main aim is sorting and separating high MgO compositions in batch runs. MgO content typically varies from 0.5-7.0 percent, with 2-3 percent being an ideal range.

Run of mine (ROM) pebble sorting, second example

The analyser is located after a mechanical sampling system and before two piles. Continuously measuring percentage MgO allows sorting between the low and high concentration piles. Grade variations are bimodal with MgO levels holding consistently for extended periods of time at either one or four percent. The main aim is to quickly detect the switchover (bimodal transition) from low to high MgO. For these sorting decisions, using a five-minute rolling average of the MgO measurement provides greater statistical certainty. ■

Many global phosphate producers are considering installing PGNAA to optimise their downstream processing, improve mine grade control, and carry out stockpile blending more expertly. The range of applications includes:

- Run of mine (ROM) bulk sorting
- Stockpile reclaim analysis
- Monitoring of washed phosphate stockpile
- Mine loadout tracking for trains or trucks.

A number of additional applications are also under evaluation:

- Fertilizer feed acid blending
- Food-grade purified acid monitoring
- Carbonate concentrate/tailings
- Low-grade kiln feed
- Beneficiation recovery
- Flotation final products
- Chlorine/water balance
- Blending/reagent control in flotation cells.

Laser-induced breakdown spectroscopy

Laser-induced breakdown spectroscopy (LIBS) has been developed for monitoring and control applications in mining and mineral processing. One advantage of LIBS is its ability to detect and measure light elements, unlike conventional analytical techniques such as XRF analysis. The technology can be installed to analyse dry granular materials on conveyor belts or slurry materials.

Outotec launched its *Courier 8 SL* LIBS-based analyser in 2013 for on-line measurement of elemental concentrations in beneficiation plant feed, tailing, and concentrate slurries. According to Outotec, the benefits of using LIBS for on-line analysis of slurries include:

- Accurate monitoring of changes in feed mineralogy
- Improved control of concentrate quality
- Improved recovery through early detection of process disruptions
- Reduced need for time-consuming and labour-intensive manual sampling
- More efficient use of energy and raw materials.

Phosphates processing and concentration is one of the main target markets for the *Courier 8 SL*. Its applications include:

- Final concentrate quality control: measurement of P content and Ca/P ratio
- Flotation recovery optimisation and reagent control: measurement of P in feed, concentrates, and tailings

PHOTO: LYNCIS

MAYA M4L LIBS-based analyser.

- Measurement of 'penalty' elements: Mg and Si.

The *MAYA* on-line laser analyser, a LIBS-based system manufactured by **LYNCIS**, provides direct, safe, efficient and accurate elemental analysis of phosphates and potash on conveyor belts.

LYNCIS has extensive experience of developing LIBS analysers for mining and industrial applications. The company has direct access to the latest innovations, being headquartered in Lithuania, one of Europe's biggest hubs for laser, optical and spectral technologies.

MAYA analysers come equipped with state-of-the-art optical systems and can accurately report phosphate content as either BPL or P_2O_5. They can also successfully detect and measure Al_2O_3, SiO_2 and other undesirable impurities in phosphate rock and process feed.

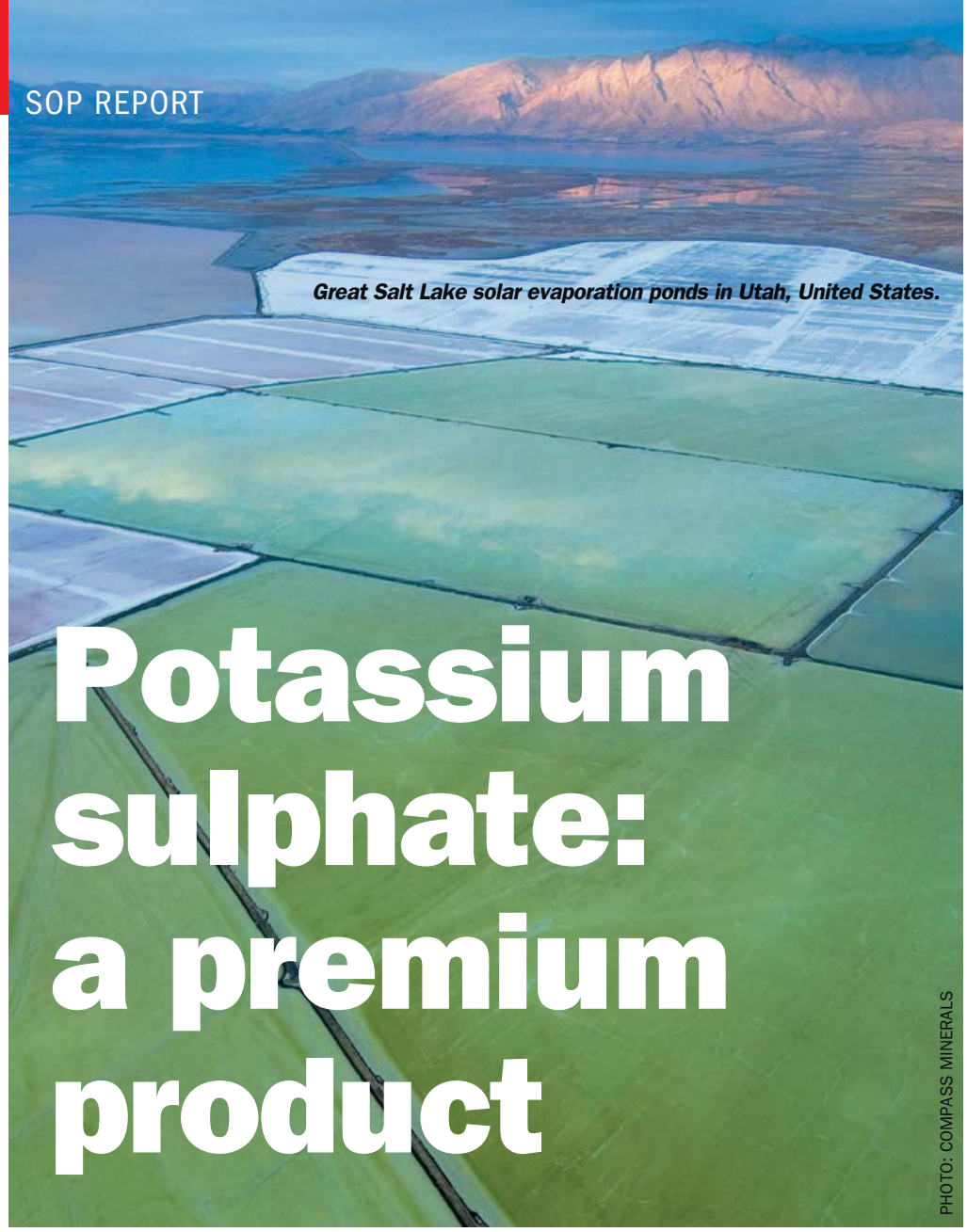
LIBS-based analysers manufactured by LYNCIS have been installed by two leading fertilizer companies, the US phosphates producer Mosaic and Russian potash producer Uralkali. These provide real-time elemental analysis for process monitoring and control.

MAYA analysers have the following applications in phosphate and potash production:

- Controlling ore quality based on elemental analysis (K, Na, P, Ca, Mg, Fe, C, etc.)
- The regulation of flotation reagent dosage and water, according to the quality of the ore, resulting in increased P_2O_5 recovery
- Determining the content of insoluble precipitates
- Controlling final product quality.

