Welcome to our interactive version of Fertilizer International Issue 477

Please use either the buttons on the left or top right of the page to navigate your way around this interactive PDF

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Cover: *Field with rapeseed. Alexander Narraina/Shutterstock.com*

Phosphates market report

Process analysers

Read this issue online at: www.fertilizerinternational.com

Published by: BCInsight

INTERNATIONAL Fertilizer

www.fertilizerinternational.com

NUMBER 477 MARCH | APRIL 2017

CONTENTS

PHOSPHATES AND POTASH INSIGHT

REGULARS

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Spring innovation

> **Innovation is needed to add extra value to phosphate fertilizers and deliver production efficiencies.**

Phosphates 2017, CRU's annual phosphates conference, marks its tenth anniversary this March by returning to Tampa, Florida, the home state of the US phosphates industry.

Technical innovation will be a key conference theme this year. There's a whole plenary session devoted to the subject, together with a series of technical showcase presentations running over the course of the three-day event. During the plenary, JDCPhosphate's David Blake will state the case for making research and development a priority, especially at the current low point in the market.

In his introduction to Phosphates 2017, Chris Lawson, CRU's head of phosphates, also spoke of the need for innovation, in order to add extra value to downstream phosphate fertilizers and deliver production efficiencies (p50). The new wave of low-cost production capacity set to be commissioned in Saudi Arabia and Morocco this year will add fresh urgency to the need for the industry to innovate, in his view.

I suspect many North American delegates will be receptive to this message. That's because the global influence and prestige of the US phosphates industry, and its long tradition of production and engineering excellence, is built on continuous innovation.

Whenever something novel and ingenious is taking place at the phosphates sector's cutting edge, chances are North American expertise will be close at hand. For example, *MicroEssentials*, Mosaic's sulphur-enhanced product range, is arguably the most successful example of phosphate product innovation globally. *MicroEssentials* products are currently applied to around 11% of US farmland, broke the one million t/a production barrier in 2013, and now accounts for one-fifth of Mosaic's phosphates output. The success of *MicroEssentials* certainly exemplifies one maxim about innovation: "If you want something new, you have to stop doing something old."

We aim to keep our readers informed about influential innovations in the industry. We report on one such breakthrough this issue – the adoption of on-line, real-time analysers at phosphate mines, beneficiation plants and acid reactors (p52). These offer increasingly sophisticated regulation and control of the phosphates production process.

The reasons driving their adoption are compelling. "Most companies get their lab results every four or every six hours, even every eight hours in some cases. That means you're running your flotation process, your acid reactor or your mining operation blind," explains Seth Spiller of automated analyser company LexMar Global, speaking at last year's Phosphates 2016 conference in Paris.

What is most exciting about new process monitoring technology is that its full potential will only be realised as we move to the automated plants of the future. The real benefits and rewards of incorporating on-line analysis are only likely to become apparent as companies start to shift to distributed control systems, in which autonomous controllers feed information to a central plant operator.

How far away the industry is from fully-automated phosphates production is debatable. Yet the time devoted to discussing automation at last year's AIChE Clearwater conference does suggest the industry is at least readying itself for such an eventuality.

Another sign that innovation is holding sway this spring is the return of SYMPHOS, the 4th International Symposium on Innovation and Technology in the Phosphate Industry. The flagship biennial conference is being held at the UM6P Congress Center, Ben Guérir, Morocco, for the three days 8-10 May.

The previous event, SYMPHOS 2015, attracted more than 1,300 participants. Seven workshops and 19 plenary lectures were held over three days, and a total of 148 papers were presented. These were published in a special volume of *Procedia Engineering* last year.

More than 1,500 delegates are expected to attend this year's event, organised and hosted by OCP. SYMPHOS 2017 will highlight the latest advances in phosphates industry research and development. It will also showcase scientific and technological innovations, new agricultural applications, sustainable development and renewable energy.

In an increasingly competitive market, innovation is no longer an optional extra. Phosphates 2017 and SYMPHOS 2017 should provide valuable insights for producers as they strive to cut their costs further. After all, the recovery of the industry and its future prosperity will partly depend on innovation and reinvention, from the mine all the way to the farm gate. ■

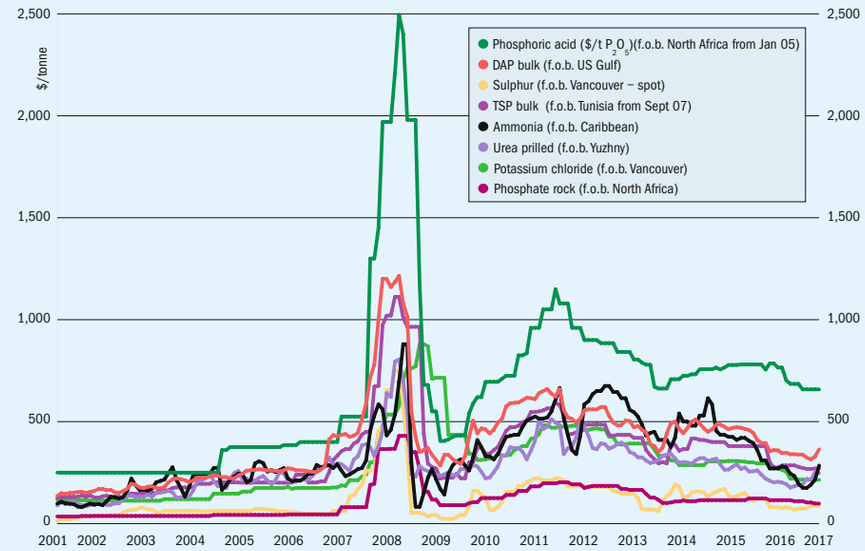
S. Inglethorpe

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Market outlook

Historical price trends $/tonne



Source: BCInsight

Market insight courtesy of Integer Research

AMMONIA

Global supply was severely disrupted at the start of 2017. Ammonia supplied through the Black Sea was at standstill until a dispute between Russian ammonia producer Togliatti and the Ukrainian pipeline operator Ukrkhimtransammiak was finally resolved on 3 February. The dispute caused the Yuzhny benchmark to rise to a 13-month high of $295/t f.o.b. in early February. Trinidadian producers also continued to suffer from gas curtailments of around 10-30%, although the reasons for this remain unclear. Recent short-term supply issues should be alleviated from March onwards by the availability of additional ammonia from capacity expansions in the US, South America and Asia.

UREA

The global market remained under pressure in early 2017, as a spate of short-term supply shortages spurred price increases. The Yuzhny urea price rebounded to $257/t f.o.b. in the second week of February, up by $42/t on December 2016. Chinese producers have largely exited the international urea market due to a strong domestic season and capacity rationalisation. There have also been supply shortages out of Ukraine, with both OPZ and Cherkassy not operating at all so far this year. An upcoming Indian tender in March should keep price sentiment upbeat.

PHOSPHATES

Finished phosphates prices continued to climb in January. All the major benchmarks increased by around $10-20/t and export cargoes were typically in the range of $330-340/t f.o.b. Ammonia and sulphur market uncertainties are underpinning higher prices, with producers raising offers as a way of passing on rising costs. Supply may tighten if producers cut output in a bid to raise export prices and netbacks. Some Chinese phosphate plants are also being mothballed on government orders. Global phosphates demand remains moderate, however, and average phosphate rock and phosphoric acid prices are flat currently.

POTASH

Optimism continues to creep into the market. Participants are encouraged by signs that China will agree 2017 volumes earlier than last year, possibly in late February or March. Sinochem has reportedly already met Canpotex for contract discussions. Encouragingly, stock levels in China were said to be 1.8 million tonnes at the end of 2016, considerably down on the three million tonne level of a year earlier. Suppliers are said to be pushing for a $15-20/t increase above the $219/t cfr price agreed with China last year.

MOP price benchmarks have been relatively stable since the start of year with adjustments limited to plus or minus $5/t. Vancouver and Middle East prices decreased mid-January but have since held their position at around $225/t f.o.b. Price movements in Brazil have been more substantial, increasing by $8/t this year to $245/t cfr by mid-February.

The market appears to have tightened on the supply side. Both BPC and Canpotex are reporting to be sold out due to strong global demand, the latter until the end of

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

April. Mosaic has responded by resuming production at its 2.6 million t/a Colonsay mine in January.

SULPHUR

Sulphur prices reached a ceiling in January, suggesting the upward momentum seen in 2016 has peaked. The tepid processed phosphates market appears to have taken its toll on trade. Middle East producer prices stalled in the first two months of the year. However, at around $88-90/t f.o.b., they remain robust, given the challenges in downstream markets. Chinese and Indian markets have helped shore up price levels, despite the absence of spot business in February. In China, thin demand over the Chinese New Year, and a hand-to-mouth purchasing strategy, slowed import interest with many buyers deciding to retreat to the sidelines. Meanwhile, the balanced supply situation – together with pockets of tightness in Russia and the Middle East – has brought about firmer price ideas for spot business. The recent uptick in finished phosphate prices has been linked to higher raw material costs, rather than a major shift in market sentiment.

Market price summary $/tonne – Mid-February 2017

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phosphoric Acid
f.o.b. Caribbean	285	n.m.	f.o.b. E. Europe 80-90	f.o.b. US Gulf	360-370	n.m.	n.m.
f.o.b. Yuzhny	300-320	242-252	-	f.o.b. N. Africa	340-380	270-280	505-810
f.o.b. Middle East	300-345	231-264**	-	cfr India	345	-	580*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	193-235	-	cfr US Gulf	35-40	f.o.b. Vancouver	83-88	
f.o.b. Middle East	190-232	-			f.o.b. Arab Gulf	86-90	
f.o.b. Western Europe	-	€440-460			cfr North Africa	70-85	
f.o.b. FSU	184-226				cfr India	103-107+	

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)*

MARKET DRIVERS

- **Ammonia:** Although earlier supply shortages have now been resolved, the market is likely to remain tight through the second quarter, keeping prices at higher levels. Seasonal demand should emerge from the end of February into March as the spring application season begins in Europe and North America. Prices should stay higher but below the level of February's spike. The Yuzhny price benchmark is forecast to trade around $240-275/t in March. Beyond the second quarter, the market looks long with weaker price sentiment as capacity expansions in the US and South America come on-stream.
- **Urea:** There has been little downside to the market in recent months. Market players are anticipating demand to increase in late February and into March as seasonal applications get underway. An import tender from India expected in March has also bolstered sentiment and supported pricing. Yuzhny availability could continue to be severely curtailed if OPZ fails to agree a new gas supply contract. For Yuzhny, a prilled urea price benchmark of $250-270/t f.o.b. is expected in March, as market players continue to be optimistic about pricing gains. The numerous capacity expansions expected might lead to softer prices heading into the second quarter.
- **Phosphates:** The lowering of Chinese capacity utilisation rates to around 50% during the first quarter may provide a short-term price boost. Price expectations could, however, move lower going into the second quarter as China still has a significant finished phosphates surplus. More certainty in global ammonia and sulphur markets could also pressure prices. Overall prospects for the year will become clearer during the second and third quarters, as demand picks up in India, Brazil and North America, and additional low-cost Moroccan and Saudi Arabian capacity is absorbed into the market. On balance, we expect to see average DAP export cargoes trending in the $330-340/t f.o.b. range going forward.
- **Potash:** The outlook for the coming year is generally positive. Global MOP demand is expected to be 62 million tonnes in 2017, up 2.3 million tonnes on the 2016 estimate. Many key markets also started 2017 with lower inventories year-on-year. The need to refill these should strengthen the demand base this year.

  Brazil and China imports increased markedly in the three months ending January 2017, with import statistics showing a 45% year-on-year increase. Brazilian demand is currently supported by higher local currency prices for soybeans, corn and sugar. China is also expected to see a strong uptick in year-on-year demand, as buyers fill inventories depleted by 2016's delayed contract settlement.

  This robust demand picture coincides with new greenfield capacity coming on-stream. K+S Legacy in Saskatchewan and EuroChem Usolskiy in Russia are targeting first production before the end of the year. However, this new capacity is likely to have more of a market impact next year.
- **Sulphur:** Although sulphur pricing is underpinned by the short term supply/demand balance, with producers eyeing potential increases into March, many end-users appear to be resisting higher pricing. The outlook is therefore likely to remain flat/stable in the short term, with the potential for weaker sentiment as the year progresses. One of the main market factors in 2017 will be new projects adding fresh availability to the global balance. The latest restart attempt for the Barzan project in Qatar is set to add around 800,000 tonnes of capacity. Sulphur from the long awaited Kashagan project in Kazakhstan is also expected to materialise during the second quarter, adding up to one million tonnes of capacity. Activity in China will also be key looking ahead. China's import requirements could be affected by rising domestic sulphur production from new oil and gas sector projects.

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

EGYPT

Damietta nitrogen complex commissioned

thyssenkrupp Industrial Solutions has commissioned Egypt's largest nitrogen fertilizer complex in the Damietta free trade zone.

The complex, located 160 km north-east of Cairo, will be operated by the Egyptian Nitrogen Products Company (ENPC), a wholly-owned subsidiary of Misr Fertilizer Production Company (MOPCO). At full capacity, the world-class plant will be capable of producing 2,400 t/d of ammonia and 3,850 t/d of urea.

"We are elated to have continuous production at our new world-scale fertilizer complex in Damietta," said Greg McGlone, ENPC's managing director. "Together with our partner thyssenkrupp we were able to successfully take this mega-project from start to completion, despite the extremely challenging political and economic circumstances in Egypt over the past nine years."

Ralf Richmann, CEO of thyssenkrupp's fertilizer & syngas technologies business unit, added: "This project demonstrates once again the immense trust of the major players within the fertilizer industry in our technological capabilities and experience gained in the construction of more than 130 fertilizer plants worldwide."

ENPC commissioned thyssenkrupp to build the new turnkey fertilizer complex in 2007 – the largest single fertilizer contract secured by thyssenkrupp at that time. The contract specified the construction of two ammonia plants and two urea plants, as well as product handling and storage facilities. thyssenkrupp was tasked with delivering basic and detailed engineering, the supply of equipment and the construction and commissioning of the complex.

Ammonia is synthesised at the complex using thyssenkrupp's proprietary process while urea production is based on Stamicarbon's process. All of the plant's processes comply with stringent Egyptian and European standards. ■

UNITED STATES

Borger expansion complete

Agrium has successfully completed its Borger, Texas, expansion.

The new 610,000 tonne capacity urea/diesel exhaust fluid (DEF) plant at the site was completed on schedule and within cost and has now entered commissioning, according to a company statement. Production is expected to begin before the end of March.

The dual output plant will dedicate 100,000 tonnes of urea capacity to DEF production. The ability to produce and market DEF, a product used to cut diesel vehicle nitrogen oxide (NOx) emissions, will strengthen Agrium's diversification into non-agricultural markets.

"Achieving this critical milestone in our Borger nitrogen expansion project, on-time and on-budget, is another example of our commitment to operational excellence at Agrium," commented Chuck Magro, the company's CEO and president. He said completion of the project would improve product availability in an important agricultural region, diversify the company's product range and increase supply chain integration.

North American nitrogen production capacity is growing rapidly at present. The commissioning of Borger, Texas, follows CF's completion of its Port Neal, Iowa, and Donaldsonville, Louisiana, expansions. Ifco's Wever greenfield nitrogen complex in Iowa is also approaching completion (*Fertilizer International* 478, p9).

Manatee phosphate expansion approved

The Mosaic Company has won approval for an expansion of phosphate mining in Manatee County, Florida.

The Manatee County Commission approved a rezoning and a master mining plan by 5-2 in a 15 February vote. The decision clears the way for the extension of phosphate rock mining operations at Mosaic's Wingate East property in the Myakka-Duette area of the county, Florida's *Herald Tribune* reported.

The 3,596 acre property flanks Duette Road and is located to the east of Mosaic's Wingate Creek mine. Mosaic expanded operations at Wingate Creek in 2012 after winning approval for a 661 acre mine development from the Manatee County Commission. Mosaic also operates the large-scale Four Corners Mine which spans Manatee, Hillsborough, Hardee and Polk counties in Florida.

"You've heard from our opponents a lot of misstatements of fact," Hugh McGuire, Mosaic's attorney, told county commissioners. McGuire said the company's testimony showed it can properly mine the property for phosphate and environmentally restore it subsequently. "This hearing is not a referendum on phosphate mining," McGuire added.

Idaho phosphate mine approved

Agrium's proposed 2.4-mile-long open pit phosphate mine in southeastern Idaho has been approved by two US federal agencies, the Bureau of Land Management (BLM) and the Forest Service, according to local news reports.

The new Rasmussen Valley mine will have an expected life of eight years. BLM officials said the new mine will preserve 1,700 jobs and generate about $85 million per year for the local economy in Caribou County. Agrium already operates the 500,000 t/a Conda phosphate plant at Soda Springs in Idaho. JR Simplot and Monsanto also operate mines in the state.

Idaho's phosphate province has 17 Environmental Protection Agency superfund sites, a legacy of pollution inherited from previous mining activity. Regulators are nevertheless satisfied that the new mine will avoid these past problems. "The water quality issue is the No 1 issue that we deal with when it comes to determining impacts with mines that are being permitted now," Bill Volt, BLM's environmental planning coordinator told *Idaho Statesman*.