Having compositional information for the phosphate rock feed prior to beneficiation is particularly valuable, suggests LYNCIS, as it makes early and timely process interventions possible. These can improve production outcomes and save on operational costs. *MAYA* analysers offer safety, simplicity and low cost of ownership, according to the company, by ensuring high performance conveyor belt measurements based on robust calibration.

The first MAYA analyser in the phosphates industry was sold to US producer Mosaic in 2008. This unit was installed for continuous control of the ore feed quality by discarding high MgO rock (> two percent MgO pebble content). For this installation, calculations suggest that using instantaneous LIBS measurement to reject high MgO rock, rather than the delayed results of laboratory analysis, could potentially improve plant profitability by $5.9 million. This estimate was based on a production level of 1.9-2.0 million tonnes and other pricing and technical assumptions. These cost savings are partly delivered by lowering the water and flotation reagent consumption required in the beneficiation of high MgO ore. ■



Great Salt Lake solar evaporation ponds in Utah, United States.

PHOTO: COMPASS MINERALS

Potassium sulphate: a premium product

The global market for potassium sulphate is on the rise. It has become the preferred potassium fertilizer for many chloride-sensitive, high-value cash crops. This speciality potash product also commands a price premium.

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

As a fertilizer, potassium sulphate (K_2SO_4, sulphate of potash, SOP) has emerged as the most commonly used alternative to potassium chloride. Whilst MOP may be the preferred potassium fertilizer for cereals and oilseeds, SOP often finds favour for more chloride-sensitive, high-value cash crops, notably fruits, vegetables, tobacco and tree crops (*Fertilizer International* 458, p48).

The other obvious advantage of SOP is that its sulphate content also provides a concentrated source of sulphur in plant-available form. This makes SOP a highly effective product for correcting sulphur deficiency in crops, via direct soil application or through fertigation and foliar treatment.

The other main chloride-free alternatives to MOP are:

- Potassium nitrate (NOP, $KNO_{3)}$
- Potassium magnesium sulphate (SOPM, langbeinite, $K_2Mg_2(SO_4)_3$)
- Polyhalite ($K_2Ca_2Mg(SO_4)_4.2H_2O$)
- Monopotassium phosphate (MKP, KH_2PO_4)

These can all offer agronomic advantages over potassium chloride under certain crop and soil conditions.

Total agricultural use of potash globally exceeds 100 million tonnes annually. On a product basis, the market divides into MOP (70%), SOP (9%), NPKs (18%) and SOPM/others (3%). Global MOP deliveries, an estimated 64 million tonnes in 2019, are forecast to increase to 64-66 million tonnes this year.

Potassium sulphate – key advantages

Potassium sulphate is the most commonly used alternative to potassium chloride. Fertilizer grades of SOP typically range from 50-54 percent K_2O and contain around 18 percent sulphur in sulphate form.

The key advantages of SOP over MOP are its chloride-free nature and high sulphur content. Indeed, SOP has the lowest salt index of the three most commonly-applied potash fertilizers (MOP, NOP and SOP). Its use is generally advised for:

- Chloride-sensitive crops – including many fruits and vegetables
- Areas at risk from salinity, particularly semi-arid or arid regions with low rainfall, where excessive use of chloride-containing fertilizers could eventually 'poison' the soil.

SOP also remains the cheapest low-chloride source of potassium, according to Tessenderlo Kerley International. The ability to supply plant-available sulphur is becoming increasingly valued too (*Fertilizer International* 476, p19). Sulphur fertilization is particularly important in crops with a high sulphur demand such as brassica, canola and onions.

A sizeable and growing market

The global SOP market has more than doubled in size over the last two decades to reach 7-8 million tonnes currently. The market grew particularly rapidly between 2012 and 2017, driven upwards by rising demand in China (Figure 1).

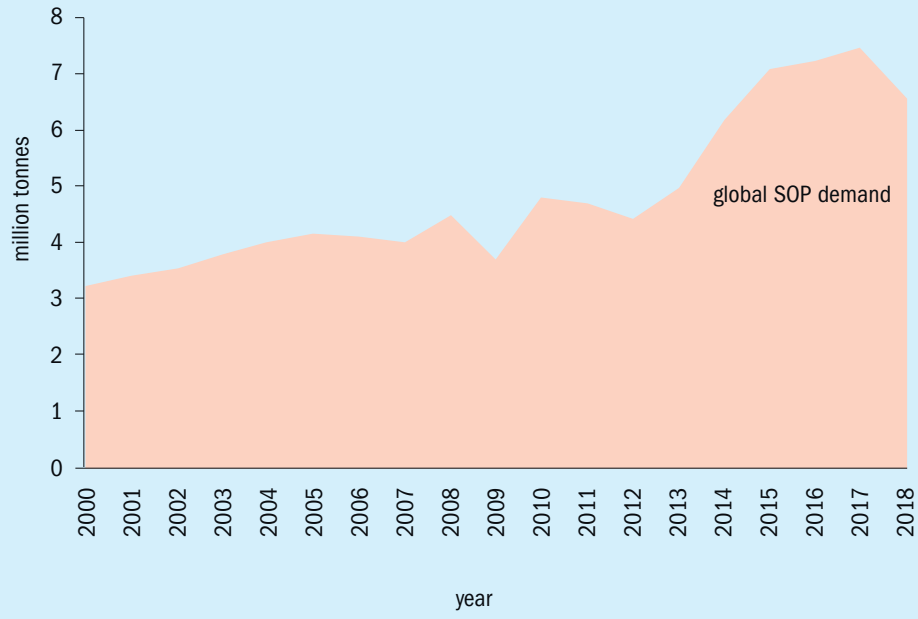
Further demand growth (1.3 percent p.a.) is expected over the next two decades, according to some forecasts, with the global market expanding to 8.7 million tonnes by 2040.

In contrast to the last decade, SOP demand is expected to increase more rapidly (2.3 percent p.a.) outside of China over the next 20 years. Other demand projections are more bullish with 2-3 percent growth out to 2040, accompanied by a rise in SOP prices to $961-997/t by the end of this period.

Large amounts of standard and granular SOP products are currently consumed in the manufacture of compound and blended NPK fertilizers. Indeed, growing demand for SOP-based NPKs is expected to drive up consumption in the European market.

The water-soluble segment, although representing less than 10 percent of the

Fig. 1: **Global SOP demand, 2000-2018**



Source: Australian potash

total SOP market, is growing at a faster rate of around five percent p.a. Most water-soluble SOP, unlike granular product, is sold straight, although some is used to manufacture water-soluble and liquid NPKs.

Demand for more?

There is still unmet SOP demand in the market, according to Tessenderlo Kerley International: "We believe that SOP market growth is probably constrained by supply. The supply/demand balance remains very tight – it is difficult to supply all demand – [and] if there was more product on the market it would almost certainly be consumed. So, potentially, growth could be even higher if more production was available."

The demand potential for SOP is mainly concentrated in five countries, according to an analysis by CRU, being linked to specific crop types grown domestically in each of these economies:

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

CRU calculated the potential SOP demand in these countries based on the acreages of chloride-sensitive crops grown. China emerged as the country with the highest potential level of SOP demand, with India coming a distant second and the United States ranked third. Russia, Brazil and Nigeria also appear to be significantly under-consuming SOP, based on the potential for potash removal by chloride-sensitive crops (*Fertilizer International* 475, p49).

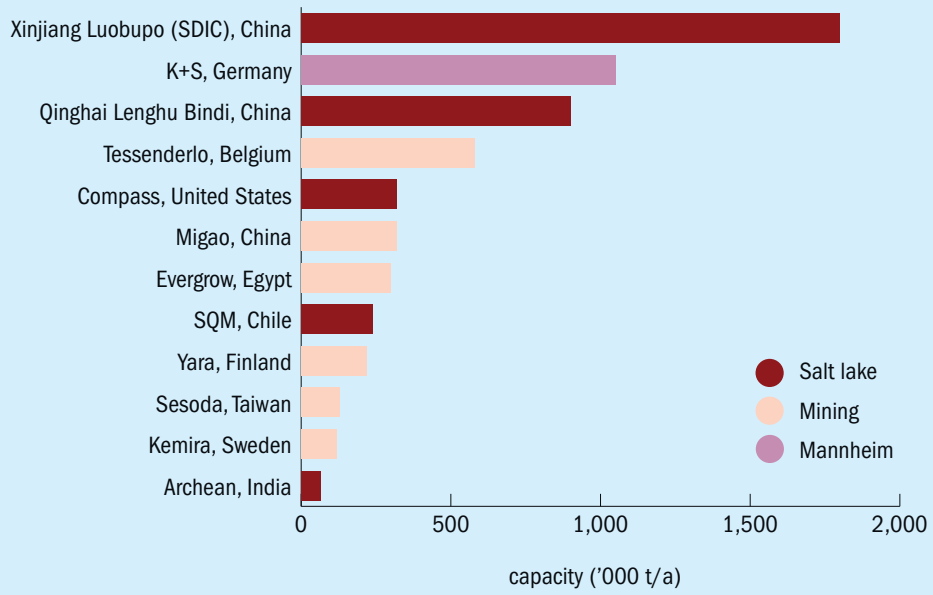
"Cultivation of chloride-sensitive and intolerant crops has grown very rapidly in areas of significant population growth, such as Africa, South Asia and Southeast Asia," CRU concluded. "We think there's a lot of future potential in these regions."

Primary and secondary producers

Annual global production capacity for SOP exceeds 11 million tonnes, according to some estimates (Figure 2), although actual output, and hence global supply, depends on the operating rates of individual producers.

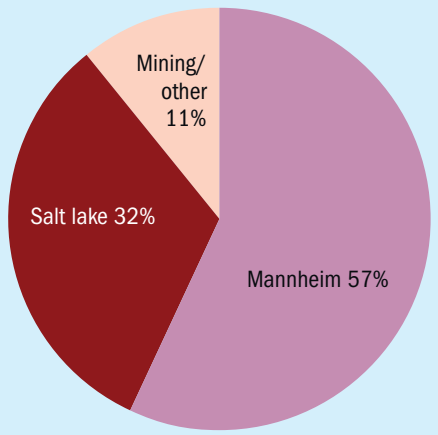
SOP is mainly manufactured via two production processes: primary production from salt lake brines or by the secondary Mannheim production process from potassium chloride ore. These two production routes account for around 57 percent and 32 percent of production capacity, respectively

Fig. 2: **Major global SOP producers, by capacity.**



Source: Australian Potash/Argus/other

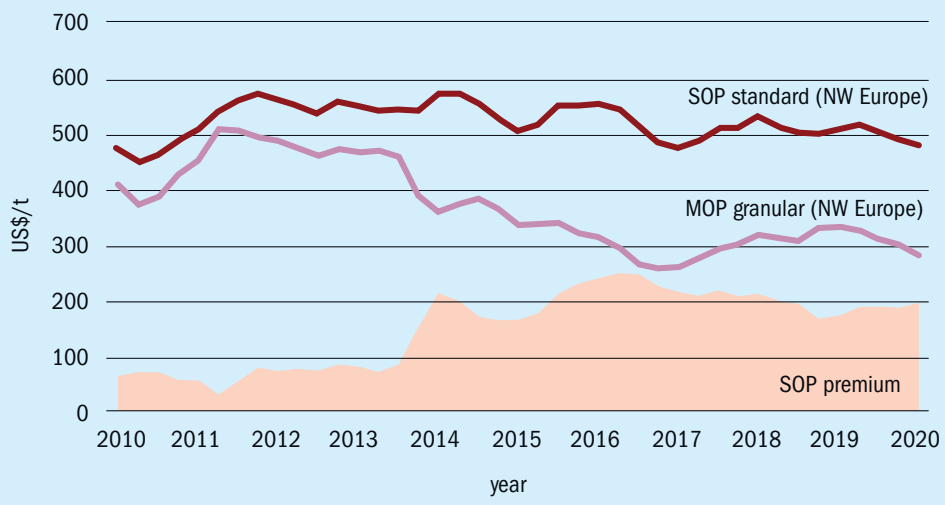
Fig. 3: **Global SOP production, by process**



Total global production capacity: 11.2 million t/a

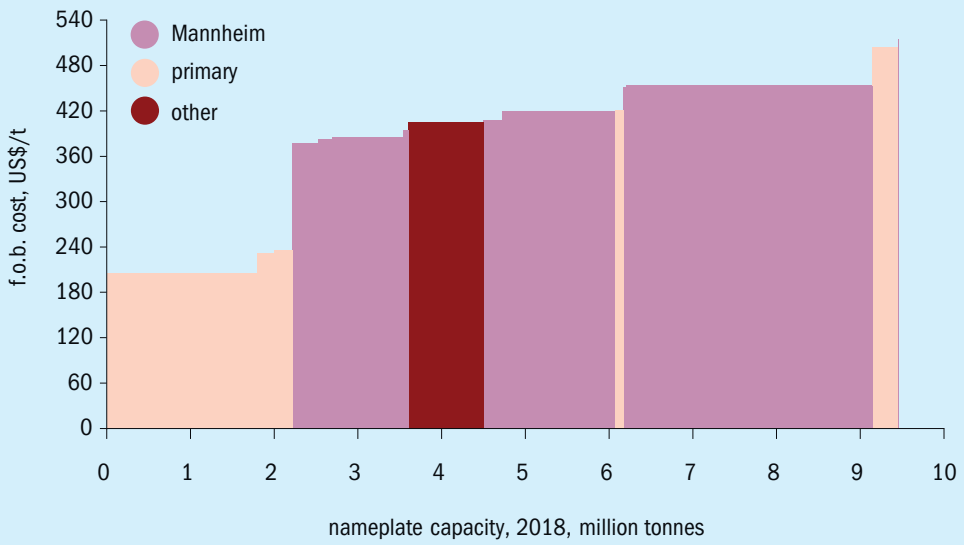
Source: Australian Potash/Argus

Fig. 4: **MOP vs SOP prices, f.o.b. NW Europe, 2010-2020**



Source: Salt Lake Potash

Fig. 5: **Cost curve for the global SOP industry, 2018**



Source: modified from Australian Potash/Argus

(Figure 3). In Germany, K+S also produces SOP from kieserite and potassium chloride ore using a re-crystallisation process.