Domestic industry "injured" by Chinese AS imports

The US looks set to impose anti-dumping duties on Chinese ammonium sulphate (AS) imports, following a determination by the US International Trade Commission (USITC) on the 8 February.

This concluded that US industry is being "materially injured" by AS imports from China. It also cites an earlier determination by the Department of Commerce that these imports are being "subsidized and sold in the United States at less than fair value".

USITC's positive determination clears the way for the imposition of anti-dumping and countervailing duties on AS imports from China. The Department of Commerce set these at 206.72% in a preliminary determination last October.

The US government began to investigate Chinese AS imports in May last year, following a petition from PCI Nitrogen. The value of Chinese AS imports into the country is substantial having reached $63 million in 2015.

ALGERIA

Government approves four phosphate projects

The Algerian government has approved four phosphate processing projects, according to the country's press agency. They include two projects in Souk Ahras, one in Tebessa and one in Skikda.

Abdessalem Bouchouareb, Algeria's industry and mines minister, revealed plans to boost phosphates processing capacity during a working visit to the country's Oran province on 15 January. He confirmed the government had recently approved four projects proposed by the energy, industry and mines sectors, adding that "petrochemistry" had a very important place in Algeria's economic policy.

BELGIUM

Prayon launches new nitrate fertilizer

The Prayon Group has added a new product, *Calcium Nitrate EXTRA*, to its *Hortipray* range of fertilizers. The company, a world leader in the phosphates sector, is marketing the product as an ideal alternative to liquid calcium nitrate.

The new highly-soluble product has a higher calcium oxide content (17-0-0 + 33% CaO) than standard calcium nitrate grades. It also guarantees that at least 17% nitrogen will be available as nitrates.

"Compared to standard products, the crystals in *Calcium Nitrate EXTRA* contain fewer water molecules, resulting in a higher concentration of nutrients," explained Kurt Verhelst, Prayon's horticulture customers coordinator for Northern Europe. "The more concentrated product helps growers reduce their transport and storage costs."

Unlike typical calcium nitrate products, *Calcium Nitrate EXTRA* contains a negligible amount of ammonium. This is an advantage for hydroponic cultivation as excessive ammonium can cause growing problems and result in yield and quality losses in crops.

Calcium Nitrate EXTRA will be distributed worldwide by Prayon. As part of its customer support, the company is offering to recalculate irrigation recipes to demonstrate the new product's financial and technical benefits to growers.

NETHERLANDS

Stamicarbon signs agreement with Schoeller Bleckmann Nitec

Stamicarbon and Schoeller Bleckmann Nitec (SBN), part of the Christof Group, are to collaborate more closely in future. The Dutch urea licensor and Austrian equipment manufacturer recently signed a new cooperation agreement over the fabrication and supply of high-pressure (HP) equipment for urea plants.

Both companies have been working closely together for many years on the design, engineering, manufacturing and delivery of HP equipment, particularly pressure-resistant stainless steel reactors and heat exchangers installed in the synthesis sections of Stamicarbon-designed urea plants.

Under the new agreement, HP equipment, based on Stamicarbon urea technology and using *Safurex* stainless steel, will now be delivered within 12 months of ordering. SBN will also keep standardisation material and prefabricated parts in stock from now on.

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

INDIA

Deepak Fertilisers starts up NPK plant

The new Taloja NPK plant in India's Maharashtra state owned by Deepak Fertilisers & Petrochemicals Corporation Ltd (DFPCL) is set to enter production. The INR 8 billion ($119.5 million) plant is ready for commercial production after the successful completion of trials, the company said in a statement on 10 February.

The plant has the ability to manufacture NPKs in a range of grades and will eventually increase the company's production capacity from 300,000 t/a currently to 1.1 million t/a in a phased ramp-up. This extra capacity will make DFPCL the largest NPK fertilizer manufacturer in Maharashtra.

The plant's state of readiness should allow DFPCL to begin supplying high-quality NPK fertilizers to farmers during India's upcoming kharif season. The company plans to target the new production capacity at Southern and Northern agrarian markets in India, in addition to its core markets in Maharashtra, Karnataka and Gujarat states.

"It is a great moment of pride for us as we celebrate the 25th year of our *Mahadhan* brand with the commissioning of our expanded NPK capacities," said Sailesh Mehta, DFPCL's chairman and managing director. "Trials have been successful and we are geared up to launch the commercial production of the new grades soon. Enhanced availability of NPK will help generate higher sales and improve the performance of the segment."

INDIA

2017/18 subsidy rates leaked

Inter-ministerial panel recommendations on the 2017/18 rates for India's nutrient based subsidy (NBS) scheme have been leaked by a senior government official. Quoted by India's *Infracircle* website, the anonymous official revealed that that the panel has advised the government to:

- Increase the nitrogen subsidy to INR 19.412/kg from INR 15.854/kg
- Increase the phosphates subsidy to INR 13.629/kg from INR 13.241/kg
- Cut the potash subsidy to INR 12.781/kg from INR 15.470/kg

Setting NBS rates is a complex undertaking which takes account of international and domestic fertiliser prices, exchange rates and inventory levels.

A potential 17% cut in the potash subsidy to INR 7,669/t ($114.61/t) for 2017/18, from INR 9,280/t currently, was separately reported by *Reuters* on 16 February. Such a subsidy cut – if subsequently implemented by the government – would have major market implication due to the scale of Indian potash demand.

India's finance minister Arun Jaitley kept the country's overall fertilizer subsidy unchanged at INR 700 billion ($10.36 billion) in his 2017/18 budget. An official government announcement on 2017/18 NBS rates is expected by the end of March or early April.

IRAN

Outotec to deliver two sulphuric acid plants

Outotec has reached agreement with the National Iranian Copper Industries Company (NICICO) over the delivery of two sulphuric acid plants for the Sarcheshmeh and Khatoon Abad copper smelters in Kerman province.

The €50 million order is covered by a confirmed letter of credit and was booked into Outotec's order intake at the end of last year. Outotec will deliver project engineering, main process equipment and instrumentation for the acid plants as well as spare parts and supervisory services for their installation and commissioning. Project deliveries are scheduled to take place in mid-2018.

"We are pleased to complement our earlier deliveries of Flash Smelting technology for NICICO's two copper smelters with modern Outotec off-gas cleaning systems and sulfuric acid plants. With these investments, the smelters will have full compliance with the latest environmental standards", said Kalle Härkki, head of Outotec's metals, energy & water business unit.

PAKISTAN

Fertilizer subsidies restored

Pakistan's government acted to restore fertilizer subsidies in January within days of announcing their withdrawal. Its change of heart followed protests by the fertilizer industry, farmers and political parties.

The government initially withdrew the subsidies on 10 January because the financial allocation for the current fertilizer year was exhausted. It then acted to reverse this decision three days later, after the country's prime minister Nawaz Sharif intervened personally.

In related news, Pakistan's ministry of national food security and research (MNFSR) has released PKR 6.5 billion ($62 million) in cash to clear a backlog of outstanding fertilizer subsidy claims. These cover the current 2016/17 fertilizer year which ends on 30 June.

The decision to release the cash follows the news that Pakistan's Fertilizer Imports Council sent a letter to finance minister Muhammed Ishaq Dar saying it would suspend DAP imports until outstanding subsidy payments were released.

The government has been offering per bag subsidies of PKR 300 for phosphates (DAP) and PKR 400 for urea since July last year. These subsidies should have been disbursed within 15 days of sale but it is believed that more PKR 5 billion ($49 million) in subsidy claims, dating from September to December last year, remain unpaid.

The government has blamed the payment delays on the complexity of the subsidy disbursal system. This relies on verification of sales from the provinces rather than information provided by companies or collected centrally by Pakistan's National Fertiliser Development Centre (NFDC).

SAUDI ARABIA

Waad Al-Shamal nears completion

Ma'aden released a further progress update on the Waad Al-Shamal project, its joint venture with SABIC and Mosaic, on 29 January. Construction progress reached the following levels, as of the end of December last year:

- Beneficiation plant at 90.4% completion
- Sulphuric acid plant at 95.7% completion
- Phosphoric acid plant at 90.9% completion
- Diammonium phosphate (DAP) plant at 78.2% completion

The project's ammonia plant has already entered commercial production. Ma'aden expects construction of the remaining plants will be "predominantly completed and trial operations will begin" during the first half of 2017.

ERITREA

Colluli project secures mining licence

Australian mining junior Danakali Limited has been granted a mining licence for its Colluli sulphate of potash (SOP) project in Eritrea.

The ASX-listed developer announced it had secured the licence from the Eritrean energy and mines ministry on 1 February, following the signing of a mining agreement.

The mining licence extends over an area of more than 60 km^2 and lasts for 60 years of the mine's expected 200-year life. It allows potassium, calcium, sodium and magnesium salts and bromine to be mined from the Colluli deposit.

"This is another very significant milestone for both Danakali and the Colluli Mining Share Company (CMSC). There is a clear and compelling investment case that supports the Colluli development," said Paul Donaldson, Danakali's managing director. "The fact that Colluli is the most advanced sulphate of potash project in the world is a testament to that."

In a further sign of progress, Danakali recently appointed construction firm Fluor to lead the front end engineering design (FEED) and optimisation process for the Colluli project. Global Potash Solutions have also joined the project's FEED and optimisation team.

SOUTH AFRICA

Yara launches liquid fertilizer plant

Yara Cape has opened a $2.3 million liquid fertilizer plant at Malmesbury in South Africa's Western Cape region.

The new facility will enable Yara to supply several important markets located within a 300 km radius, including farms growing cereals, vegetables, fruits and grapes.

"With this latest investment we affirm our belief in the agricultural potential of South Africa and our aspiration to be the leading crop nutrition company in the country," said Terje Knutsen, executive vice president, Yara Crop Nutrition.

Ig Ferreira, Yara Cape's general manager, added: "We are grateful and proud to announce the completion of this construction without injuries. With the increased capacity of this investment, we once again illustrate our commitment to Western and Southern Cape farmers and their needs."

TURKEY

Government partially lifts nitrates ban

The Turkish government has lifted the ban on the sale of calcium ammonium nitrate (CAN).

The Turkish minister for food, agriculture and livestock, Faruk Celik, announced in January that the government will allow domestic sales of CAN to resume in a controlled manner. He also completely lifted the ban on domestic purchasing of potassium nitrate and sodium nitrate. The ban on ammonium nitrate (AN) looks set to continue indefinitely, however, due to security concerns.

The Turkish government swiftly imposed a ban on nitrate fertilizers following a deadly bomb explosion in Istanbul in June 2016. Despite the ban on domestic movements, producers have been allowed to export CAN in recent months. The continuation of the ban on AN was expected.

"We have already forgotten about AN [production] for any future use. Probably we can meet any [AN] requirement of the domestic market through imports," a domestic nitrates producer told analysts ICIS. "There will still be some restrictions on CAN sales in Turkey but we need to wait for the official circular," added an international nitrates trader.

The combined AN and CAN market in Turkey is around 1.8-2 million t/a. It is one of the largest import markets for AN, with imports totalling 340,000 tonnes between January and November 2016. The country also has a large domestic production capacity for AN and CAN fertilizers. ■

FERTILIZER INDUSTRY NEWS

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

People

Martin Jarosick has joined CF Industries as vice president, investor relations. Mr Jarosick previously served as vice president, investor relations and treasurer at Axiall Corporation, prior to joining CF. His responsibilities at Axiall Corporation included investor relations strategy and execution, as well as the strategic planning process. Before this, Martin held various treasury, strategic planning, and investor relations roles at two other firms, The Home Depot and Progress Energy.

"Martin brings to CF Industries broad investor relations and finance experience, as well as a background in the chemicals industry, which will serve us and our shareholders well," said Dennis Kelleher, senior vice president and chief financial officer, CF Industries. "We look forward to the contributions Martin will make in communicating the CF story to shareholders, potential investors and other stakeholders."

Mr Jarosick has an MBA from the University of North Carolina and a Mechanical Engineering BSc from the Georgia Institute of Technology. He is a CFA® charterholder and is IRC™ Credential certified.

Dmitry Sokov joined EuroChem Group on 15 February as the head of its Russian subsidiary, JSC MCC EuroChem. Mr Sokov is based in Moscow and will manage day-to-day operations and further develop EuroChem's business in Russia. He reports to the group's CEO, Dmitry Strezhnev.

Mr Sokov previously held a number of senior management positions at JSC Cordiant during a long career with the company, most recently serving as its CEO from 2012. He holds an MBA in strategic management from the prestigious Higher School of Economics at Russia's National Research University. He also has a financial management degree from Moscow State Technological University.

Dmitry Strezhnev, EuroChem's CEO, commented: "We are pleased to welcome Dmitry Sokov as head of EuroChem's well-established business in Russia. With his wealth of management experience in the Russian chemical industry, we are confident that Dmitry will significantly contribute to the implementation of the Group's strategy in one of its key markets and will actively grow EuroChem's fertilizer business there."

Mhamed Ibnabdeljalil and **G David Delaney** were recently appointed to the board of Itafos, formerly Mbac Fertilizer Corp. **Marten Walters** also joined the company as vice president of operations in January.

The appointment of seasoned industry leaders to the Itafos board and management team was welcomed by board chairman, Brent de Jong: "Itafos is very pleased to announce the expansion of the board and management team of the company and to strengthen its industry expertise with this strong executive leadership. All three individuals have extensive industry experience and demonstrated track records of driving profitable growth and transforming businesses."

Dr Ibnabdeljalil and G David Delaney will offer governance best practice, strategic guidance and overall counsel to the Itafos management team in their new board positions. Marten Walters will oversee all aspects of the company's physical operations in his new role.

To make way for the appointment of Mr Delaney, Itafos also announced the resignation of **David Andrew Parsons** from the board. He will continue to serve the company in an advisory role.

Adel Hattab, MSc (Eng), MBA, has been appointed Outotec's executive vice president for strategic customers and business development, with effect from the start of April. He has been on the company's executive board since 2014, first as head of the EMEA region and, since February 2016, as head of the markets unit. In his new role, Mr Hattab will lead the development of strategic customer relationships, sales processes and customer experience. He will also be responsible for global marketing and market intelligence operations.

Markku Teräsvasara, Outotec's CEO, wished Mr Hattab every success in his new role: "I am glad that Adel Hattab, who has extensive experience in demanding business leadership roles and excellent customer relationship capabilities, will take this strategic role in leading the development of our key customer relationships and Outotec's transformation to a customer-focused, market-driven company. He will work in close cooperation with Outotec's business units and market areas to develop and implement our customer success strategy to maximize customer acquisition and satisfaction as well as the company's profitability."

Olli Nastamo, who is currently responsible for Outotec's strategy, marketing and operational excellence, will lead the operational excellence organisation from the start of April. As a member of the executive board, he will continue to report to CEO Markku Teräsvasara.

Calendar 2017

MARCH

13-15

Phosphates 2017, TAMPA, Florida
Contact: CRU Events
Tel: +44 20 7903 2444
Email: conferences@crugroup.com
Web: www.crugroup.com

APRIL

24-26

TSI World Sulphur Symposium, DUBLIN, Ireland
Tel: +1 202 331 9660
Email: sulphur@sulphurinstitute.org
Web: www.tsi.org

MAY

8-10

SYMPHOS 2017, 4th International Symposium on Innovation in the Phosphate Industry, BEN GUERIR CITY, Morocco
Contact: SYMPHOS Technical Committee
Tel: +212 5 23 39 80 10
Email: symposiumocp@ocpgroup.ma
info@symphos.com
Web: www.symphos.com

22-24

85th IFA Annual Conference, MARRAKECH, Morocco
Contact: IFA Conference Service
Tel: +33 1 53 93 05 25
Email: conference@fertilizer.org
Web: www.fertilizer.org

JUNE

9-10

41st AIChE Annual Clearwater Conference 2016, CLEARWATER, Florida
Email: chair@aiche-cf.org
Web: www.aiche-cf.org

29-30

International Fertiliser Society Technical Conference, LONDON, UK
Contact: International Fertiliser Society, PO Box 12220, Colchester, CO1 9PR, UK
Tel: +44 (0)1206 851819
Email: secretary@fertiliser-society.org
Web: fertiliser-society.org

PHOTO: ALEXANDER NARRAINA / SHUTTERSTOCK.COM

Canola crop nutrition

Canola, also known as oilseed rape and rapeseed, is one of world's three main oilseed crops. World production, in the region of 68 million tonnes annually, is concentrated in EU countries, Canada, China, and India and satisfies around one-fifth of global vegetable oil demand. We report on the vital role fertilizers play in successful canola cultivation.

The name rapeseed or oilseed rape is applied to commercial oil seed plant species belonging to the genus Brassica (*Fertilizer International* 472, p40). They include the oilseeds of turnip rape (*Brassica campestris*), swede rape (*Brassica napus*) and mustard (*Brassica juncea*). Rapeseed is one of the three main oilseed crops grown globally, the other two being soybean and sunflower.

Rapeseed contains glucosinolate, a naturally-occurring pungent compound that is also found in mustard, cabbage, and horseradish. Its presence, however, can limit use in human and animal nutrition. Because of this, more nutritionally-acceptable forms of oilseed rape, low in glucosinolate and erucic acid, were developed by selective breeding during the 1960s and 1970s. Such varieties are widely cultivated in Canada where they are known as canola.

Commercial oilseed rape crops vary regionally as follows:

- The winter forms of *Brassica napus* predominate in Europe and the US
- The spring forms of *Brassica napus* and *Brassica campestris* are mainly grown in Canada, as winter forms are unable to tolerate the country's harsh low-temperatures winters.
- Oilseed rape grown in India – toria and yellow and brown sarson – derive from *Brassica juncea* and *Brassica campestris*
- In China, *Brassica campestris* and *Brassica juncea* are often replaced by special varieties of *Brassica napus*

Fig 1: **World rapeseed oil and meal production, 2016/17**

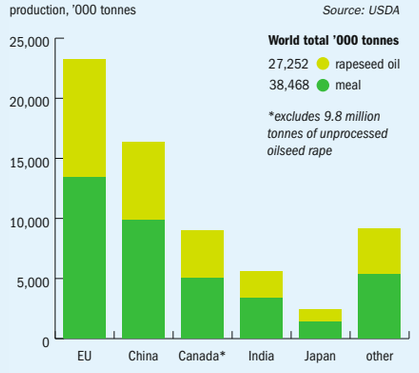
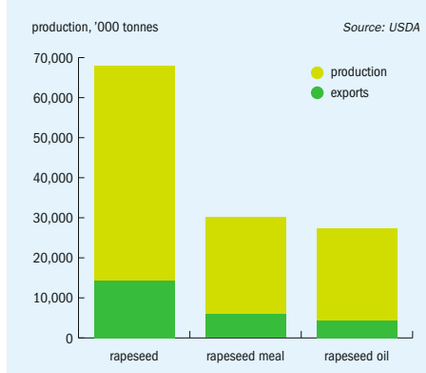


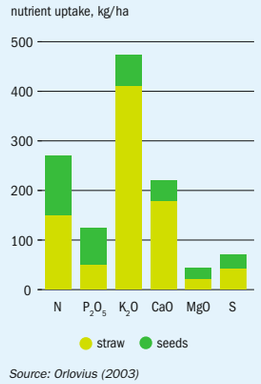
Fig 2: **World production and exports for rapeseed, rapeseed oil and rapeseed meal, 2016/17**



FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

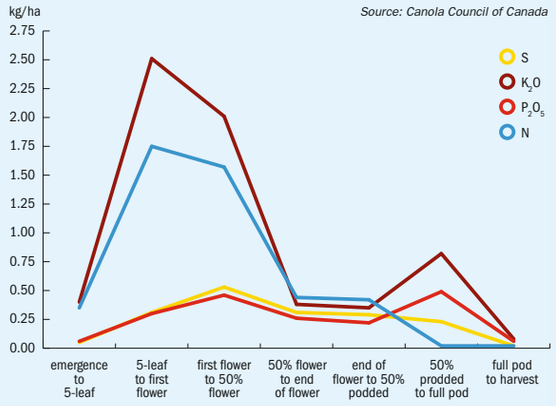
BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Fig 3: **Total uptake of macronutrients of oilseed rape**



Source: Orlovius (2003)

Fig 4: **Nutrient uptake by growth stage for canola**



Nowadays, varieties are also grown for specific end-markets. High erucic acid rape (HEAR), for example, is used in a range of industrial processes, such as inks, lubrication and as a slip agent in the production of polythene. High oleic, low linolenic (HOLL) rapeseed oil is a stable vegetable oil that performs well at high temperatures due to its low trans fatty acid and low saturated fat content[1].

Production and use

Annual world rapeseed production stands at 67.9 million tonnes currently, having grown by almost a half in the last decade (Figure 1). Rapeseed oil accounts for 40% of this volume. Rapeseed meal for the animal feed market is responsible for much of the remainder. World production is dominated by five main producing countries and regions: the EU, Canada, China, India and Japan. Just three of these countries – the EU, Canada and China – collectively control more than three-quarters of world production.

Around one-fifth (14.4 million tonnes) of global rapeseed production is traded internationally. Global exports of rapeseed meal (5.9 million tonnes) and rapeseed oil (4.4 million tonnes) are also substantial (Figure 2). Canada is the leading export nation. It currently sells around 9.8 million tonnes of oilseed rape to other countries, giving it a global export market share of over two-thirds. Canada is also responsible for 75% of rapeseed meal and 72% of rapeseed oil exports at present.

In contrast, the EU, although the world's largest producing region, is a net importer, due to the scale of its market demand. The country imported some 3.7 million tonnes of rapeseed in 2016/17. Oilseed rape was a barely known crop in the EU prior to the 1970s. Its subsequent popularity with EU farmers, and the large expansion in growing area, is largely a result of favourable commodity prices, policies supporting biodiesel production and Common Agricultural Policy (CAP) subsidies. China and Japan, although both major oilseed rape growing-countries, also need to import oilseed crop products on a large-scale to meet domestic demand.

Oilseed rape is valued commercially for:

- Biodiesel
- Cooking oil and foodstuffs such as margarine, salad dressings and mayonnaise
- Cake and meal as a high-energy protein source in animal nutrition
- Renewable feedstock for the chemicals industry
- Green manure and forage crop

Over the years, the content of unpleasant-tasting erucic acid has been reduced from 40 percent to zero by breeding to make rapeseed oil more acceptable for human diets. At the same time, beneficial linoleic acid (omega-6) and linolenic acid (omega-3) content – the so-called essential fatty acids – has been increased[2].

Compositionally, the fatty acid content of vegetable oils is split between four constituents: saturated fatty acids, linoleic acid, linolenic acid and mono unsaturated oil acids. Overall, rapeseed oil possesses a number of valuable compositional characteristics compared to other vegetable oils. As a proportion of total fatty acids, it has[2]:

- The lowest saturated fatty acid content (6-8%)
- A high mono unsaturated oil acid content (58-60%)
- A favourable ratio of (2.5:1) of linoleic acid (20-26%) to linolenic acid (10%)
- Good nutritional levels of vitamin E and plant sterols

Nutrient uptake

Nutrient uptake by oilseed rape is largely influenced by:

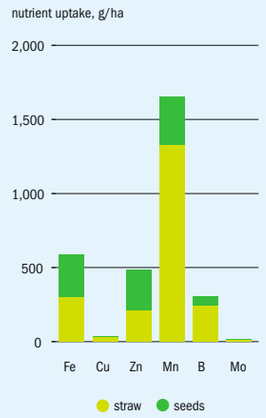
- Crop species
- Growing season: winter or spring form
- Plant dry matter
- Yield achieved
- Water availability

Total nutrient uptake – typically up to 450 kg/ha for K, 200-300 kg/ha for N and 90-130 kg/ha for P – is considerably higher than for cereals (Figure 3). The crop's high sulphur uptake (50-70 kg/ha) is consistent with oilseed rape's known high requirement for this element and its susceptibility to sulphur deficiency. Calcium and magnesium uptake is also significant[3].

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Fig 5: **Total uptake of micronutrients of oilseed rape**



Source: Orlovius (2003)

Nutrient uptake by growth stage is shown in Figure 4. The uptake of potassium, nitrogen, sulphur and phosphorus peaks during flowering and seed pod development.

Micronutrient uptake can be in excess of 1.5 kg/ha (Figure 5). Zinc and boron uptake starts early and continues until maturity, whereas take-up of iron, copper and manganese is at its maximum during flowering and falls back afterwards as these nutrients are lost with leaf fall[3].

Importantly, plant nutrients mainly reside in straw material rather than seeds (Figure 3 and Figure 5). This means that the net export of nutrients from the field will be just a fraction of total plant nutrient uptake when crop residues are returned to the soil.

Nutrient uptake varies from region-to-region. Spring rape in Canada (2 t/ha yield) has a relatively high nutrient removal (120 kg/ha N, 50 kg/ha P_2O_5, 95 kg/ha K_2O and 25 kg/ha S), for example, compared to lower-yielding (1.5 t/ha) mustard varieties in India (80 kg/ha N, 40 kg/ha P_2O_5, 85 kg/ha K_2O, 25 kg/ha S and 20 kg/ha MgO).

For winter forms grown in Europe, substantial nutrient uptake occurs in autumn (50-100 kg/ha of N and K_2O and 20-40 kg/ha of P_2O_5 and CaO) due to the high amount of dry matter (2-3 t/ha) developed before winter's onset. Nutrient uptake starts early and is intensive once spring growth begins. This is particularly true of potassium, which is rapidly removed (6-12 kg/ha/day K_2O) from the start of spring growth until flowering. As a result, total potassium uptake of winter rape is characteristically high, with 350-450 kg K_2O/ha being required for a seed yield of 3.5 t/ha[3].

Nutrient deficiency and testing

Deficiency symptoms are summarised in Table 1. All oilseed crops require nitrogen and sulphur fertilizer applications each year. Nitrogen application rates usually follow general recommendations or are planned according to the mineral nitrogen content of soils. Phosphorus, potassium, calcium and magnesium requirements can be determined by testing field soil samples

Table 1: **Oilseed rape: nutrient deficiencies and testing**

Nutrient	Deficiency symptom	Appropriate test	Test details*
Nitrogen (N)	● Leaf yellowing in early spring, starting with older leaves ● Plant stunting ● Reduced leaf number and pod size	Soil	Plan annual applications by measuring measurement of soil mineral nitrogen levels, if necessary
Sulphur (S)	● Diffuse yellowing of youngest leaves which may curl ● Pale flowers	Tissue	Use the malate: sulphate ratio test if deficiency is suspected
Phosphorus (P)	● Purpling of older leaves. Symptoms only show when soils very deficient	Soil	Target soil index: 2 (16-25 mg/l)
Potassium (K)	● Yellowing/browning of leaf margins	Soil	Target soil index: 2 (121-180 mg/l)
Magnesium (Mg)	● Yellowing between veins on older leaves ● Brown or purple colouration spreading in from leaf edge	Soil	At Mg index 0 and 1, apply 50-100 kg MgO/ha every three or four years
Boron (B)	● Young leaves are smaller and puckered ● Margins turn down and tissue becomes brittle and is easily torn ● Stem cracking and poor flowering	Soil	Less than 0.8 mg/l (soil hot water extraction) may indicate deficiency
Manganese (Mn)	● Yellowing/mottling between veins which remain greener ● Symptoms appear first on middle leaves then spread to older leaves	Tissue	Mn levels less than 20 mg/kg may indicate deficiency
Molybdenum (Mo)	● Reduced leaf area ● Pale and limp leaves	Soil	Deficiency likely below 0.1 mg/l (ammonium oxalate extract)

Source: AHDB (2015)

**UK: Defra Fertilizer Manual, RB209*

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Table 2: **Potassium, sulphur and magnesium recommendations**

	Removal (kg/ha)				
Nutrient/product	**K_2O**	**SO_3**	**MgO**	**Korn-Kali** (40% K_2O + 6% MgO + 12.5% SO_3)	**ESTA Kieserit** (25% MgO + 50% SO_3)
Total removal (including harvest residues)	210	50	40	525	160
Removal through main crop	40	40	20	100	100

Source: K+S

every 3–5 years. Boron, manganese, and molybdenum deficiencies are also limiting factors for oilseed rape productivity[1].

Crop sulphur requirements can be estimated from tissue analysis. A sulphur content above 0.5-0.6% in fully expanded leaves indicates adequate status for winter rape varieties in Europe. Deficiency and the need for sulphur fertilization is shown by values below 0.3%. Similar thresholds have been reported for spring crops in Australia and mustard varieties in India. In Canada, sulphur contents below 0.2% and 0.25% in tissue samples at the flowering stage indicate low and marginal sulphur supply, respectively[3].

Nitrogen and sulphur application

Nitrogen application produces the greatest yield response (1-2.5 t/ha) of any nutrient. The main nitrogen applications to oilseed rape are in spring when the crop is growing rapidly. This timing also helps ensure nitrogen is used by the crop instead of being lost through leaching or volatilisation[1]. Winter crops also need sufficient nitrogen for good autumn establishment.

> **Nitrogen application produces the greatest yield response (1-2.5 t/ha) of any nutrient.**

Nitrogen can be applied as urea or ammonium nitrate, although the use of ammonium sulphate nitrate or ammonium sulphate has the advantage of combining nitrogen and sulphate applications in a single fertilizer. Early application of N as highly-available nitrate helps support lateral branching and the development of shoot buds[3].

Each tonne of crop per hectare (seed plus straw) typically requires a 60 kg/ha nitrogen input. A crop yield target of 3.5 t/ha would therefore have a total nitrogen requirement of 210 kg/ha. In practice, nitrogen applications rates are adjusted downwards to take account of soil nitrogen stores. A nitrogen guide value of 200 kg/ha, supplied by both fertilizers and soil reserves, is recommended in Germany for a 2.5-4 t/ha yield range.

For winter forms of oilseed rape, autumn nitrogen applications of up to 70 kg/ha are recommended, to be applied before the end of September.

Spring nitrogen applications are necessary for healthy numbers of lateral branches, which in turn control seed pod numbers and yield. Nitrogen applications are normally divided into two, with roughly 50-60% of total N being supplied by the first application.

The field application of urea ammonium nitrate (UAN) solution (28-30% N) by sprayer is common in Europe. Foliar application of UAN provides a very rapid nitrogen response and is often combined with fungicides or insecticides[3].

Oilseed rape crops, being a type of Brassica (*Fertilizer International* 472, p40), are sensitive to sulphur deficiency and have high sulphur requirements. Mild sulphur deficiency can limit plant growth and reduce seed yields, even when no symptoms are visible. In industrialised countries, deficiency is on the rise due to declining sulphur deposition from the atmosphere as a result of clean air policies (*Fertilizer International* 467, p19)[3].

Sulphur applications are generally recommended for oilseed rape in Europe due to reduced atmospheric deposition. Yield responses of 0.3-0.5 t/ha have been reported for sulphur applications on winter-rape in Germany. A sulphur application rate of 20-30 kg/ha was generally sufficient for optimum seed yields, although this rose to 70 kg/ha for severely-deficient soils. In India, optimum seed yields have been obtained with sulphur applications of 30-40 kg/ha. Leaf area index and photosynthesis rate were also enhanced by sulphur application[3].

An early application to coincide with spring growth is recommended when soils are known to be sulphur-deficient. Sulphur is important for early plant development, and late application typically leads to lower seed yields and lower oil content. Because of this, broadcast applications should be completed before stem elongation at the latest. A small application of 10-20 kg/ha sulphur is suggested for winter forms showing deficiency in the autumn.

To encourage oxidation to plant-available sulphate, the general advice for elemental sulphur is to broadcast in advance of seeding and then work into the soil. Sulphur also plays an important role in nitrogen efficiency. Trials have shown that nitrogen utilisation is boosted from 6% to 25% as the sulphur content of rape leaves increases from 0.2% to 0.65%[3].

Crop quality

As well as affecting the yield of oilseed rape, nitrogen also has a major influence on seed quality characteristics such as oil, protein and glucosinolate content. Excess glucosinolate in seeds is a key quality consideration as it limits the use of cake and meal in animal nutrition. Too low a content, on the other hand, is also undesirable as it reduces plant resistance to stress and disease[3].

Seed and oil yields increase markedly with nitrogen applications up to 200 kg/ha. The effect of nitrogen on seed glucosinolate concentration, in contrast, appears to vary with sulphur status. Under sulphur-deficient conditions, increasing nitrogen supply acts to depress glucosinolate content, whereas nitrogen seems to have the opposite effect, elevating glucosinolate, when sulphur is sufficient. Increasing sulphur availability also raises glucosinolate content. Higher oil content and glucosinolate levels will generally occur in crops which show a high yield response to sulphur[3].

Fertilizer recommendations

European producer **Yara** recommends nitrate-based fertilizers, such as granular ammonium nitrate (*YaraBela EXTRAN*) or calcium ammonium nitrate (*YaraBela CAN*), as the most efficient form of nitrogen for oilseed rape, due to their yield benefits over urea.

Autumn nitrogen applications to the seedbed or soon after emergence are recommended at an optimum rate of around 60 kg/ha. 'Placing' nitrogen fertilizers at drilling, by restricting field application to where plants are growing, can reduce this to 25 kg/ha, according to Yara. Trials have also shown that including phosphate at drilling has the potential to boost yields by 0.57 t/ha. Yara also suggests applying boron to plants in the autumn to increase frost resistance using the liquid fertilizers *YaraVita Bortrac 150* (<3 litres/ha) or *Brassitrel Pro* (<4 litres/ha)[2].

In Europe, Yara recommends dividing spring nitrogen applications (190-220 kg/ha) between the stem extension stage and the flowering stage of growth. During stem extension, an initial 60-80 kg/ha application in February is suggested, with additional applications depending on canopy development. A nitrogen application of 40-60 kg/ha is recommended during subsequent flowering.