The main primary SOP producers include:

- SDIC Luobupo at Lop Nur, Xinjiang, China
- Qinghai Lenghu Bindi, Kunteyi, Qinghai, China
- Compass Minerals, Ogden, Great Salt Lake, Utah, United States
- SQM, Salar de Atacama, Chile
- Archean Group, Great Rann of Kutch, Gujarat, India.

Leading secondary producers include:

- K+S, Werra, Germany
- Tessenderlo, Ham, Belgium
- Migao, four sites, China
- Yara, Kokkola, Finland
- Kemira, Helsingborg, Sweden.

Pricing, premiums and costs

SOP commands an attractive price premium over MOP. This has averaged $269/t over the last five years with European SOP prices remaining relatively stable at $500-600/t over this period (Figure 4). While the MOP (f.o.b. Vancouver) price fell over the course of 2019, trading in the region of $240-320/t, the SOP price (f.o.b. Western Europe) generally traded above $490/t ($490-520/t) – offering attractive premiums of at least $170/t last year. This premium has since widened due to the further decline in the Vancouver MOP benchmark during 2020.

Although an over simplification, the SOP industry's cost base broadly divides between lower cost primary (brine) and higher cost secondary (Mannheim) operations (Figure 5). Not only is the Mannheim production route exposed to raw material price volatility, it is generally more energy intensive than brine production, particularly in comparison to China's large-scale primary producers which occupy the lowest position on the industry's cost curve. The management and disposal of the hydrochloric acid by-product of the Mannheim process is an added burden for secondary producers.

Because of their position further up the cost curve, it is the conversion costs for the Mannheim process – roughly $100/t above the MOP raw material cost – that helps set the floor price for SOP. The industry's cost curve (Figure 5) also suggests that about 50 percent of producers will make a loss at SOP price levels below $410/t.

As analysts CRU have commented previously: "Primary producers tend to be very large-scale and low cost. Whereas secondary producers are significantly exposed to fluctuations in price for both input MOP and output SOP. They pay particular attention to the premium between the two as this significantly impacts their margins. Secondary producers do well in the market when premiums are high."

China's central market importance

China's primary SOP capacity is concentrated in the far western inland provinces of Xinjiang and Qinghai. The country's SOP production capacity has expanded fast, rising from less than two million tonnes in 2007 to more than seven million tonnes currently, equivalent to about two-thirds of global capacity. The Chinese SOP market has been transformed over the last decade by the entrance of low-cost primary producers such as Xinjiang-based Luobupo (*Fertilizer International* 475, p49).

Secondary producer Migao Corporation, meanwhile, manufactures SOP at four Mannheim production sites in China with a combined capacity of 320,000 tonnes. While China's primary SOP capacity is located inland, the coastal provinces of Guandong and Shandong

dominate secondary production. A location near to ports is also a matter of necessity for secondary producers as they rely on imports for their main raw material, MOP. Secondary producers also benefit from a logistical advantage, being closer to the centres of agricultural demand in southern provinces (*Fertilizer International* 475, p49).

China accounts for more than half of global SOP consumption and has been the engine of global demand growth over the last decade. Domestic SOP demand has been driven upwards by a rapid rise in the cultivation of chloride-sensitive crops such as fruit, vegetables, tea and tree nuts in recent years. Consumption is concentrated in southern provinces where the majority of the country's fruit and vegetables are grown. Rapid demand growth in the Chinese market has generally been strong enough to absorb newly-commissioned primary and secondary SOP capacity and keep prices stable. The concentration of primary production in western provinces has, however, resulted in a geographical mismatch with demand (*Fertilizer International* 475, p49).

Europe dominates world trade

Only six SOP producers globally have the capacity to produce more than 300,000 t/a. Leading producers outside China include:

- Tessenderlo Kerley International (*GranuPotasse*, *SoluPotasse*, *K-Leaf*) in Belgium
- K+S Group (*KALISOP*, *soluSOP, hortiSUL*) in Germany
- Compass Minerals (*Protassium+*) in the United States

These three SOP producers collectively account for more than 50 percent of ex China world SOP supply.

World trade in SOP largely comes from just four countries, namely Germany, (K+S Group), Belgium (Tessenderlo), Taiwan, (Sesoda) and Chile (SQM). Historically, Germany and Belgium combined have together accounted for over 80 percent of global SOP exports. The recent announcement of an offtake agreement with Kemira's Helsingborg plant in Sweden should consolidate and bolster Tessenderlo's – and Europe's – market position (p56). Chile primarily supplies SOP to the Americas, augmented by minor supplies to Europe and Africa, whilst Taiwanese exports target smaller markets in East Asia.

In contrast to the concentration in export supply, SOP imports tend to be highly dispersed with annual import deliveries of tens of thousands of tonnes being typical of most markets around the world (*Fertilizer International* 475, p49).

China opens the floodgates

Is the stable pattern of international SOP trade about to change? Last year, the Beijing government surprised the market by announcing the lifting of export tariffs on Chinese SOP from the start of January 2019. This move, according to analysts ICIS, could potentially open the floodgates and release "a deluge of refined SOP" onto the world stage[1].

Tariff removal has had significant market effects. A comparison of January-June trade data for the last three year reveals that Chinese SOP export volumes rocketed from just above 3,000 tonnes in 2018 to more than 200,000 tonnes in 2019 (Table 1). This export trend looks set to continue, according to ICIS, even as China starts to retire its older Mannheim operations.

First half data for 2020 shows that Chinese SOP export volumes fell back slightly, coming in at just under 187,000 tonnes. Iran, Myanmar, South Africa, Japan and India, and Latin American countries such as Mexico, Peru, Chile, Costa Rica and Ecuador, were among the top ten export destinations (Table 1).

Table 1: **Major Chinese SOP export destinations, January-June, 2018-2020**

Country	Exports, Jan-Jun (t)			(%)
	2018	2019	2020	2020
Iran	0	100,615	40,566	21.7
Mexico	0	15,942	25,504	13.7
Peru	0	5,367	20,958	11.2
Myanmar	148	17,793	16,949	9.1
South Africa	0	7,406	11,782	6.3
Chile	0	7,231	10,536	5.6
Japan	60	3,654	7,497	4.0
India	1,235	7,844	5,405	2.9
Costa Rica	0	3,059	4739	2.5
Ecuador	0	2,182	4162	2.3
World	**3,293**	**203,444**	**186,824**	**100**

Source: TDM via ICIS

> **China accounts for more than half of global SOP consumption and has been the engine of global demand growth over the last decade.**

"At seven million tonnes a year, in a market as small as SOP, demand from a new location – even one or two hundred thousand tonnes – can upset the balance," one major European SOP producer told ICIS last year [1].

"Chinese tonnes are definitely putting more pressure on the market. We're not seeing Chinese tonnes in Europe yet – though it's only a matter of time," the source added.

China is likely to continue to ship SOP internationally, if the government keeps export tariffs at zero, suggests Andy Hemphill, senior editor for potash at ICIS. "Although China's January-June 2020 exports are down some eight percent year-on-year, this is likely a side-effect of the coronavirus, and not evidence of a change in China's potential as a power-player in SOP," Hemphill told *Fertilizer International*. "The question remains whether the globe's increasing hunger for SOP will absorb Chinese tonnes, without a noticeable effect on the market balance." ■

References

1. Hemphill, A. 2019. *Seed money - The growing SOP fertilizer market*. ICIS Insight, July 2019.

Great Salt Lake solar evaporation ponds in Utah, United States.