A good supply of potassium increases the frost and drought resistance of oilseed rape, according to **K+S KALI GmbH**. The German producer also emphasises the role magnesium plays in seed pod development, and the importance of sulphur for oil content and fatty acid formation. It recommends the application of *Korn-Kali* and *ESTA Kieserit* to meet oilseed rape's K, Mg and S nutrient needs (Table 2).

For foliar applications, K+S recommends supplying Mg and S with 20-25 kg/ha of *EPSO Top* (5% concentration) to address hidden deficiencies during periods of high nutrient demand. Several split applications between the rosette and flowering stage are advised. Identical applications of the company's *EPSO Microtop* product can also correct micronutrient shortfalls.

In the UK, producer **CF** recommends using *DoubleTop 27N (30SO_3)*. This compound ammonium nitrate/ammonium sulphate product is suitable for spring application to crops that have a high sulphur demand, including oilseed rape and winter cereals. Oilseed rape's large sulphur requirement is such that it can remove up to 250 kg SO_3/ha from the field by July, according to the company.

CF recommends a single application of *DoubleTop* (375kg/ha = 112 kg SO_3/ha) in late February followed by supplementary application of ammonium nitrate *(Nitram)* to meet nitrogen application rates. Alternatively, *DoubleTop* can be split between two equal applications (187 kg/ha = 56 kg SO_3/ha), the first in February and the second during the crop's stem extension stage. ■

References

1. AHDB, 2015. *Oilseed rape guide. Second edition.* UK Agriculture and Horticulture Development Board (AHDB), Kenilworth, England.
2. Yara, 2015. *The Nutrition of Oilseed Rape.* May 2015, Yara UK.
3. Orlovius. K., 2003. *Fertilizing for High Yield and Quality Oilseed Rape.* IPI-Bulletin No. 16. International Potash Institute, Basel, Switzerland.

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

The rise of Gulf sulphur

The Middle East edged ahead of North America as the world's leading sulphur-producing region last year. **Meena Chauhan**, head of sulphur and sulphuric acid at Integer Research, explores the rise of sulphur production in the countries of the Gulf and the impact on the market of this eastwards shift in supply.

The global sulphur market has grown in step with energy production over the years. Since 2011, world sulphur production, from a combination of oil and gas recovery, the Frasch process and other methods, has increased significantly to reach a total of 63 million tonnes in 2016.

North America has long been the largest regional sulphur producer globally. Collectively, the US and Canada accounted for more than 24% of world sulphur production in 2015, despite the continued decline in Canadian sulphur, a consequence of the country's falling gas production.

That situation changed in 2016 when, in a major shift to the market, the Middle East became the top ranking regional sulphur producer, with North America dropping back to second place (Figure 1).

Middle East sulphur ascends

The Middle East is fast becoming the most energy intensive region in the world. It is continuing to develop large-scale oil and gas projects and successfully bring these to fruition. Accompanying this rise in hydrocarbon output comes a substantial increase in sulphur recovery – due to the hydrogen sulphide content of natural gas (sour gas) and the heavy nature of the crude oil being processed in countries across the region. This has seen Middle East sulphur production increase to 25% of global supply in 2016, primarily led by developments in the sour gas sector (Figure 1).

Combined US and Canadian sulphur production, meanwhile, totalled just under 14 million tonnes in 2016, a downward slippage to what is still a significant 22% share of global output. Looking ahead, North America's share of world supply is expected to decline further to below 20% by 2020.

In recent years, the global sulphur market has been tight with demand exceeding supply. This overall deficit in the supply/demand balance has influenced price levels across key benchmarks. Significant sulphur volumes were held in block inventories in some countries, despite the supply deficit, mainly because logistical constraints limited when and how block sulphur could be moved to the market for export.

The United Arab Emirates (UAE)

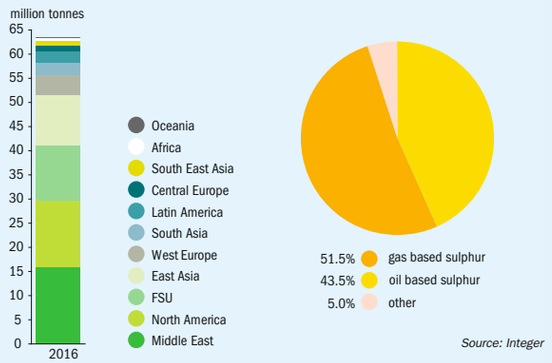
Sulphur output in the UAE is concentrated in the sour gas sector. The country has emerged as the world's fourth-largest sulphur producer and was catapulted to the top spot in Middle East producer rankings last year. Sulphur produced in the country is marketed for export out of the port of Ruwais by the Abu Dhabi National Oil Company (ADNOC). The company, which was founded in 1971, has a number of subsidiaries working across the oil and gas sector, both upstream and downstream, and is involved in all aspects of the petrochemicals supply chain.

As recently as 2013, the country's sulphur production was just over two million tonnes, the majority of this derived from the Habshan complex. Several expansions have been completed at Habshan since its initial construction in 1984, significantly increasing its processing capacity. Liquid sulphur produced at the complex is transported to the Ruwais granulation facility prior to export.

More recently, the Abu Dhabi Gas Development Company's $10 billion Shah sour gas project has dramatically increased UAE sulphur production. Its three million t/a sulphur production capacity has more than doubled the country's output. The project, a joint venture between ADNOC (60%) and Occidental Petroleum Company (40%), eventually started up in April 2015, after a series of delays.

The UAE is expected to further boost its energy production in future in order to meet the country's growing domestic demands. In keeping with its 2030 strategy, the country unveiled a 'Gas Master Plan' at the end of

Fig 1: **Global sulphur production, 2016**



FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

last year. If realised, the plan will increase the UAE's sour gas output and, consequently, the country's sulphur recovery also looks set to rise.

Saudi Arabia

Saudi Arabia was originally the largest sulphur-producing country in the Middle East, with state-run Saudi Aramco owning and operating interests across the oil and gas sector. However, Saudi Arabia's sulphur output, estimated at over 4.5 million t/a, now ranks second in the Middle East, having been eclipsed by the UAE's sulphur output.

Most of Saudi Aramco's oil and gas facilities are located in the country's eastern province. Saudi sulphur production is primarily derived from gas processing. However, crude reserves in the country are also significant, with expansions and projects set to tap into these reserves.

The large-scale Wasit gas project commissioned in 2016 has been the key sulphur capacity development in Saudi Arabia in recent times. Wasit can process 2.5 billion standard cubic feet of gas per day. It was also expected to be the first project in the country to use *Sunfinol-M* gas treatment – a new technology that improves the efficiency of sulphur recovery units from 95% to more than 99%. Oil refining capacity in Saudi Arabia has also increased with the start-up of the Satorp and Yasref refineries.

Qatar

Qatar's Barzan project, a joint venture between Qatar Petroleum and Exxon Mobil, looks on-track to finally commence this year, and will add significant sulphur supply to the export market once commissioned. Setbacks were encountered during the attempted start-up of the $10 billion project last October. The discovery of a gas pipeline leak led to the start-up date being pushed-back into 2017. This latest setback follows several earlier technical delays to the project.

The Barzan project is operated by RasGas and is being delivered in two phases, the second due to follow the first in quick succession. In total, both phases combined will add around 800,000 t/a to Qatar's sulphur capacity. All the sulphur produced by Barzan is expected to be placed into the international export market. It is unclear how this output will be split between spot and contract volumes – although Integer Research anticipates a mixture of both.

Iran

Iran is another major Middle East sulphur producer. The sulphur output from its natural gas sector amounted to nearly two million tonnes in 2016. South Pars gas field, located on Iran's border with Qatar in the Gulf, is one of the country's main sources of sulphur. The field is operated by Pars Oil and Gas Company (POGC), a subsidiary of the National Iranian Oil Company (NIOC). The massive project to develop South Pars is split into 24 phases, the development of each phase being priced at around $1 billion. At full capacity, the project is set to produce 820 million cubic metres of gas per day. Under international sanctions, the export of sulphur from Iran was restricted as only limited trade options were available to the country.

Kuwait

Unlike the majority of sulphur producers in the Middle East, sulphur production in Kuwait is largely recovered from its oil refining sector. Kuwait has significant proven oil reserves and expansions are underway to raise production capacity by 2020. Existing refineries at Mina Abdulla and Mina Al-Ahmadi, for example, are being upgraded and expanded as part of the Kuwait National Petroleum Company's (KNPC) Clean Fuels Project. This mega project also includes plans to construct a new grassroots refinery at Al Zour, while shutting down the existing 200,000 bbl/day Al-Shuaiba refinery.

The long-delayed Al Zour project – construction was originally due to start in 2008 – has now been approved. Contracts were signed in 2015 and commissioning is now expected in 2019.

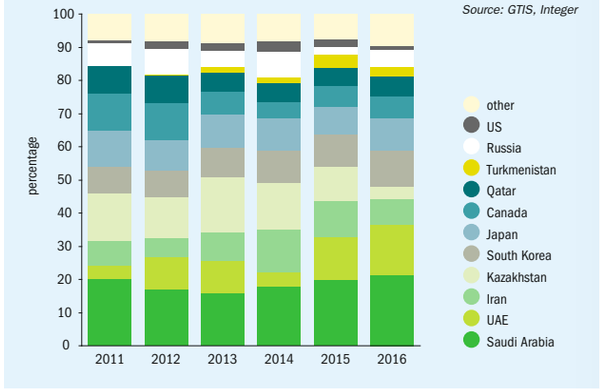
The large-scale overhaul of Kuwait's refining sector will increase sulphur recovery. Sulphur exports from Kuwait through the port of Shuaiba should therefore rise significantly above the current one million t/a level in future.

Trade flows shift

The rise of new oil and gas projects in the Middle East has led to changes in sulphur market dynamics, global trade and the global supply/demand balance. Sulphur industry prices are measured by a range of quotes. The Middle East f.o.b. benchmark has risen in prominence over the years due to the increased production share from new projects in the region. As supply has increased, export availability has also risen, especially as domestic demand from sulphur-consuming industries in many Gulf countries is limited. This has led to significant shifts in trade, particularly the trade flows to core markets such as China, India and North Africa.

China is the largest sulphur import market in the world, absorbing over a third of total global trade. Back in 2011, Middle East trade to China, led by Saudi Arabia, represented around 40% of the country's sulphur imports. This market share remained stable until a significant jump in 2015 raised the region's contribution to almost half of China's total sulphur intake (Figure 2).

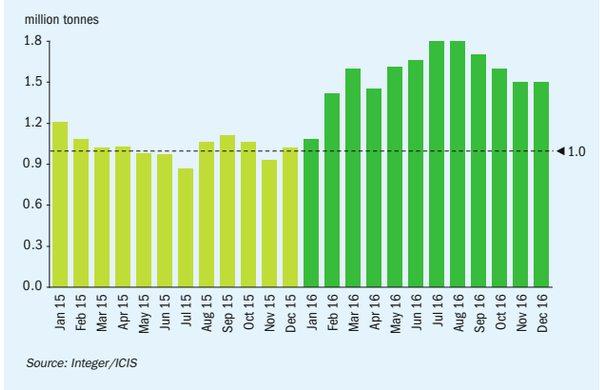
Fig 2: **China's sulphur imports, market share 2011-2016**



FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Fig 3: **China's sulphur port inventory, 2015-2016**



Source: Integer/ICIS

Saudi Arabia has remained China's leading sulphur supplier throughout this period, although its market share has shifted, particularly with the start-up of the UAE's Shah gas project. In 2015, the UAE's share of China's imports leapt to over 13%, compared to around 4% the previous year The UAE's share then increased further to over 15% in 2016. Part of this shift in the import mix has been at the expense of other Middle East suppliers such as Iran. Its exports to China have fallen back in recent years, dropping below 10% to just 8% in 2016 (Figure 2).

Other sulphur-producing regions, such as the Former Soviet Union (Kazakhstan, Turkmenistan and Russia), have also been affected by the rise in Middle East supply, with trade to China from the region dropping from over 20% in 2011 to 17% in 2015 (Figure 2). Much of this downturn was due to the depletion of Kazakhstan's sulphur stocks. Indeed, Kazakhstan may start to regain some of its lost market share in China with the anticipated start-up of the Kashagan project in 2017.

Looking ahead, the Middle East is expected to maintain its market share of sulphur imports into China, although rising domestic production from Chinese oil and gas projects could curtail the country's net import requirements. This has potentially significant implications – as new markets will need to absorb volumes displaced from any future reduction in China's imports. Whether Saudi Arabia will remain China's leading supply source is also open to question. Especially as higher sulphur consumption at large-scale processed phosphates facilities in Saudi Arabia is increasing domestic sulphur demand.

Long-term storage

The status of the global sulphur supply/demand balance is being closely watched by the industry at present. The market is now entering a transition having shifted from being in deficit to a net surplus. This sea change has been partly brought about by supply developments in the Middle East.

The world's sulphur balance is calculated by comparing global supply against global demand. However, this calculation does not include sulphur stored as stocks and inventories. Now that the sulphur market is in surplus, stocking capacity is likely to be an area of increasing interest, with a particular focus on those producers or end-users with the capacity for long-term storage. China, for instance, has the capacity to absorb in excess of two million tonnes of sulphur at its major ports. In practice, however, lower volumes have been held in stocks over the past two years, averaging one million tonnes in 2015 and 1.6 million tonnes in 2016 (Figure 3).

Historically, Canada has been the swing supplier of sulphur, typically moving tonnes to storage during low periods in the market. Some Canadian sulphur suppliers have vast sulphur storage capacities: around nine million tonnes of sulphur is currently held by Syncrude in Alberta, for example. Outside of Canada, although some producers do occasionally store sulphur in block form – such as during logistical or technical challenges – regular blocking may not be a part of their usual marketing process. The paucity of long-term sulphur storage capacity at a producer level in the Middle East is also an emerging issue. Additionally, even Canadian producers have preferred to move sulphur to market in recent years, as the additional cost of bringing sulphur back from storage represents too high a risk due to price volatility.

By its very nature, new sulphur supply is a by-product controlled by oil and gas production rather than the direct needs of the sulphur market. This means that the pressure is now on to find locations where any surplus in the market could be placed. FSU producers such as Russia and Turkmenistan have been cited as potential locations where part of the supply surplus could be absorbed, especially given the limitations on long-term sulphur storage elsewhere.

Rising demand

Sulphur demand in the market outlook is driven by the fundamentals of the processed phosphates sector, together with industrial markets such as metals leaching.

In 2016, total global sulphur demand was estimated at just over 62 million tonnes, a 3% year-on-year rise. The largest regional consumer in 2015 was East Asia, led by China, representing 30% of global demand, with no change in this regional ranking in 2016.

Looking ahead, Africa is set to increase its share of global demand from 15% currently to 18% by 2020. Phosphates expansions such as OCP's Jorf Lasfar Hub in Morocco are becoming important outlets for global producers of sulphur due to the increased opportunities for trade. Moroccan sulphur imports have been on the rise through 2016, the country's demand being second only to China. Morocco is procuring increasing volumes of sulphur from the Middle East, negatively impacting the share of supply from the FSU region. Morocco has the potential for a significant rise in sulphur imports, with producers from North America, the Middle East, Europe and the FSU competing to place volumes.

As supply continues to grow, sulphur producers globally are increasingly looking to diversify their trade with new and growing markets. As a consequence, trade patterns are expected to continue to undergo major transitions in the coming months and years. ■

References

All data in this article are taken from Integer Research's *Sulphur Market Dynamics Quarterly*.

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Prills vs granules: size matters

Physical properties, including size, do matter when it comes to the finishing stage of fertilizer production. We explore the link between fertilizer product quality and finishing technology. Anti-caking agents are widely-used to maintain product quality, and the range of products on the market is also reviewed.

The caking of fertilizers, if not prevented, can be a major headache during storage, transport and field application. It can destroy the value of fertilizers, halt loading and unloading, damage handling equipment and be a safety hazard.

Caking often occurs when fertilizers contain moisture or are exposed to humidity. This allows water soluble salts to crystallise and form solid bridges between particles. Fertilizer stored under pressure can also deform plastically and fuse, especially when stockpiled in bulk in open bins.

Surface caking can also be a warehouse hazard due to the formation of unstable cliffs in fertilizer stockpiles. These can become dislodged and fall when equipment operators remove material from the base of piles.

The choice of finishing technology, because it controls the size and strength of fertilizer particles, has a particularly strong influence on fertilizer caking and handling behaviour.

The rise of granulation

Fertilizers such as urea are commonly formed into either prills or granules during the finishing stage of the production process. Recent large-scale nitrogen fertilizer plants, such as OCI-Sonatrach's 1.26 million t/a capacity Sorfert plant in Algeria and the 1.35 million t/a Qafco VI plant in Qatar, are dedicated to granular urea production. Prilled urea production, in contrast, tends to be associated with legacy plants in China, South Asia and the Former Soviet Union (FSU). Uralchem, for example, a company with a long tradition of nitrogen production, currently produces urea prills from two Russian production sites with a combined capacity of 1.2 million t/a (*Fertilizer International* 472, p 15). However, other FSU producers such as EuroChem, Russia's largest nitrogen fertilizer company, manufacture granular urea from its 1.9 million t/a of production capacity.