PHOTO: COMPASS MINERALS

SPOTLIGHT ON COMPASS MINERALS

Largest SOP producer in the western hemisphere

Compass Minerals manufactures potassium sulphate (SOP) products from two locations in North America.

Its market-leading *Protassium+* granular SOP product is produced at the company's plant near Ogden, Utah, from brine extracted from the Great Salt Lake using a natural solar evaporation process. *Protassium+*, a premium, low-chloride potassium fertilizer, is used in speciality agriculture, pharmaceutical and industrial applications. The Ogden operation also has the unique ability to supplement brine-based production by converting potassium chloride (MOP) into SOP.

Compass Minerals also produces high-analysis grades of water-soluble potassium sulphate – some with more than 99.7 percent purity – at its 40,000 ton capacity Wynyard plant at Big Quill Lake, Saskatchewan.

Utah and Saskatchewan operations

The company's Utah operation is the largest primary SOP production site in the western hemisphere – and is one of only four large-scale operations globally that produce SOP from the solar evaporation of brine. Approximately 55,000 acres of solar evaporation ponds (see photo) produce SOP and other salts, including magnesium chloride, from the Great Salt Lake's naturally-occurring brine.

Its other Wynyard, Saskatchewan, operation is Canada's only SOP production plant. At this site, Compass Minerals creates SOP by combining sulphate-rich brines with externally-sourced MOP using ion exchange and glaserite processes. The resulting SOP is highly pure and is marketed as a speciality crop nutrient product and for non-agricultural speciality applications.

Investing for efficiency, increased capacity and growth

Targeted investments by Compass Minerals have expanded capacity and increased efficiency at its Utah SOP plant. These have included processing plant and evaporation pond upgrades. As a result, SOP production capacity has now increased to 550,000 tons. These investments have helped Compass Minerals to continue to supply growing North American SOP market demand and maintain its position as the consistent supplier of choice.

> **"Our manufacturing process is highly efficient and allows us to be positioned globally as a low cost producer."**

"As the only US producer and manufacturer of OMRI-certified [organic] sulphate of potash, we continue to leverage this unique asset accelerating capacity to meet market demand," commented George Schuller Jr, chief operating officer at Compass Minerals."Through solar evaporation at our Utah facility, our manufacturing process is highly efficient and allows us to be positioned globally as a low cost producer."

Long-term SOP production at both Ogden and Wyngard looks secure. Compass Minerals holds the numerous environmental and mineral extraction permits, water rights, licenses and other government approvals needed to allow operations at both sites to continue well into the future.

Protassium+

Protassium+ provides speciality crops with the vital potassium they need for healthy growth, high yield and harvest quality. It also helps with crop stress and improves resistance to drought and disease. Other key characteristics are:

- **High sulphur**: Sulphur helps support plant functions that have a positive influence on yield, quality and marketability. Sulphur deficiency is also on the increase – highlighting the need to replenish this nutrient so crops can deliver more profitable returns.
- **Low chloride**: Many speciality crops, turf and ornamental plants are particularly chloride-sensitive. For these plants, continued application of potassium sources with a high chloride content or salt index is undesirable as they have a toxic effect. The use of *Protassium+*, in contrast, helps avoid the build-up of chloride or salt in soil that can result in lower yields, lower quality, poorer appearance and lost income.
- **Low salt**: SOP has the lowest salt index (per unit of K_2O) of all the major potassium sources. Because of this, *Protassium+* is able to minimise the risk of soil toxicity.

SPOTLIGHT ON K+S

Unique process, unique products

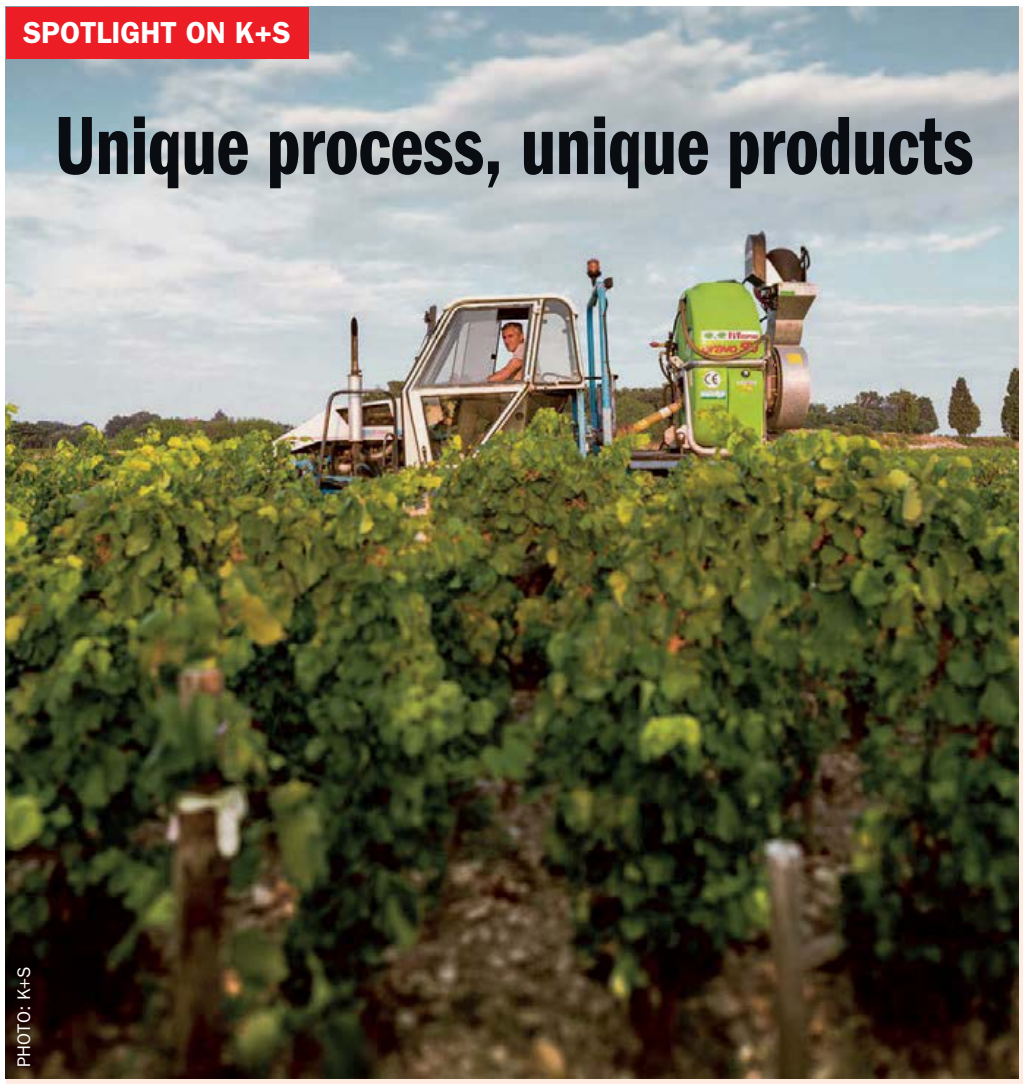


PHOTO: K+S

Patentkali ensures good quality, high yields and great tasting grapes.

Germany's K+S is the world's fifth-largest and Western Europe's largest producer of potash products. The company manufactures a range of potassium sulphate (SOP) and SOP-based products at three production sites in Germany (Wintershall, Hattorf and Bergmannssegen-Hugo). These include *KALISOP®*, its granular SOP product range, and speciality products such as *Patentkali®*.