Some modern plants are dedicated to prill production, notably Engro's 1.26 million t/a Enven urea plant in Pakistan. This entered service in 2010 and produces prills from a 125 metre-high prilling tower, the country's fifth-tallest structure. Some companies, such as SABIC and Yara International, market both prilled and granular urea.

Granular urea currently enjoys a price premium of around 10% over prilled products. Black Sea and Middle East granular urea were recently trading at $260/t and $280/t f.o.b. respectively, for example, some $20-30/t higher than the $240/t and $250/t f.o.b. prices for prilled urea from the same two hubs.

Prills versus granules

Prills are small spherical aggregates formed by the solidification of molten droplets as they fall downwards against an upward stream of air in a prilling tower. Fertilizer prills are small, lightweight, low in impurities and break down easily when applied to land. They can also be convenient to transport, store and use.

Prilling towers are widely used in the manufacture of urea, ammonium nitrate and compound fertilizers and have the capacity to produce around 600-2,000 t/d of finished product. Their capital cost can be one-third that of equivalent granulation units. They are also generally easier to operate and maintain due to their simpler design.

Prilling is not without its drawbacks as a finishing process, though. Prilling towers are a major source of urea plant emissions, for example, due to the levels of particulates and ammonia present in discharged cooling air. Operating prilling towers at high loads can also be detrimental to finished product quality as this generates more dust and produces prills with higher moisture contents. This can cause caking problems during subsequent storage, transport and handling.

To avoid such problems, most new large-scale urea plants now incorporate granulation as a finishing stage. The granules produced offer distinct quality advantages over prills – the main differences being larger size and higher strength (Tables 1 and 2). Granulated urea has a larger average diameter than prilled urea, 2.7 mm for granules versus 1.9 mm for prills, a difference that is visible to the naked eye.

Changes from factory to field

Without proper handling and storage, the physical qualities of fertilizers can deteriorate during their journey from the factory to the field, being influenced by[1]:

- Physical properties of finished fertilizers at the production stage
- The storage environment and fluctuations in temperature and humidity
- Loads and impacts during handling and transport

Chemical composition and the type of finishing process both determine the intrinsic physical properties of fertilizer products. The most important qualities of products during subsequent handling, storage and spreading are:

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Table 1: **Typical specification sheet: urea granules**

Chemical properties	Typical	Range	Physical properties	Typical	Range
Total nitrogen (N) content, wt-% N	46.2	46.0-46.6	size guide number (SGN)	270	240-320
Biuret content, wt-%	1.0	0.85-1.5	uniformity index (UI), %	52	50-55
Moisture content, wt-% H_2O	0.25	0.1-0.4	bulk density (loose), kg/m³	720	700-740
Formaldehyde (HCHO), wt-% F	0.4	0.2-0.6	bulk density (tapped), kg/m³	810	800-860
Free NH_3, ppm	75	50-150	angle of repose, degree	30	38-32
pH in water solution, 10% wt/wt	7.8	7-9	crushing strength, kgf	3.5	3-4

Source: van Bommel (2016)

Table 2: **Typical specification sheet: urea prills**

Chemical properties	Typical	Range	Physical properties	Typical	Range
Total nitrogen (N) content, wt-% N	46.1	46.0-46.6	size guide number (SGN)	190	140-240
Biuret content, wt-%	0.8	0.85-1.5	uniformity index (UI), %	54	50-55
Moisture content, wt-% H_2O	0.35	0.1-0.4	bulk density (loose), kg/m³	740	730-760
Formaldehyde (HCHO), wt-% F	0.2	0.1-0.3	bulk density (tapped), kg/m³	780	760-860
Free NH_3, ppm	125	50-150	angle of repose, degree	28	26-30
pH in water solution, 10% wt/wt	7.8	7-9	crushing strength, kgf	1.2	1-3

Source: van Bommel (2016)

- Hygroscopic behaviour
- Caking
- Average particle size, shape and size distribution
- Particle strength and mechanical resistance
- Segregation
- Tendency to generate dust and fines
- Bulk density
- The chemical and physical compatibility of components in blends

Quality and size

Finished fertilizers can cake during storage and transport, forming unwanted and hard-to-handle lumps, especially when exposed to humidity or placed under loads when kept in piles. Caking behaviour is particularly influenced by particle size as this parameter determines both the material's surface area – and hence its ability to take up moisture from air – and the number of contact points between particles. A wide particle size distribution also has an effect, as a mix of smaller and large particles in a product will increase the number of contact points.

Urea particles are prone to moisture absorption, decomposition and caking at moisture contents as low as a quarter of one percent. Prilled urea products are especially susceptible to caking as they have almost three times as many contact points and a two-fifths higher surface area than granulated urea. This is revealed by comparing the theoretical characteristics of a cubic metre volume of urea prills (1.9 millimetre-size) with an identical volume of urea granules (2.7 millimetre-size). This volume would contains either:

- 146 million prills with 1,750 million contact points and a surface area of 165 metres squared
- 51 million granules with 610 million contact points and a surface area of 116 metres squared

In practice, a typical 50 kilo bag of prilled urea (roughly 70 litres) will have a total surface area of 12 square metres and some 10 million contact points, dramatically increasing the potential for caking relative to a granulated product.

As well as being larger, urea granules are stronger than prills, with relative crushing strengths of 3.5 kgf versus 1.5 kgf, and are therefore more resistant to crushing and compaction when placed under pressure in stored piles.

Even when packed as closely as possible, spherical fertilizer particles will still only occupy around three-quarters of the total product volume. The remaining one-quarter void space is a problematic because it can fill with either moist air or fine and broken particles. The presence of fine particulates within the void space needs to be avoided as these act as bridges and dramatically increase particle contact points, creating a perfect environment for caking into large lumps or solid piles (Figure 1). Effective sieving and a tight particle size distribution, by eliminating the presence of fines and broken particles within voids, keeps fertilizers within specification and helps ensure a high and consistent product quality.

PHOTO: UREAKNOWHOW

Fig. 1: *Urea lumps (left) and severely caked storage pile (right).*

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

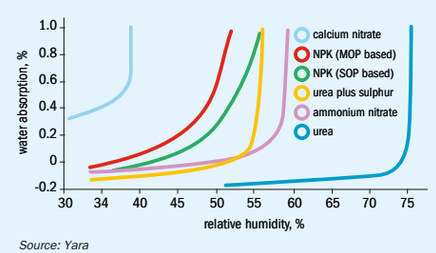
Inspired by
The School of Athens, Raffaello Sanzio 1509-1511
Vatican Museums. Photo Scala Archives

AMMONIA
NITRATES & PHOSPHATES
UREA
MELAMINE
METHANOL
SYNGAS

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

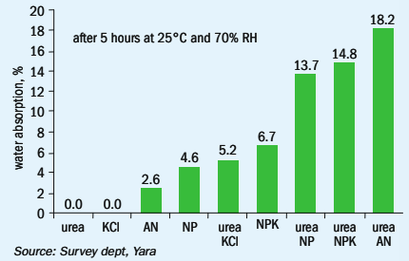
BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Fig 2: **Critical relative humidity (CRH) of various fertilizers at 25°C**



Source: Yara

Fig 3: **Water absorption in blends**



Source: Survey dept, Yara

Humidity problems

All fertilizers tend to be hygroscopic to some degree (Figure 2) and are therefore prone to water absorption during storage and handling (Figure 3). Water uptake can trigger a range of undesirable physical changes[1]:

- Particles start to swell or crack and become soft and sticky
- Dust and fines can form
- Particle strength is reduced and the tendency to cake increases
- Handling and field spreading equipment can become clogged
- Storage warehouse floors become slippery
- Ammonium nitrate loses its thermal stability

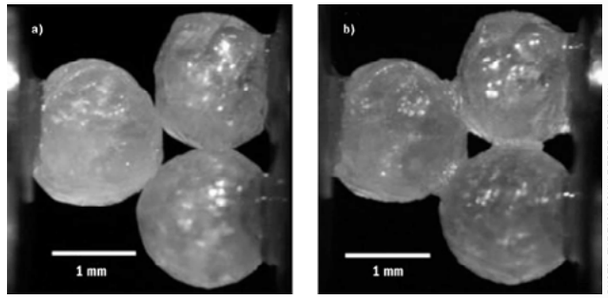


PHOTO: THE FACHSCHULE TRIER, GERMANY

Fig. 4: *Three-particle system of urea prills before (a) and after (b) solid bridge formation*

Under tropical conditions, where temperatures of 30°C and 80% relative humidity (RH) can be the norm, the exposed surface of urea piles can absorb 3.5 kg/m² of water within 72 hours from highly moist air. Condensation from air will also transfer moisture to stored fertilizer piles when temperature falls below dew point during the night time. Avoiding wide variations in temperature and RH is therefore critical for reducing crusting, caking and lump formation during warehouse storage and bulk transport.

The moisture content of finished products is also an important quality consideration as it can lead to dust formation and caking subsequently. Fine needle-like crystals can form from liquid held within capillaries, becoming a dust nuisance during bulk transfer and bagging. Cement formed from a liquid meniscus at particle contact points can also cause urea to become caked when stacked or bagged (Figure 4).

The caking tendency of bagged products can be measured using the IFDC's small bag method (S-106)[2]. Products are subjected to an applied pressure of 0.3 kg/cm² – equivalent to the pressure applied to the bag at the bottom of a 20-high stack – and checked for lumps and hardness after three and six months.

Granulated NPKs

Their variable particle-size and chemistry generally make NPKs more prone to caking than urea prills and granules. For NPKs, water absorption is generally triggered when RH exceeds 50-55%, a threshold known as the critical humidity, as can happen in tropical countries during the rainy season and daily temperature fluctuations.

Urea-based NPK blends are highly hygroscopic and will absorb 14.8 % water by weight when exposed to 70% RH for five hours at 25°C (Figure 3). Under tropical conditions (30°C and 80% RH), the surfaces of NPK (17-17-17) piles can absorb as much as 5.8 kg/m² of water within 72 hours, almost double the surface take-up of urea granules. In practice, NPK materials stockpiled under humid conditions at Asian plants can develop a thick discoloured crust five centimetres deep after just 24 hours, even when covered with protective plastic sheeting.

The high moisture content of NPK granules, typically 0.9% for a 17-17-17 composition, is another significant quality factor (Table 3). The fact that a one metre volume of granulated NPK has about 1,126 million contact points – almost twice that of granulated urea – also promotes caking behaviour.

Maintaining quality

Fertilizer product quality can be maintained by keeping physical parameters within certain values and adopting storage and handling recommendations[3]:

- **Large granules:** 95% between 2-4 mm, SGN > 250
- **Uniform size:** uniformity index > 55
- **Low angle of repose:** keep to <30 degrees by more efficient sieving
- **Low moisture:** keep end-product moisture content < 0.8%
- **Low granule porosity:** <0.5% desirable
- **High granule strength:** >3.0 kg crush

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Table 3: **Typical specification sheet: NPK 17-17-17 granulated**

Chemical properties	Typical	Range	Physical properties	Typical	Range
Total nitrogen (N) content, wt-% N	17.0	16.5-17.5	size guide number (SGN)	220	140-240
Total phosphate (P) content, wt-% P_2O_5	17.0	16.5-17.5	uniformity index (UI), %	52	50-55
Total potash (PK) content, wt-% K_2O	17.0	16.5-17.5	bulk density (loose), kg/m³	800	760-840
Total sulphur (S) content, wt-% S	4.7	4-5	bulk density (tapped), kg/m³	833	800-860
Moisture content, wt-% H_2O	0.9	0.8-1.5	angle of repose, degree	29	27-31
pH in water solution, 10% wt/wt	7.8	7-9	crushing strength, kgf	3.1	2-5

Source: van Bommel (2016)

strength for three millimetre granules, for example

- **Low fines and dust:** ensure no material <1mm in product
- **Temperature control:** maintain a constant warehouse temperature to prevent the migration and absorption of moisture
- **Storage:** avoid keeping bagged products with a high caking potential in high stacks
- **Warehouse management:** apply the first in/first out principle

Coating systems

The degradation of finished products during handling and transport can be reduced or avoided by surface coating with anti-caking agents (*Fertilizer International* 453, p26; *Fertilizer International* 464, p32). These agents, which are often combined with a pigment, reduce water absorption under humid conditions and help prevent caking and dust formation. They include both manufactured and natural compounds and need to be harmless to soil, plants and humans. Coating chemicals generally function by:

- Controlling dust formation
- Minimising caking and particle bridging
- Enhancing powder flow
- Reducing moisture absorption
- Enhancing appearance
- Regulating nutrient release

Urea, ammonium nitrate, calcium nitrate and NPK fertilizers are more hygroscopic and will therefore often benefit the most from the addition of anti-caking agents, according to Indian process chemicals manufacturer Fertibon Products. In comparison, the need for anti-caking treatment for fertilizers such as phosphates and ammonium sulphate can be lower as they are less hygroscopic.

Yara Technology Centre has developed a range of coating systems for its fertilizer product range. These can reduce dust release during bulk handling by up to 90%. Treating *YaraLiva* calcium nitrate fertilizers with the company's proprietary *Tropicote* coating also drastically reduces water absorption[1].

Novochem Fertilizer Additives markets a range of anti-caking and moisture repellent agents *(NovoFlow)*, concentrated anti-caking agents *(NovoFlake)*, dedusting agents *(NovoDust)* and colouring agents *(NovoTint)*.

Clariant Mining Solutions offers the comprehensive *Flotigam* and *Fertala* range of anti-caking, water repellent and anti-dusting additives for nitrates (AN, CAN), phosphates (MAP, DAP, SSP and TSP) and NPK fertilizers. Many of these additives are paraffin-based although the formulations of some anti-caking and dust binding products such as *FLOTIGAM V 5696* are made from vegetable oil. *FERTALA 4902* is a specially designed anti-caking additive for fertilizers at high temperature.

The *CHEMISIL* range of additives offered by Spanish firm **Chemipol** are designed to prevent fertilizer caking during manufacture and storage, and are based on two main formulations. *CHEMISIL NS* is a soluble sulphonated coating agent designed to prevent caking in bagged fertilizers stored under load on pallets. The anti-caking agent *CHEMISIL AG*, in contrast, is a highly-absorbent form of silica dioxide used to prevent agglomeration during the manufacture of powdered fertilizers.

ArrMaz has been a leading provider of coatings and process control chemicals to the fertilizer industry since the late 1960s. The company coats over 40 million tons of fertilizers every year for some of the world's major fertilizer producers with its *Dustrol* range of dust control agents and *Galoryl* range of anti-caking agents. These are generally suitable for all solid fertilizers including granules, prills and powders. *Dustrol* coatings supress dust by forming a barrier around granular products and will also adsorb dust after it is generated. The company's *Galoryl* range is targeted at the industrial ammonium nitrate and nitrogen fertilizer market and is available in both aqueous and non-aqueous formulations.

China's biggest fertilizer additive producer **Forbon Technology** manufactures four anti-caking agents for urea, phosphates and compound fertilizers under the *Hisoft* brand name. These oil-based and powder-form coating agents are designed to solve fertilizer quality problems such as caking, dust generation and weak granule strength.

India's **Neelam Aqua & Speciality Chem** markets the *NEELCOAT* range of anti-caking agents for granular NPK, phosphate and ammonium nitrate fertilizers. These also have dust suppressant properties. The company also offers three *UREACOAT* anti-caking formulations for urea, the first designed for prills, the second incorporating neem oil and the third including an urease inhibitor.

Fertibon Products manufactures a wide range of fertilizer additives, including anti-caking agents and colourants, at its production site in Maharashtra, India. These are non-toxic and are also designed not to damage conveyor belt systems as they are inert when in contact with rubber.

Kao Global Chemicals sells paste and powder anti-caking agents for a wide range of fertilizers (AN, CAN, DAP and NPKs) under the *SK FERT* marque. It also offers the liquid anionic surfactant product *URESOFT A-10*, a low-toxicity anti-caking agent designed especially for urea and ammonium sulphate.

Pastillation: the third way

One solution to the problem of ageing, high-emission urea prilling plants, and the competition between low quality prills and granules on the market, is to retrofit a pastillation unit at the finishing stage (*Nitrogen+Syngas* 313, p53). The *Rotoform* pastillation system offered by **Sandvik Process Systems**, widely-used in sulphur solidification, is a practical and effective debottlenecking or revamping option for fertilizer plants. The system will granulate urea, blended urea mixtures and a wide range of other fertilizers including:

- Fertilizer-grade urea
- Technical urea for urea-formaldehyde, melamine and ad blue production
- Urea-macronutrient blends
- Urea-micronutrient blends
- Urea-ammonium sulphate
- Sulphur-bentonite
- Ammonium nitrate
- Calcium nitrate
- Magnesium nitrate
- NPKs synthesised using the nitrate or urea route

The *Rotoform* system uses urea melt as a feed and can be installed in parallel with a plant's prilling tower. Sandvik's Rotoform HS system has 5 t/h capacity for urea, compared to 15 t/h for sulphur, and can be brought in and out of production as required. Capacity can be further increased by adding extra units to the production line in parallel.