K+S is the largest SOP producer outside of China, producing between 700,000-900,000 tonnes of SOP annually, according to market circumstances. Additionally, the company's produces between 200,000-230,000 tonnes of *Patentkali®* every year – described by K+S as its most important SOP speciality product.

Production process

K+S currently has the capacity to produce up to nine million tonnes of potash and magnesium products each year. From several deposits in Germany, crude ore is mined underground by conventional drilling and blasting. Large shovel loaders convey the ore to crushing plants. From there, the crushed ore is transported onwards by conveyor to the extraction shaft. Once brought to the surface, the ore is processed to obtain potassium chloride (KCl), magnesium sulphate ($MgSO_4$), kieserite ($MgSO_4 \cdot H_2O$), epsom salt ($MgSO_4.7H_2O$), potassium sulphate (K_2SO_4) and rock salt (NaCl).

The crude ore consists of various natural minerals such as sylvite (KCl), halite (NaCl), langbeinite ($K_2Mg_2(SO_4)_3$), kieserite ($MgSO_4.H_2O$) and clay. During processing, most of the halite is firstly removed using a physical extraction process to obtain a concentrate of sylvite, langbeinite and kieserite, the main valuable mineral components. This mineral concentrate is then dissolved in water. Purified SOP is finally obtained from the resulting solution via crystallisation. This purification step is carried out without the use of any chemicals or additives. The finely-crystalline SOP obtained is dried and marketed as *KALISOP®* fine. Dried SOP is also compacted into granules using roller presses and marketed as *KALISOP® gran*.

Patentkali® is produced at two German production sites, Wintershall and Bergmanssegen-Hugo, and contains both SOP and kieserite. It is manufactured by combining together two K+S products – *KALISOP®* and *ESTA® Kieserit* – both of which are approved for organic farming. *ESTA® Kieserit* is manufactured by extracting kieserite from crude ore using a patented electrostatic separation process (ESTA).

KALISOP® and *Patentkali®*

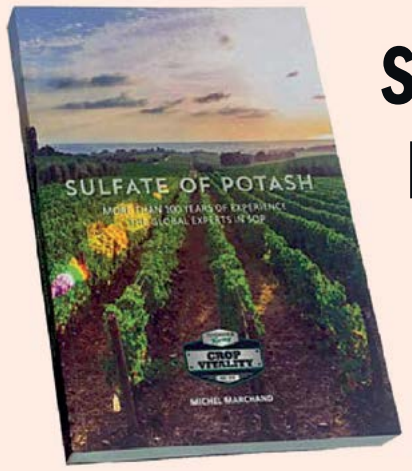
Due to their unique production process and natural origin, the *KALISOP®* product range from K+S:

- Require relatively low energy input to manufacture
- Has a neutral to slightly alkaline pH
- Has very low heavy metal contents
- Are approved for organic farming.

KALISOP® provides a highly-concentrated plant-available supply of sulphur and potassium. It is classed as an organic fertilizer and is virtually chloride-free, making it ideal for chloride-sensitive crops. The low salt index of *KALISOP®* also means it is particularly suitable for high-value cash crops grown in intensive cropping systems.

KALISOP® is offered in granulated form and as a fine powder. It is also available as *KALISOP® Premium*, a round granulated product. *KALISOP® Premium* is ideal for bulk blending because of the roundness and stability of its granules. Its round shape also makes accurate spreading possible even at large widths. K+S also offers two premium water-soluble SOP products, *soluSOP® 52* and *hortiSUL®*, for fertigation systems and foliar application.

Patentkali® is a speciality potassium fertilizer with a high magnesium and sulphur content. It is well-suited to chloride-sensitive agricultural, horticultural and forestry crops due to its low chloride content (3% Cl maximum). *Patentkali®* is particularly suitable for crops such as potatoes, vegetables, fruits, grapes and sunflowers. It is certified for organic farming and provides nutrients at an ideal potassium-to-magnesium ratio of 3:1. ■



Sulfate of Potash: More than 100 years of experience

We talk to **Nicolas White**, Portfolio & Knowledge Director at Tessenderlo Kerley International, about the company's new agronomic book on SOP – *Sulfate of Potash: More than 100 years of experience*. At almost 350 pages, the book is unique in its depth and breadth of coverage.

How valuable is the book in your view and who is it aimed at?

We're very proud of it. The book brings together all our agronomic knowledge on SOP for the first time in one reference. There's arguably no other book that covers SOP plant nutrition in such depth.

The information in the book shows how to optimise the use of potassium sulphate fertilizer in crop production. It is the culmination of many years of field trials and, because of this, we believe the book is unique and of real value to growers. It's sure to become an essential point of reference for every agronomist who provides advice and makes recommendations on potassium fertilization using SOP.

Could you tell us a little more about the author.

Without question, Michel Marchand is one of the world's leading experts on potassium sulphate fertilization. Michel, who has recently retired, was formerly the senior agronomist at Tessenderlo Kerley International as well as the former chairman of the Sulphate of Potash Information Board (SOPIB) agronomy committee. For many year's Michel was the foundation of our knowledge base for potash and SOP fertilization.

Many people have benefitted from Michel's SOP expertise, thanks to his extensive international experience and 40 years working in agriculture. During his distinguished career, Michel demonstrated the benefits of SOP by conducting numerous field trials across the world in collaboration with different research organisations – and then presenting these findings at many international conferences.

The book draws on more than 100 years of expertise. It covers the nutrients needs of a vast array of crops – almost 50 different crop types.

Yes, as you can imagine, it's taken a huge amount of time and resources over many years to collect this information. Indeed, last year, Tessenderlo Group celebrated 100 years of SOP production in Belgium. In this time we have become recognised as one of the leading suppliers of high quality SOP products.

Our *SoluPotasse*® water-soluble grade SOP is the market-leading reference product. Tessenderlo Kerley International is also the only company to offer a special grade, *K-Leaf*®, designed especially for foliar application.

We are also one of the few SOP producers that has a dedicated team of agronomists to advise and support our customers and their growers. Over the years, our expertise has allowed us to build up a network of partners who also advocate the use of SOP – as an important chloride- and nitrate-free potash source. That's allowed us to enhance and build knowledge on SOP within our team. Our aim, of course, is to continue to share this knowledge!

Has SOP usage by crop type changed and evolved in recent years. If so, what's been driving that – and where do you see real growth potential ahead?

Globally, the key market for SOP crops remain cash crops – fruits, vegetables and others – where quality as well as yield influence the crop's marketability and value. In addition, many of these crops are either sensitive or intolerant to chloride, which means the use of potassium chloride as a potash source is not recommended.

SOP has always been priced at a premium compared to MOP, because of the absence of chloride and because of the added value of sulphur in the sulphate form that the product contains. The SOP market has grown steadily over the last couples of decades and has almost doubled over the last 10 years.

SOP growth has more or less tracked the global growth in potash demand. That said, the MOP and SOP markets should be considered as distinct and separate. MOP is used principally in field crops, whereas SOP is used in cash crops. MOP tends to be used in temperate or tropical climates, while SOP is often used in arid or semi-arid climates.

The producers of MOP, with a few exceptions, are also a different group of companies to SOP producers. Hence the market supply-demand characteristics of the two products are very different – as has been demonstrated on several occasions in the last decade.