Table 4: **Typical properties prills, granules and pastilles**

	Prills	Granules	Pastilles
Average diameter, mm	1.5-1.9	2-4	2-5
Moisture, wt-%	0.15-0.30	0.10	0.10
Formaldehyde content, wt-%	0.1-0.3 (in case of export)	0.3-0.55	Only when required
Shape	Spherical	Spherical	Split-pea
Crushing strength, N	12 (1.7 mm)	40 (3 mm)	40-75 (3 mm)
Product temperature, °C	60-80	50-60	40-45

Source: Nitrogen+Syngas *313, p53*

The quality of the pastilles produced by the system is better than prills and similar to traditional granules (Table 4). *Rotoform* pastilles are extremely uniform and split-pea shaped, being convex on one side and flat on the other. Their size can also be easily varied between one and five millimetres. Farmers who have applied the pastilles are reportedly very satisfied with the product and are prepared to pay a price premium over less costly prills. ■

Acknowledgement

This article is partly based on a 2016 feature by B. George van Bommel of BioTorTech and UreaKnowHow in our sister publication *Nitrogen+Syngas* (*Nitrogen+Syngas* 340, p44).

References

1. Yara. From *Factory to field: Properties and Handling of Yara Fertilizers*. Yara International, Norway.
2. Rutland, D., 1993. *Manual for Determining Physical Properties of Fertilizer*, IFDC-R-10, 2nd Edition. International Fertilizer Development Center (IFDC), Muscle Shoals, Alabama.
3. van Bommel, B., 2016. Size matters. *Nitrogen+Syngas* 340, p44.

Fertilizer International 477 | March-April 2017

www.fertilizerinternational.com

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Fertilizer Latino Americano 2017

Edificio Kavanagh, Buenos Aires.

More than 600 delegates from 50 countries gathered at the Sheraton Hotel and Convention Center, Buenos Aires, Argentina, 25-27 January, for the 2017 CRU/Argus FMB Fertilizer Latino Americano conference.

We report on the keynote, regional market and fertilizer outlook presentations at the CRU/Argus FMB Fertilizer Latino Americano conference held in Buenos Aires in January.

CRU's chairman, **Robert Perlman**, opened the conference with some introductory remarks:

"Buenos Aires is a fitting location to hold the 2017 Fertilizer Latino Americano conference. Why? Reforms enacted by the Argentinian government in the agricultural sector since December 2015, especially the easing of export restrictions, have awakened regional and global interest in Argentina.

"Domestic and global fertilizer producers in Argentina have also benefitted from the associated pick-up in fertilizer demand, particularly with the increased crop area that's now dedicated to more nutrient-intensive corn and wheat production.

"Agribusiness is a crucial sector for the Argentinian economy and we're delighted that we have Luis Maria Urriza, agricultural sub-secretary at Argentina's agroindustry ministry, here to outline the nation's vision for the agribusiness sector."

Global trends, regional realities

In a keynote address, **Charlotte Hebebrand**, IFA's director general, summarised current major global trends in fertilizer use, as well as some of the regional realities.

Due to its agricultural strengths, Latin America will continue to play a leading role in driving the global fertilizer outlook, in Hebebrand's view. Increasing fertilizer use in the region, she suggested, will be mostly linked to land expansions rather than rising application rates.

Opportunities for improving fertilizer use in the region do exist, however. Hebebrand identified four agricultural challenges – low yielding land, nutrient imbalances, smallholder farming and low productivity pasture – that could all be helped by better Latin American fertilization practice. Economics and politics, though, will continue to influence agricultural prospects and fertilizer consumption in Latin America, she cautioned.

Self-sufficiency some way off

Juan Lozano, CEO of Pemex, **Matthew Albrecht**, senior vice president, Canpotex and Stamicarbon's area manager **Mauricio Medici** took part in a panel discussion on global fertilizer markets. This partly focussed on the question of why the prospects for fertilizer self-sufficiency in Latin America – which looked so promising five years ago – have yet to be realised.

Mauricio Medici highlighted the gap between the 20 million tonnes of Latin American urea demand and the four million tonnes of installed regional capacity, all located on the Atlantic coast. More positively, he highlighted the potential to add nitrogen production capacity, given that Argentina has the second largest shale gas deposits in the world and the availability of natural gas in Peru.

Matthew Albrecht was not surprised that the region's potash projects had not progressed. This was simply because no one has been prepared to put up the substantial capital required to date, in his view. "It's really a question of economics," he said, adding: "Logistics has been a challenge historically, continues to be so and is the key internally in Brazil." Juan Lozano agreed, asking: "What is the point of huge production facilities when you can't get to market?"

Poor price performers

CRU's **Alistair Wallace** presented the outlook for nitrogen fertilizers. Nitrogen remains in a supply-driven phase after an unprecedented plant building boom. The market also suffered from weak demand in 2016. This was compounded by farm credit problems in Brazil and falls in South Asian demand linked to El Niño. Weaker energy prices and currencies also helped create a deflationary price environment.

In a downbeat assessment, Wallace observed that urea had been one of CRUs worst performing commodities last year, while admitting that fertilizers were all poor performers in 2016. Having lost a lot of ground in first part of the year, nitrogen prices did eventually rally late last year. Looking ahead, the urea price looks set to remain near the marginal cost set by Chinese anthracite-based producers, although CRU foresees a rise in prices from around $222/t currently to $260/t by 2019.

Wallace raised the prospect of the market entering a demand-driven phase from 2019 onwards. This could see urea prices eventually rising above $300/t by the end of the decade, driven upwards by a combination of higher energy prices and a tighter global supply/demand balance. The expectation that China will close 12 million tonnes of capacity over the next few years should help rebalance the market.

The demand outlook for the nitrogen market also looks positive. CRU expects global demand growth of 2.1% p.a. over the next five years, spurred on by rising South Asian and East Asian demand. China, though, remains a risk. The country's nitrogen consumption is stagnant and the removal of corn subsidies by the government could limit demand going forward.

Managing new P&K capacity

Paul Burnside gave the CRU view on the state of the potash and phosphate markets. P & K fertilizers have both lost around a third of their value in the last two years, observed Burnside, to the extent that both are now at their cost floor. Last summer, MOP found price support at around $200-220/t (cfr Brazil), for example, while DAP prices bottomed at $290-300/t (f.o.b. China) towards the end of 2016.

Asia will remain the driving force behind P & K market growth over the next five years, in Burnside's view, although India and South East Asian countries look set to replace China as the main engines of global growth. The outlook for P & K markets also hinges on how extra supply from major new capacity projects is managed in future. Despite the extra tonnages expected from OCP and Ma'aden, phosphate prices should continue to be underpinned by Chinese production costs, according to Burnside. Looking ahead, China's phosphate producers will continue to act as swing export suppliers globally with Canada's potash producers playing the same role in the potash market.

The future of fertilizers in Argentina was discussed in a session moderated by **María Fernanda González Sanjuan** of Fertilizar Asociación. Views were exchanged by a five-member panel drawn from Argentina's leading fertilizer and agricultural organisations. The participants were **Francisco Llambias** of Profertil, **Federico Bert** of AACREA, **Edmundo Nolan** of Aapresid, **Marco Prenna** of Asociación de Cooperativas Argentinas (ACA), **Jorge Bassi** of Fertilizar Asociación and **Pablo Pusetto** of Consorio del Puerto de Ingeniero White. The discussion ranged widely, covering prospects for fertilizer plants, infrastructure and mine investment in Argentina, to the state of the agricultural commodities markets, and policies to stimulate fertilizer demand.

Tackling a ten billion dollar problem

In a session on micronutrient and speciality fertilizers, **Antonio Papas** of Koch drew attention to the scale of nitrogen losses from ammonia volatilisation globally. This is a 10 billion dollar problem responsible for nitrogen losses of 25% worldwide, suggested Papas, a percentage that equates to some 38 million tonnes of wasted urea production. However, the use of proven urease inhibitors (NBPT) in stabilised fertilizer products is able to cut ammonia volatilisation losses by a half. It can also improve farm economics.

Citing a University of Illinois trial, Papas suggested that using Koch's *Agrotain* urease inhibitor with urea applications can boost US corn yields by up to 1,750 kg/ha. This provided $242/ha of extra revenue against an extra application cost of $17/ha. Average corn yield improvements achieved with *Agrotain* were $1000 kg/ha.

EuroChem Group's **Nils Berger** explained the agricultural and environmental benefits of both nitrification and urease inhibitors. He suggested the former can reduce net N_2O emission by up to 90%, while the latter can cut ammonia volatilisation losses by up to 60%. EuroChem markets *ENTEC 26*, an ammonium nitrate/sulphate (26% N + 13% S) product stabilised with the nitrification inhibitor DMPP. The company also offers *UTEC 46*, a liquid urease inhibitor for treating urea.

Iodine innovation

Speciality plant nutrition, and potassium nitrate specifically, is an important business segment for Chilean producer SQM, explained **Alfredo Doberti**. Speciality product sales volumes of 846,000 tonnes in 2015 generated revenues of $636 million for SQM and contributed 29% to company profits. The firm also has a 47% share of the global potassium nitrate market.

SQM is expanding potassium nitrate production from one million t/a to 1.5 million t/a over the next two years. It is investing $140 million in a new 300,000 t/a nitrates plant. This is scheduled to enter production mid-2018. Increasing the efficiency of its existing plants will add a further 200,000 t/a to SQM's capacity.

SQM is also gearing up to launch *Speedfol Iodine SP*, the latest addition to its range of micronutrient foliar fertilizers. The results of wheat and rice trials suggest its use can increase daily iodine uptake from foodgrains by 4-to-24 times. As part of efforts to tackle the problem of human micronutrient deficiency, the company has joined the Harvest

CONFERENCE REVIEW

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Plus initiative and raised awareness by contributing to 'Zinc & Iodine Days' in China, India, Thailand, Mexico and Brazil.

Large Latin sulphur market

An update on sulphur fertilizer markets was provided by CRU's **Peter Harrisson**. He noted that the growing area of sulphur-hungry crops such as soybeans and rapeseed is increasing globally. At the same time, the use of high-analysis fertilizers, and less sulphur deposition from the atmosphere, also means that sulphur deficiency is a growing problem.

Deficiency is most prevalent in Asia, Africa and Latin America. Around 45% of world crops are not getting enough sulphur and the problem has now become yield limiting. Because of this, the industry is starting to recognise the value of sulphur as a crop nutrient – and develop new products to meet rising demand. Premium sulphur-enhanced fertilizer products are now coming onto the market as a consequence.

Central and South America is the largest regional market for S fertilizers with a sulphur consumption of 2.4 million nutrient tonnes in 2015. The use of ammonium sulphate (AS, 1.19 million tonnes S) and single superphosphate (SSP, 0.68 million tonnes S) predominates currently. Despite this, the region remains in deficit, says Harrisson, with a 0.55 million tonne sulphur nutrient gap. This deficit is likely to deepen to 0.8 million tonnes sulphur by 2020. One way of filling the current deficit would be to substitute around 30-40% of DAP/MAP and urea consumption with sulphur-enhanced fertilizer equivalents, Harrisson concluded.

More from the start

The case for using phosphate starter fertilizers in Argentina was outlined by INTA's **Ricardo Melgar**. Starter fertilizers are applied in close proximity to seedlings at planting, in either granule or liquid form. They enhance the development of seedlings by providing an accessible source of nutrients close to their roots.

MAP and DAP are the main agricultural sources of P used in Argentina. A typical pampas farmer already applies P as starter in grain production. But, with the exception of wheat, the average P_2O_5 application rates (38 kg/ha for wheat, 40 kg/ha for corn and 30 kg/ha for soybean) are not enough to replenish the average export of P at crop harvest (29 kg/ha for wheat, 69 kg/ha for corn and 33 kg/ha for soybean). As a consequence, negative phosphorus balances affect the soil availability of this nutrient in some regions of Argentina, due to the crop export of P exceeding applications.

Farm profits and demand on the up in Brazil

Despite the turbulent political and economic backdrop of the last two years, Brazil remains global agriculture's powerhouse. The outlook for Brazilian agribusiness in 2017 looks largely positive, according to **Cleber Viera** of Agroconsult. The country's fertilizer market looks set to grow this year to 34.7 million tonnes – up from 33.5 million tonnes in 2016 – and 2017 farm profitability also looks attractive. Fertilizer logistics in Brazil, however, remain "a big issue to be solved", cautioned Viera.

The soybean crop is expected to devour over two-fifths of domestic consumption (15.3 million tonnes) this year, and is helping drive Brazilian fertilizer demand growth. Soybean profitability in 2016/17 looks likely to rise to between $352/ha and 429/ha, depending on growing region, a recovery from the $127/ha to $262/ha profit range of 2015/16. Demand from Mato Grosso in the country's centre west remains pivotal. This region is expected to account to close to one-fifth of total domestic fertilizer usage this year (6.6 million tonnes).

Peace comes to Colombia

Olaf Hektoen of Yara gave the outlook for Colombia. He reported that, despite the FARC peace process, several "armed and delinquent groups" are still present across the country. Nevertheless, with the prospect of peace, agricultural initiatives such as the Colombia Siembra Program could bring an extra one million hectares of crops into production in the next three years.

Agriculture and forestry covers 26.5 million hectares of Colombian land. Some 11 million hectares of this are devoted to crops and a further six million hectares to livestock. The agricultural sector has been growing at 3.1% p.a. (2000 to 2007 figures) and accounted for 6.1% of national GDP in 2015, although this has declined from the 7.5% share of two decades ago. Eight crops (coffee, sugarcane, rice, potato, yucca, African palm, banana and maize) account for almost 80% of Colombia's agricultural production. A significant agricultural productivity gap exists between Colombia and comparable countries. Coffee productivity (0.69/t/ha), for example, is around half that of Brazil's (1.29 t/ha).

The country's fertilizer consumption has grown by a sluggish 0.9% p.a. over the last 15 years, and has largely stagnated since 2011 at around 1.6-1.8 million tonnes. Production at Yara's 730,000 tonne capacity Cartagena NPK plant is divided between three products: *Monomeros NPK* (330,000 t/a), *Yara NPK* (300,000) and *Yara CN* (100,000 t/a). The Cartagena plant operated at 600,000 tonnes capacity in 2016, with 150,000 tonnes of this volume exported. This meant that imported fertilizers (1.25 million tonnes) met almost three-quarters of total Colombian demand last year (1.7 million tonnes), estimates Yara.

Brazil for sale

Changing trade flows in the Americas were highlighted by Argus Media's **Blake Hurtik**. North American phosphates exporters have been shifting to MAP, with Brazil a particular target market, with less DAP to India. Phosphates imports from Saudi Arabia are also starting to make their presence felt in the region. In terms of phosphates assets, it has been very much a case of "Brazil for sale", commented Hurtik. He listed notable Brazilian acquisitions since 2013, namely Yara's $750 million purchase of Bunge, Mosaic's $2.5 billion buy-out of Vale and the sale of Produquimica to Compass Minerals.

US nitrogen exports are also coming to the region, Hurtik advised. This is especially true of urea ammonium nitrate (UAN). Helped by the start-up of CF's Donaldsonville plant, the US exported over one million tonnes of UAN to Latin America in 2016, with Argentina being a major destination. More consistent Algerian and Egyptian urea production in 2016 also saw their January-October exports rise to two million tonnes, a 437,000 tonne year-on-year rise.

In the potash market, Brazil remains a "huge buyer" of granular MOP, comments Hurtik. Looking ahead, there is the prospect of potash market "stability and sunlight" this year in his view. This is in large part due to the rationalisation in Canadian potash capacity. Both Canpotex and BPC are now fully committed for the first quarter of this year. There has also been strong winter buying on the US market. However, whether China will step in at the usual time for contract shipments remains a key question for the 2017 potash outlook. ■

March-April 2017

phosphates & potash INSIGHT

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Phosphates market report

We look at the current state of the phosphates market ahead of CRU's Phosphates 2017 conference in Tampa this March. Some price benchmarks fell by a third during 2016 in response to oversupply, falling Indian import demand and declining input costs. Looking ahead, China looks set to continue in its role as a swing exporter, and the country's production costs should underpin phosphate prices in the face of increasing supply from Morocco and Saudi Arabia.

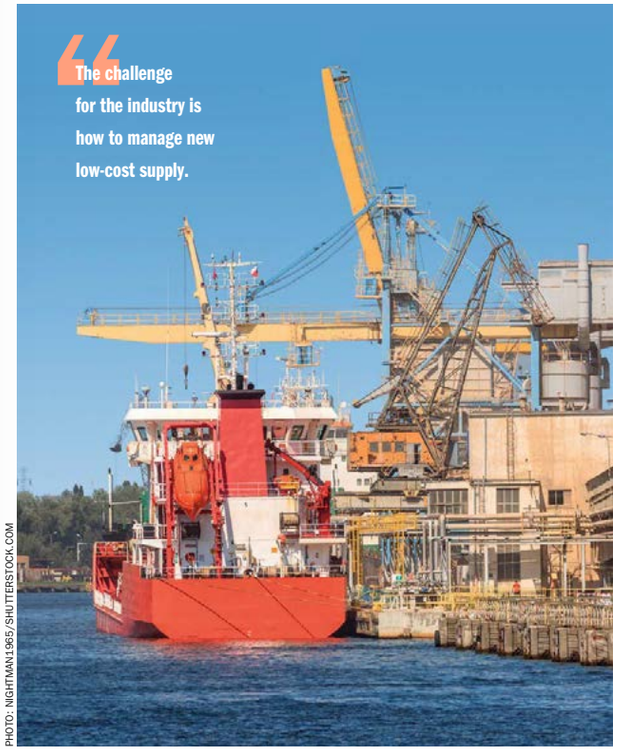


PHOTO: NIGHTMAN1965/SHUTTERSTOCK.COM

Loading phosphate fertilizers in the port of Gdansk, Poland.

2016 was a tough year for phosphates producers and their margins. Finished phosphate prices dropped across all key hubs over the course of the year. The North African f.o.b. benchmark for diammonium phosphate (DAP), for example, fell from $445/t to $328/t between January and December last year – a decline of more than 25 percent.

Prices declines in the finished phosphates market were also felt further upstream. Phosphoric acid contracts between Morocco's OCP and Indian buyers dropped by $135/t during 2016, arriving at $580/t cfr by the year's end. The Moroccan phosphate rock benchmark, stable at around $132/t f.o.b. for much of the preceding 18 months, also underwent a downward correction from the third quarter onwards, eventually settling at $103/t as 2016 drew to a close[1].

While phosphate prices moved lower in 2016 – responding to oversupply, falling Indian import demand, competitive pressures and declining input costs – a recent improvement in fundamentals has helped support the market.

"The key factors to watch in 2017 will be the strength of Indian demand, the ramp up of new export supply and any potential shifts in China's exports – as new capacity repositions producers on the cost curve," comments PotashCorp in its latest market outlook[2].

The arrival of new low-cost supply in ever larger volumes is a key challenge for the phosphates sector currently, according to Paul Burnside, principal consultant at analysts CRU[3]. "Following a period of high prices, where there was a lot of investment in capacity, we're now at the point where a lot of that new capacity is coming on-stream. The challenge for the phosphates industry, really, is how to manage that new supply without it being too disruptive."

Pricing falls to marginal cost

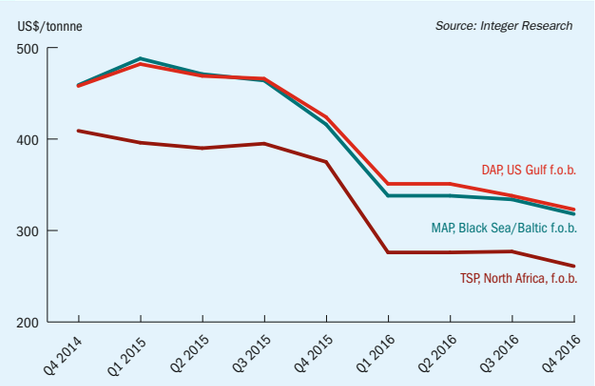
Phosphate fertilizer prices fell by around one-quarter to one-third last year, the exact decline depending on the product and the price benchmark (Figure 1).

Speaking during a recent webinar[4], Oliver Hatfield, Integer Research's director of fertilizers, commented: "We're in the weak part of the cycle – that's fairly clear. Finished phosphates prices were under pressure throughout 2016, due to a combination of global oversupply, weak raw material prices and disappointing demand.

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Fig 1: **Selected quarterly phosphate fertilizer prices, 2014-16**



"We've seen ammoniated phosphate prices down in the low three hundreds. That's a function of the fact that the market's been long for some time now with oversupply [acting] in combination with relatively weak raw materials costs. In fact, for a while now pricing for ammoniated phosphates has been at the marginal cost, at the high end of the cost curve – that's roughly where price has been established."

Similar price trends have been observed upstream at the phosphate rock and phosphoric acid end of the supply chain.

"Phosphoric acid pricing has more or less tracked the finished end of the business," comments Hatfield. "It's been long on product and oversupplied and price has been more or less close to marginal production."

He continues: "The rock market has been a little bit more robust, at least until quite recently. It has arguably been more balanced, tighter, better managed on the supply side – and that's been reflected in the price being somewhat higher than the marginal cost."

Underlying costs fall

Raw material price weakness in 2016 is revealed by the fact that leading price benchmarks for ammonia and sulphur fell by about 54% and 28%, respectively, over the course of the year. Raw material prices appear to have bottomed in the final quarter of last year, however, suggesting that floor prices for finished phosphates may edge up as 2017 progresses.

"It's certainly true that falling raw material prices has made a significant contribution to the weakness in ammoniated phosphate prices, particularly for ammonia where we've seen the price collapse," comments Hatfield. "The market's got really long for ammonia. That's allowed finished phosphates prices to fall further."

Currency movements against the US dollar in key phosphate producing and consuming regions have also had important market effects.

"We mustn't ignore exchange rates. These have been an important feature of the market over the last year or two, on the supply and on the demand side," comments Hatfield. "Weakening local currencies against the US dollar have boosted the competitive position of some leading phosphate producers. However, unstable and weaker rates in key importing countries has negatively affected demand."

He adds: "We certainly shouldn't forget other costs too, particularly energy, which have flattened the cost curve and allowed prices to soften up."

Upside to prices?

CRU reported a $170 fall in the China DAP f.o.b. price, from around $460-470/t level in August 2015 to a floor price of around $290-300/t by last November.

"Phosphate fertilizer prices have lost at least a third of their value for the last couple of years but seem to have reached a floor – that's approaching $300/t f.o.b. China in the case of DAP," comments CRU's Paul Burnside. "That is the cost floor so we're seeing a production response from the Chinese industry at that price level, with prices acting as a tap to control the volume of exports coming out of China – this is what needs to happen next."

Chinese exports have been weighing on prices over the last two years. CRU expects China to continue to be the swing exporter into the early 2020s, although cost escalation may support modest price increases.

"Chinese exports have been weighing on prices for some time and we're now around the cost floor. Over the next 2-3 years, OCP and Ma'aden are going to place a lot of extra volume into the market. But, given that we've still have this cost floor from China, prices should hold up despite those additional volumes. Looking further out into the 2020s, there is actually an upside to prices as we see cost inflation raising the cost floor."

Faltering financial performance

Falling raw material prices and, consequently, lower production costs in 2016 offered only limited consolation for phosphate producers – as the greater weakness in finished phosphate prices eroded their profitability year-on-year. Quarterly phosphate sector profits fell by 38% between the third quarter of 2015 and the third quarter of 2016, according to Integer Research. They calculate that collective phosphate industry profits for the first nine months of 2016 dropped to below $3 billion[4].

"Overall, profitability has declined. The effect of the weakness in prices, largely a function of oversupply, has been stronger than the effect of lower production costs," comments Oliver Hatfield. "When we look at January-September 2016 gross profits compared to the previous year, profitability has continued to soften – which is obviously disappointing from a producer perspective."

The profitability of leading North American phosphate producers Mosaic, PotashCorp and Agrium appear to have been particularly badly affected. Collectively, the gross margins for the phosphate segments of their businesses fell year-on-year, reflecting difficult market conditions. Average gross margins, which had been as high as 20% in North America at the end of 2014, even dipped to 4% at one point in mid-2016[4].

"Different producers have had a different experience compared to their peers. In North America, for the three leaders [Agrium, Mosaic, PotashCorp] the picture is more or less the same – quite weak and single-digit gross margin percentages for these very capital-intensive businesses," comments Hatfield. "That's a sign of businesses which have been struggling – cyclically struggling I should emphasise – in the last few quarters."

Table 1: **Competitive advantage of ammoniated phosphate producers based on their relative raw material and location positions**

Country	Phosphate rock	Ammonia	Sulphur	Proximity to customers	Comments
India	Poor	Poor	Poor	Good	Producers require government support
China	Mixed	Mixed	Mixed	Poor-to-average	Highly diverse industry, from low-cost, fully-integrated to high cost, non-integrated
US	Average/good	Mixed	Average	Average	Declining rock availability, import top-up necessary
Morocco	Good	Poor	Poor	Average	Enjoys a significant rock cost advantage
Russia	Good	Good	Good	Poor	Boosted by rouble's depreciation but for how long?
Saudi Arabia	Good	Good	Good	Average	Low-to-medium cost in all raw materials, but carries an opportunity cost?

Source: Integer Research

Production costs count for everything

Middle East and North African (MENA) phosphates producers OCP, Ma'aden, JPMC and ICL have generally fared better financially, compared to their North American peers. Collectively, their average gross margins were down, second quarter 2015 to second quarter 2016, but still managed to remain above 15%[4].

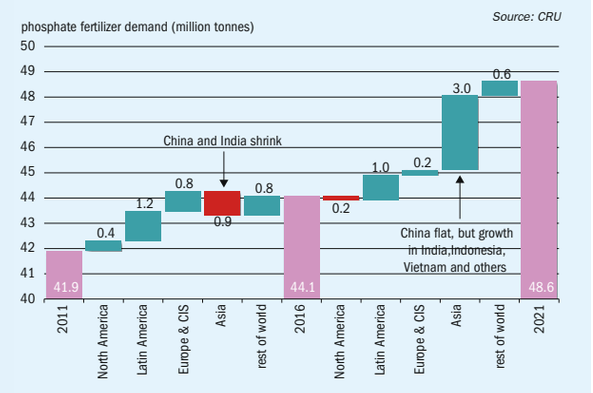
"As ever, low production costs, integration and scale provide some insulation to the cyclically weak market," observes Hatfield. Production costs count for everything and in this region we have two of the most cost-competitive companies in OCP and Ma'aden. They've weathered the storm better. Profitability has weakened in both cases but they're still returning reasonable gross margins."

The weak rouble, by lowering domestic phosphate mining and processing costs, has also helped integrated Russian producers PhosAgro and EuroChem maintain healthy margins during this period of pressured pricing. Average Russian quarterly phosphate gross margins were down, second quarter 2015 to second quarter 2016, but kept above 30%[4].

"It's a combination in Russia. The rouble's devaluation has had a positive effect but we mustn't also forget that these guys are more or less fully-integrated. They have the rock, they make the ammonia and have advantageous access to sulphur," observes Hatfield. "That in combination with a weaker rouble has given them a boost and allowed them to improve their cost position against their peers [and] outperform the Americans."

In Integer's view, the disparities in financial performance highlighted here are partly a reflection of the competitive advantage enjoyed by those phosphate producers with raw material access and proximity to customers (Table 1).

Fig 2: **Phosphate fertilizer demand, historical and forecast**



Demand coming back from Asia

In the last five years, phosphate fertilizer demand has contracted in Asian markets by some 0.9 million tonnes, according to CRU, mainly in China and India (Figure 2). In China, this has been linked to structural changes in the industry and concerns about the over-application of phosphates. Demand in India, in contrast, has been largely limited by subsidy reforms and the higher domestic prices these have triggered[3].

Fortunately, Asian demand prospects look more encouraging over the next five years. CRU expects regional phosphate fertilizer demand to grow by three million tonnes between now and 2021 (Figure 2). Latin America will also provide an extra phosphate demand stimulus of one million tonnes[3].

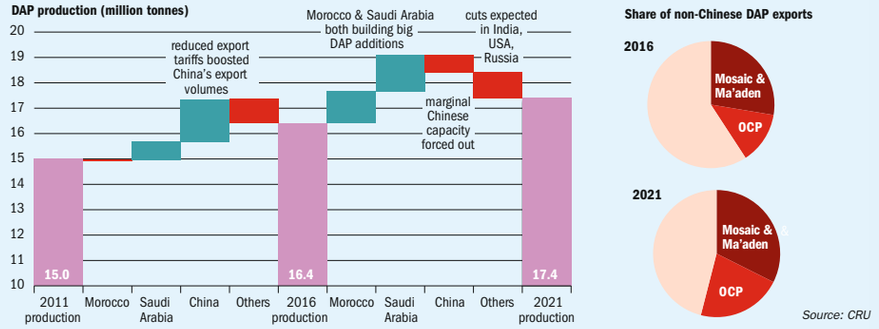
"How do we see that changing from 2016 to 2021? Well growth coming back from Asia, not necessarily from China but from a lot of other countries, including India, Indonesia and Vietnam," comments CRU's Paul Burnside. "Latin America will also continue to be a strong contributor to growth prospects for phosphate."

India will remain a key phosphates market, suggests PotashCorp, despite the slowdown in demand last year. Consump-

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Fig 3: **DAP supply growth, historical and forecast**



tion was depressed due to a combination of factors, including high inventory levels, fertilizer subsidy uncertainties and the removal of currency notes from circulation. As a result, Indian DAP imports fell to 4.3 million tonnes last year, 1.5 million tonnes down on 2015. India's domestic DAP production, in contrast, rose in 2016, up 0.8 million tonnes to 4.4 million tonnes, the highest level this decade. Buying commitments for phosphoric acid imports kept domestic operating rates high and maintained phosphate fertilizer inventory levels[2].

Encouragingly, Indian DAP imports, despite a slow start, are expected to recover to 5.5 million tonnes in 2017 with domestic production falling back to 3.6 million tonnes[2].

China maintains output

Market oversupply had little effect on Chinese phosphates production last year, as Ibi Idoniboye, head of phosphates and NPKs at Integer Research observes[4]: "Interestingly, over the last year, China actually didn't reduce phosphates production. They maintained roughly the same production rate as previous years. This led to a level of oversupply into the market as there was also other capacity coming online."

He continues: "China had quite high stocks and obviously the amount of volume has been weighing on the market. The low export tax and availability of Chinese product onto the market over the course of last year did impact on prices."

CRU is forecasting phosphate consumption to grow at around two percent per year over the next five years[3]. Looking ahead, the challenge for the industry, according to Paul Burnside, is whether those growth rates are going to be sufficient to absorb new capacity. Chinese producers will eventually be squeezed by Moroccan and Saudi Arabian DAP supply growth in his view.

"The last five years have really been about the arrival of Saudi Arabia with Ma'aden ramping up DAP production. We've also seen huge amount of DAP production and export growth from China. If we look at the next five years, we've got another phase of expansion from Saudi Arabia. In Morocco, OCP are also focussing more on downstream fertilizers including DAP."

China shifting from expansion to contraction

The Chinese domestic market for phosphate fertilizers has contracted in recent years and the country's forward demand outlook also remains flat. Chinese phosphate producers have therefore needed to look outwards and sell surplus product into international markets – although they have now begun to cut output in the face of cost pressures[3].

China currently has 18.6 million t/a of DAP capacity and 18.2 million t/a of monoammonium phosphate (MAP) capacity. Very little of the country's MAP capacity is integrated whereas close to 15 million t/a of DAP capacity is either integrated or semi-integrated[4].

Prices are at the floor for many Chinese producers currently, according to Integer Research. The country's production costs ex-works are estimated to range from $250-350/t for DAP and $240-325/t for MAP. China's average operating rate is also thought to be around 70% typically[4].

The Chinese have ramped-up phosphates exports in the last few years to deal with domestic surpluses. This has seen the country's DAP market share increase from 35% to 45% and its MAP market share increase from 10% to 30%[4].

But export volumes are starting to 'swing' – i.e. fall in unprofitable circumstances. China's DAP exports fell 1.3 million tonnes to 6.7 million tonnes in 2016, for example. The country's MAP exports also fell 1.2 million tonnes to 2.1 million tonnes last year.

"Quarterly exports from Saudi Arabia and Morocco and other major exporters have stayed fairly stable over the last couple of years, whereas we see huge swings in the volumes coming out of China," comments Paul Burnside. "China firstly serves it domestic market and when this is in a lull, and depending on the seasonal export tariff, it moves volumes into the export market. That causes a lot of market uncertainty and big short-term changes in the international supply and demand balance."

Falling production volumes from China will be one consequence of DAP supply growth outpacing demand over the next five years, predicts Burnside (Figure 3)[3].

"A number of producers are getting squeezed by these two really big investment programmes in Morocco and Saudi Arabia. Where are we going to lose volume? China is one case, India as well and a little bit in Russia. We're already seeing some production cuts in China under cost pressure. The trend of declining DAP production in the US is also continuing."

Integer's Ibi Idoniboye agrees: "Our understanding is that the Chinese are look-

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

ing to at least to reduce finished capacity by roughly three million tonnes to 2020. That could help balance the market and help support prices. While there will definitely be reductions in Chinese capacity over the next few years, we do see that being replaced with low-cost production capacity from the Middle East and North Africa."

CRU's Paul Burnside agrees that China is undergoing a shift from expansion to contraction:

"We've seen a huge amount of building and new investment in China, in phosphoric acid, DAP, MAP and other product capacity. At its peak in 2011, China was adding about two million tonnes per year of additional P_2O_5 capacity. That's come to quite an abrupt halt in the last couple of years as the market has become saturated and prices have come down.

"Not only is investment in new capacity lessening but older and non-integrated plants are coming under cost pressure. Producers are being forced to cut output in the face of increasing regulation too. Prices are also coming down to the level where some of these producers simply aren't viable any more."