What we do see for SOP is much more rapid growth in the use of special, high-grade water-soluble products for use in drip irrigation systems. The push for this has been the drive to improve both water and nutrient use efficiency.

The growth in SOP consumption will almost certainly be driven by better product knowledge and information on how to get the best fertilization results. Many of our trials – which feature in the book – have demonstrated the cost effectiveness of SOP use. This is often down to an increase in both quality and yield of the crops. SOP use can also enhance the crop's shelf life during storage and transport.

One area where we have put in a lot of effort in recent years is demonstrating the effectiveness of foliar SOP for improving yield and quality. Foliar sprays can complement the potash fertilization of soil by providing the crop with a potash boost at times of rapid growth or when the crop has a high need for potassium. The merits of applying foliar potash in the absence of a deficiency is a new idea. So a lot of education is required to make growers aware of the potential benefits.

The importance of high and consistent product quality is one of the book's themes. Why is it so important to highlight quality when it comes to SOP?

Quite simply because we believe there is a great variation in the market and that growers and fertilizer manufacturers will get the best result from using high quality materials.

Using the best quality SOP products becomes particularly important in the case of water-soluble fertilizers used in expensive equipment such as drip irrigation systems or foliar sprayers. Manufacturers of drip irrigation equipment are often astounded that growers invest heavily in these systems and then damage them by using inferior quality fertilizers.

Our research also shows that modern foliar spraying equipment benefits from a superior grade of SOP that is specifically designed for this use – which is why we developed and market *K-Leaf*® for this application.

Importantly, the book highlights a quality scoring system we have developed for water-soluble SOP products. This has enabled us to benchmark our leading *SoluPotasse*® product against other water-soluble products on the market.

The book makes a strong case for the three-fold benefits of SOP, i.e. its chloride-free nature coupled to its ability, as a dual nutrient source, to provide plants with both potassium and sulphur. How valuable are each of these three attributes in your view?

Michel, along with many others, spent a lot of time educating farmers on the importance of balanced fertilization. Despite everyone's efforts there are still regions where potash is underused compared to other fertilizers. Our team of agronomists continues to work tirelessly to try to change this.

SOP was originally introduced to offer growers a chloride-free potash source for use in crops intolerant or sensitive to chloride. This remains probably the most important benefit and is why growers pay a premium for the product compared to MOP. What we are also seeing is increasing demand in the areas at risk from soil salinity – SOP has an important role to play in these conditions, in our view.

The presence of sulphur in the sulphate form – which is readily taken up by plants – is also a valuable additional benefit now. Sulphur is indeed becoming more important and cases of deficiency are on the increase, particular as growers switch to higher yielding varieties of many crops.

This books isn't the last word on the agronomic benefits of SOP. I understand you're publishing authoritative but accessible crop brochures, starting with nutrition guides for potato and grapes.

Ensuring all of Tessenderlo Kerley International's agronomic knowledge is documented, safeguarded and shared is a key part of my role. In fact, since bringing together our thiosulphate and SOP product portfolios, we have taken the opportunity to review and enhance the information we have available on the use of all products for a wide range of crops.

There is a large amount of information available in our 'Knowledge Centre' on our website. We already have a range of application guides for our products, for example. But we're also starting to build what we hope will be an informative series of crop guides. These are based on the knowledge and experience of our agronomists deployed throughout the world. ■

Tessenderlo Kerley International partners with Kemira

Belgium-headquartered Tessenderlo Kerley International, a business unit of Tessenderlo Group, has entered into a new partnership with Kemira of Finland. The two companies have signed a long-term off-take agreement for the marketing and distribution of premium SOP (sulphate of potash) fertilizers.

Tessenderlo Kerley International has announced that in future it will off-take and market the premium water-soluble grade SOP produced by Kemira at its plant in Helsingborg, Sweden. The new deal strengthens Tessenderlo Kerley International's position in the premium water-soluble segment of the speciality fertilizer market.

As part of this new agreement – which will commence and become fully operational at the start of 2021 – Tessenderlo Kerley International will additionally have access to part of Kemira's standard powder grade SOP production output at Helsingborg as well.

Tessenderlo Kerley International is already a well-established leader in the fertigation and foliar segments of the SOP market, building on expertise dating back 100 years. The company is a top five global SOP producer – exporting to more than 90 countries from its production site in Ham, Belgium.

Geert Gyselinck, Executive Vice President of the Tessenderlo Kerley International business unit, explains the rationale behind the new partnership with Kemira:

"This long-term agreement is an ambitious step forward, enabling Tessenderlo Kerley International to grow and remain the leader in this premium water-soluble potassium sulphate market. Thanks to this contract, SOP customers around the world can now be ensured even more reliability of supply, access to highest quality product, and qualitative service and support. With Kemira, we partner with a SOP Mannheim producer who shares the same mindset towards continuous improvement and qualitative production."

Tessenderlo's Ham plant in Belgium has the world's largest production capacity for water-soluble SOP.

PHOTO: TESSENDERLO

Tessenderlo Kerley International offers a complete line of SOP fertilizers and, as well as having local sales staff in most of the key markets for SOP, the company benefits from a worldwide team of 23 agronomy managers. This team carries out research and advises customers on the benefits and use of SOP, as well as the company's range of liquid thiosulphate fertilizers.

SOP is predominantly used as a fertilizer for specialty crops such as flowers, fruits and vegetables. This type of potash delivers both potassium and sulphur to plants as readily available nutrients at high concentration. SOP's very low salinity index also makes it the potash fertilizer of choice in those areas at risk from soil salinity.

Tessenderlo Kerley International celebrated 100 years of SOP production in 2019. To commemorate this landmark centenary, the company recently published a comprehensive book on the agronomic benefits of SOP (see page 54), the culmination of many years of research.

Fertilizer International **sat down with Tessenderlo Kerley International to discuss the new partnership with Kemira.**

How will the offtake agreement benefit customers?

The agreement with Kemira increases the amount of premium water-soluble SOP that we can bring to market for the benefit of all customers. Being able to supply from two sites provides additional logistical flexibility for deliveries and enhanced output – something that is particularly important in periods of high demand.

Our agronomic team is widely recognised for its leading global expertise in SOP. All our customers will benefit from the team's agronomic know-how, backed by even more reliable commercial support and efficient supply.

Which SOP product grades are we talking about?

The Helsingborg site currently produces two product grades: standard powder grade SOP – generally used for the manufacture of compound NPKs – and water-soluble fertigation grade SOP, which is generally sold directly into the market through distributors. Our plant at Ham, meanwhile, produces a comprehensive range of SOP products. That includes powder, granular and soluble grades, as well as a special grade – *K-Leaf*® – for foliar applications.

How is SOP manufactured?

Our SOP production unit at Ham and Kemira's unit at Helsingborg both use the same Mannheim process. This converts sulphuric acid and potassium chloride (MOP) into potassium sulphate (SOP) and hydrochloric acid. The hydrochloric acid generated at both sites provides a source of raw materials for other production processes.

Why is Kemira producing SOP at Helsingborg?

Over the last couple of decades, Kemira has taken a step back from the fertilizer market, preferring to focus on other sectors instead. One of these is water treatment chemicals – which require hydrochloric acid as a starting material. For Kemira, the Mannheim process is therefore largely a means of producing hydrochloric acid, although Kemira was using the SOP generated alongside this to supply a number of clients under long-term contracts.

We also use the hydrochloric acid generated at our Ham site in Belgium in other processes, such as the production of calcium chloride.

Are both company's SOP products of comparable quality?

Yes. Both of us produce high-grade SOP by the Mannheim process and have a reputation for supplying top quality products. In particular, the water-soluble grades produced by Tessenderlo and Kemira are among the most sought after for use in drip irrigation systems.

There are some minor differences in product characteristics. However, these will potentially allow Tessenderlo to better match the characteristics of supplied products to the specific needs of individual customers.

We also have customers in common. Several companies that use SOP to make compound NPKs already source material from both companies.

What volumes of SOP are covered by the agreement?

We will off-take and market the premium water-soluble SOP produced by Kemira at its Helsingborg plant. The agreement also provides us with access to part of Kemira's standard powder grade SOP production output from the same plant.

When does the offtake agreement start?

At the beginning of 2021.

How will products produced at Helsingborg be branded in future?

Some commercial aspects of the offtake agreement are yet to be decided. The aim is to make the transition as smooth as possible for all customers. We obviously have a portfolio of well-known SOP product brands, and our goal is to further strengthen and protect their reputation. Some SOP will continue to be suppl ied in Kemira branded bags in the short term. But the long-term goal is to market and sell most SOP products under Tessenderlo Kerley International's own brand names. Nevertheless, we will keep serving customers with private label branded bags and there are customers of both companies who will prefer to purchase SOP in big bags, particularly those who manufacture high quality water-soluble and liquid NPKs.

Will products produced at Ham and Helsingborg be priced differently?

We believe the range of SOP products produced at both sites are among the best quality available in the market. Both use the Mannheim process and hence manufacture SOP products with very similar characteristics. We intend, therefore, to apply one overall pricing strategy for all our water-soluble SOP products, irrespective of the production site. Having said that, variations in logistical costs, and shipping through local ports, may lead to small differences in SOP pricing between the two units.

How will this agreement enhance Tessenderlo Kerley International's position in the market?

Today, the global market for SOP product is around seven million tonnes, with 55-60 percent of that volume coming from China. European producers currently account for only 20-25 percent of supply, much of this being incorporated by customers into NPK fertilizers for re-export to global markets.

Tessenderlo Kerley International was the first to introduce a truly soluble grade of SOP (*SoluPotasse*®) back in the mid-1990s. This has remained the leading product in this market segment ever since. The world market for water-soluble SOP grew following the global economic crisis in 2009, with many existing SOP producers moving to increase production of this higher value grade. This trend also coincided with many new SOP producers entering the market, almost all offering water-soluble SOP grades. While the quality of water-soluble SOP varies widely from one producer to another, that manufactured by the Mannheim process in Europe remains the best quality available, in our view, with *SoluPotasse*® being the reference product in the market.

Kemira, similar to ourselves, has many years of experience of the Mannheim process and, consequently, the water-soluble SOP produced at Helsingborg is of very good quality. The opportunity to fully commercialise this product, alongside that produced in Ham, will allow us to maintain our market leading position in the premium water-soluble segment in response to increased competition.

The agreement to off-take Kemira's production of water-soluble SOP means Tessenderlo Kerley International will become the largest global supplier of this premium SOP grade. This will allow us to continue to meet the needs of our customers even more reliably in future, in what is a growing market. ■

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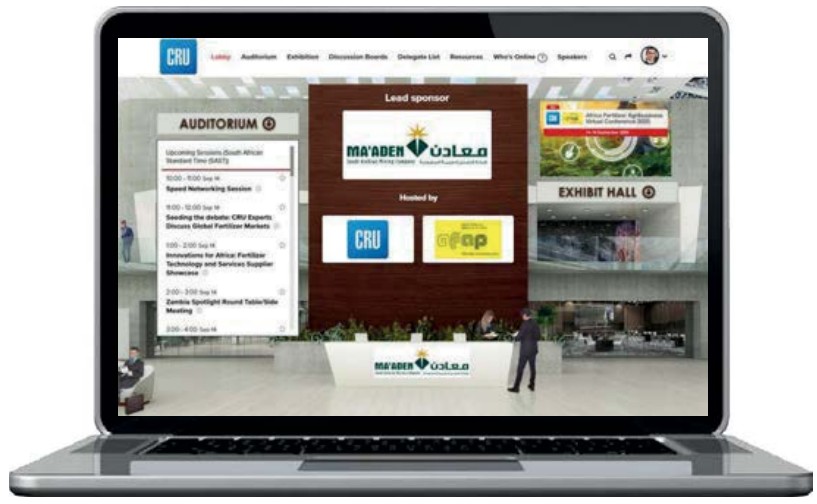

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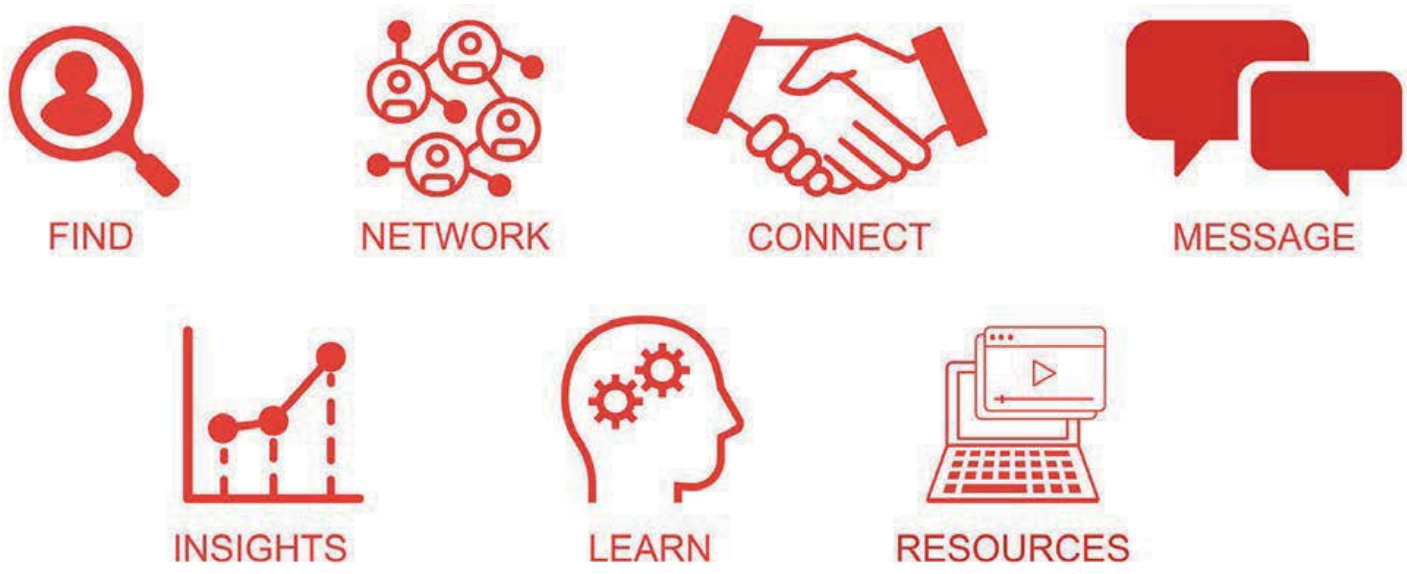

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