However, the elimination of the phosphate export tariff system in China in 2017 means Chinese producers could still act opportunistically, says Burnside: "There's no tax burden on DAP exporters – so they will be able to export if it's profitable for them to do."

Non-integrated Chinese producers struggle

The current state of the phosphates market makes it impossible for non-integrated producers to turn a profit, according to Integer Research. Cash margins for typical Chinese non-integrated DAP producers, for example, and Indian phosphoric acid- or phosphate rock-based DAP producers, have been below zero since the start of 2016[4].

"Chinese producers are at the low end of the margin scale. That is reflected in the fact that they are the main source of swing volume, balancing the market," explains Integer's Oliver Hatfield. "How does the market get balanced? Well generally speaking it's the highest cost producer which takes their volume out first."

He adds: "Non-integration anywhere, particularly with rock, puts producers at a significant disadvantage. The Indian government supports non-integrated producers when on a pure economic basis they would otherwise struggle."

Non-integrated producers are highly vulnerable, agrees CRU's Paul Burnside: "At the top end of the cost curve, we have lots of smaller producers around the world reliant on buying merchant rock. Those producers are going to find themselves squeezed by big rock producers like Ma'aden and OCP."

Key themes in 2017

Integer Research identifies five key themes to watch over the next 12 months[4]. Importantly, China will continuing to balance the phosphates market in its view.

"In terms of main themes and main influences in 2017, **China will remain top of the list**. We have to focus on the cost curve – where is the marginal cost, where is volume adjustment going to occur?," advises Oliver Hatfield. "The answer, based on our analysis of the global cost curve, is that China is where we expect the main volume adjustment to take place."

Foreign exchange stability in key markets like Brazil should also help improve demand, advises Hatfield.

"We think the market's going to grow on the demand side – there are some upsides and positives on demand. In key markets, Brazil in particular, more stability looks likely. I don't say that with 100% confidence but things are settling down there."

However, **capacity expansions in Saudi Arabia and Morocco** will outpace demand growth and increase competition.

"We already have spare capacity, we already have a market which is long on capacity. Although we expect demand to grow, it's going to be countered by continued expansion," explains Hatfield. "We've got two sizeable expansions heading our way from Ma'aden and OCP. While that's taking place, incremental supply is likely to outweigh incremental demand. So we pretty much stay where we are and expect to see China remaining as the swing volume and the main source of market balance."

Hatfield expects **raw material prices** to climb modestly this year and finished phosphate prices to rise as a consequence – although margins might not increase.

"We expect to see ammoniated phosphate prices rise, with increases mainly being raw material cost related. Sulphur prices look like being more robust. Ammonia prices have been at rock bottom. But we're now at the point on the ammonia cost curve where prices will pick up as producers adjust volumes.

"We're also seeing the oil price tick up and we expect energy prices to rise – although probably not strongly – and that will add cost pressure on the mining end of the phosphates sector."

Finally, **consolidation** will remain a feature of the market, concludes Hatfield.

"There's some obvious deals currently – Mosaic and Vale, Agrium and PotashCorp. Will that be enough to bring more control, more market balance, more supply management to the sector? Our view is not enough. The phosphates industry remains fragmented. Yes, concentration will probably grow – but not enough to significantly increase supplier power and therefore influence supplier price and margin."

Four to look out for

Looking ahead, CRU has four main phosphates market expectations[3]:

- **Asia will remain the driving force for demand growth** – but with India and Southeast Asia taking over from China.
- **The phosphates industry will also need to manage new capacity** following the completion of major projects in the Middle East and North Africa.
- **China is set to continue to act as the swing exporter**, opportunistically placing volumes on the international market if prices make this profitable.
- **Chinese production costs will underpin phosphate prices**, despite the extra tonnages expected from OCP and Ma'aden.

"Asia will still be the driving force behind phosphate demand growth but the focus may well switch from China to India, Southeast Asia and others. The phosphates industry is also going to have to manage major new capacity projects so we really need someone to act as a swing producer – and we are seeing that with Chinese exports. China's costs will also continue to underpin phosphate prices, despite the extra volumes coming on the market," sums up CRU's Paul Burnside.

References

1. Idoniboye, I., 2017. *Phosphate market: Concise review of 2016*. Integer research, January 2017.
2. PotashCorp, 2017. *Market Overview*. TFI Fertilizer Marketing Business Meeting, February 2017.
3. Burnside, P., 2017. Outlook for Phosphates and Potash. CRU/Argus FMB *Fertilizer Latino Americano*, Buenos Aires, 25-27 January 2017.
4. Hatfield, O. & Idoniboye, I., 2017. Webinar: *Phosphate market dynamics and industry outlook*. Integer Research, 27 January.

FERTILIZER INTERNATIONAL

ISSUE 477

MARCH-APRIL 2017

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England

Tel: +44 (0)20 7793 2567

Fax: +44 (0)20 7793 2577

Web: www.bcinsight.com
www.bcinsightsearch.com

Phosphates 2017 welcomes you to Tampa, Florida

CRU events will convene the 2017 Phosphates Conference at the Tampa Marriott Waterside Hotel between 13-15 March 2017.

Tampa, Florida, in the heart of the US phosphates sector, is the setting for Phosphates 2017, the annual international meeting for the global phosphates industry. This year's three-day conference offers a typically wide-ranging and highly topical mix of subjects. Leading international phosphate producers, traders, engineering and equipment providers are all expected to attend.

This year, the conference is celebrating its tenth anniversary as a must-attend annual event. The whole of the industry's value chain is represented, with a veritable 'who's who' of phosphate producers and allied companies now attending. More than 380 delegates from 36 countries attended last year's event in Paris, for example.

Phosphates 2017 provides the opportunity to gather in Florida and hear the very latest from the industry's top flight. Experts have been lined up to speak about the global and regional outlook for phosphates, trade dynamics and technical innovations in a series of lively and topical programme presentations.

Engineering aspects of the industry are also well represented. Phosphates mining, processing and production will be highlighted by brief but wide-ranging technical showcase presentations throughout the three-day event.

CRU's Head of Phosphates, Chris Lawson, sets the scene for this year's conference: "The global phosphate market has suffered heavy price falls over the past 18 months, with some benchmark prices falling below $300/t for the first time since 2009. Indeed, a wave of new capacity set to be commissioned in Saudi Arabia and Morocco over the coming 12 months will add further pressure to the market and this has triggered consolidation and the need for innovation within the industry.

"Prices are expected to find a floor in 2017, and this presents a great time to revisit the opportunities within the sector, where demand growth remains robust. Lower raw materials have somewhat helped to relieve producers of tighter margins, but there remains a need to innovate from a production and marketing level to add further value to downstream phosphate fertilizers and find production efficiencies.

"CRU's Phosphate conference in Tampa will help to answer some key questions relating to the projected recovery of the industry and the technical innovations that can help producers cut costs further. The conference also aims to address the increasing regulatory pressures phosphate producers are facing, from both a mining and end product level." ■

PROGRAMME OF PRESENTATIONS

TUESDAY 14 MARCH

08:45-09:00 WELCOME SPEECH
Robert Perlman, Chairman, CRU

09:00-10:30 KEYNOTE PLENARY SESSION
Moderated by Mike Gallagher, CRU
- **The Global Outlook: A View from Florida**
  Walt Precourt Mosaic
- **An update on OCP's global strategy**
  Mustapha El Ouafi, OCP SA
- **Global phosphates market overview and forecast**
  Chris Lawson, CRU

11:00-11:30 HIGHLIGHT PRESENTATION 1
- **View from the capital markets**
  Ben Isaacson, Scotia Capital Inc

11:30-12:30 PLENARY SESSION 2 REGIONAL SPOTLIGHTS
Moderated by Michel Prud'homme, IFA
- **Asia: How will Chinese stocks affect global prices? How is China responding to lower grade reserves? Is Vietnam emerging as a significant exporter?**
  Isaac Zhao, CRU
- **Beyond China and India: The Emergence of Broad-Based Demand Growth**
  Andy Jung, Mosaic
- **Eurasia: What factors are affecting Eurasian production financials? What role are Russian producers looking to play on the world's stage?**
  Irina Evstigneeva, Phosagro

14:00-14:30 HIGHLIGHT PRESENTATION 2
- **Agribusiness outlook**
  Terry Barr, CoBank

14:30-15:30 PLENARY SESSION 3 FEED MARKETS PANEL
Moderated by Chris Lawson, CRU
- **Speaker TBC, Phosphea**
- **John Gustin, Aliphos**
- **Peter Heffernan, Senior Consultant, CRU**

Further panellists to be announced

16:00-16:30 HIGHLIGHT PRESENTATION 3
- **Update on US Environmental regulation and permitting of phosphate operations**
  Roger Sims, Holland & Knight

16:30-17:30 TECHNICAL INNOVATION PLENARY
- **The importance of supporting and encouraging research and development during a market constriction**
  David Blake, JDC Phosphates
- **Zero waste phosphate production, dream or reality?**
  Marc Sonveaux, ECOPHOS s.a.

Further speakers to be announced

WEDNESDAY 15 MARCH TRADE DYNAMICS STREAM

09:00-10:30 SESSION 1: INDUSTRIAL MARKETS PANEL
Moderated by Isaac Zhao, CRU
- **William Schipper, Schipper Consulting**

Further panellists to be announced

11:00-12:30 SESSION 2 ROCK PHOSPHATES PANEL
Moderated by Wahome Muya, CRU
- **Mike Nunn, Elandsfontein**
- **Chris Tziolis, Managing Director, Verdant Minerals**

Further panellists to be announced

14:00-15:30 SESSION 3: MARKET DYNAMICS
Moderated by Melinda Sposari, TFI
- **Ammonia market outlook** Doug Hoadley, Consultant
- **Sulphur market outlook** Speaker TBC
- **Shipping & logistics overview**
  Arthur Savage, A.R. Savage & Son, LLC

16:00 SESSION 4: VALUE ADDED FERTILIZER
Session speakers to be announced

WEDNESDAY 15 MARCH TECH INNOVATION STREAM

09:00-10:30 SESSION 1: MINING & BENEFICIATION
Moderated by Jeff Hallberg, PotashCorp
- **Reclaiming Phosphorus, Critical Elements and Uranium from Florida Phosphate Mineral Processing Tailings**
  Dr Jinrong "Patrick" Zhang, Florida Industrial & Research Institute
- **Optimising processing costs through the assessment of geological and mining cut-off grades**
  Tim Lucks, SRK Consulting
- **The impact of rock quality in granulation processes and in final product grade** Curtis Griffin, PegasusTSI, Inc
- **So you have a P_2O_5 concentrate for sale… What else is in there?**
  Brian Campbell, Worley Parsons

11:00-12:30 SESSION 2: PHOSPHATE PLANT DEVELOPMENTS
Moderated by Nicole Christiansen, Mosaic
- **DH Phosphoric Acid Plant Conversion to HH – Focus on High CO_2 Phosphate** Malik Aqel, thyssenKrupp
- **Technology for High Yield Phosphoric Acid Reactor**
  Stephen Hilakos, Jacobs
- **Scale Inhibition for Evaporators in Phosphoric Acid Plants – a Review of a Program Approach**
  Paul Wiatr, Industry Development Manager, Nalco, USA
- **Minimizing Phosacid Plant Shut-downs: Assessing Past and Future Agitator Design for Phosphoric Acid Reactor Duty**
  Todd Hutchinson, Philadelphia Mixing Solutions

14:00-15:30 SESSION 3: FERTILIZER FINISHING & GRANULATION
- **Case study: Granulation Plant Conversion Project**
  Atusa Amiri, Mosaic and
  Dan Pelham, Hatch Associates Consultants Inc
- **Green Coatings for Fertilizers – Technical & Commercial Benefits**
  Avdhesh Mathur, NAQ Global Companies
- **Optimizing Operation of Complex Fertilizer Plants**
  G M Patel, CIFC P Ltd

16:00-17:00 SESSION 4: ENVIRONMENTAL PROTECTION AND SUSTAINABILITY
- **Efficacious Remediation of Phosphoric Acid Plant Pond Water**
  Dr Vaughn Astley, Dr Phosphate
- **Phosphogypsum Era – Worldwide Use of Our Industry's Biggest Co-Product**
  John Wing, John Wing PE
- **Improved Water Management with Predictive Cooling Pond Modelling** Andrew Nuyianes and Deborah Stetka, Hatch Associates Consultants Inc

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Phosphate process analysers

Increasingly sophisticated control of phosphates production is now possible thanks to the availability of real-time, on-line process analysers. We assess the range of technologies currently on the market and provide some examples of recent installations.

Laboratory phosphate testing, KEMWorks.

PHOTO: KEMWORKS

Traditional laboratory methods for analysing the grade (P_2O_5 content) of phosphate rock and ore concentrates 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 beneficiation plants. Infrequent and intermittent sampling also means that the results of laboratory tests are not always representative.

"Most companies get lab results every four hours or every six hours, even every eight hours in some cases," comments Seth Spiller of automated analyser company LexMar Global. "That means you're running your flotation process, your acid reactor or your mining operation blind."

It is therefore unsurprising that phosphate fertilizer producers are increasingly adopting automated on-line technologies for process and feed control at mines and beneficiation plants. 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 offer a surprisingly quick return 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 particularly promising and proven types of automated analytical systems for process control in the phosphates industry are reviewed below. These technologies were showcased by their manufacturers at CRU's Phosphates 2016 conference in Paris last year (*Fertilizer International* 472, p69).

It is important to note that there will always be a case for rigorous laboratory testing, offered by companies such as **KEMWorks**. Indeed, the validation and calibration of on-line analysers relies on laboratory testing and expertise.

Nuclear magnetic resonance

LexMar Global is the world's leading provider of Nuclear Magnetic Resonance (NMR) systems for industrial process control. The Massachusetts-headquartered company has installed more than 400 analysers globally in 45 countries, and operates five regional service centres in Texas, Morocco, Belgium, Abu Dhabi and China. Impressively, its phosphate industry customers include major players Ma'aden, Mosaic, PotashCorp and OCP, as well as chemical and oil giants such as ExxonMobil, Dow and GlaxoSmithKline.

LexMar Global markets the *MagModule II* on-line NMR analyser for on-line process measurements on phosphate slurries. These are supplied with the firm's *PMX-4300* multiplexer or *PRS-400* rotary metallurgical sampling systems. The advantages of NMR technology include:

- Direct analysis of P_2O_5
- Measures powders, pellets, slurries and liquids
- Uses no radioactive materials
- Routine re-calibration not required
- Operates on an 8-10 m^3/hour sample stream
- Fast, non-destructive analysis with results in less than five minutes
- No sample preparation necessary
- Independent of particle size
- Robust with rugged industrial design and construction

MagModule II on-line phosphate analysers can be installed at the beneficiation stage, to monitor and help regulate froth flotation, further downstream in reactor feed control or upstream in mining operations. Benefits include:

- Improved plant efficiency and increased production rates
- Better P_2O_5 recovery and improved utilisation of phosphate rock reserves
- Lower production costs
- Fewer contract penalties

Samples are collected for analysis using either a metallurgical sampler (*PRS-400*) or a multiplexer (*PMX-4300*). Advantageously, coupling an automated multiplexer allows a single analyser to take routine measurement from multiple sample points without interrupting operations.

Equipment is calibrated for P_2O_5 by comparing NMR results with laboratory-determined measurements for a range of different compositions. The technology is capable of delivering consistent, comparable results. In a P_2O_5 calibration for phosphate concentrates from three different ore bodies, for example, the correlation coefficient (R^2) between NMR-determined and lab-determined measurements was 0.995. NMR calibrations are also said to be stable – the technology is typically more stable than alternatives such as X-Ray fluorescence (XRF) or prompt gamma neutron activation analysis (PGNAA), according to LexMar Global.

One of the main benefits of on-line NMR 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, according to LexMar Global.

"Improved process control is the primary benefit of incorporating on-line analysers into your plant," explains Seth Spiller, LexMar's vice president for sales. "On-line magnetic resonance is able to give you readings in minutes versus hours. Having real time information on what your process is doing allows improved plant optimisation."

He adds: "If you can improve P_2O_5 recovery by even 1%, the payback is significant and the lifespan of your reserve actually goes up and the amount of material moving through your process goes down. Efficiencies, production costs, opex, all start to go in the right direction."

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

In froth flotation, NMR 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 turnaround measurements from four flotation streams in under 20 minutes.

NMR on-line analysers can also be installed further downstream at the reactor stage in the phosphate production process. Using NMR 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 NMR on-line analysers provide a rapid payback on investment and delivers long-term profits, according to LexMar Global. The benefits accrue even if P_2O_5 recovery is improved by just a small amount, due to the operating cost reductions achieved and improved mine life.

> **With lab test delays, you're running your flotation process, acid reactor or mining operation blind.**

The increasing automation of the mining industry will open up even greater opportunities for on-line analysis in future, in Seth Spiller's view. He explains: "As companies start to shift over to distributed control systems, in the automated plant of the future, where transducers are feeding information to a control system – that's where you're really going to start to see the benefits of incorporating on-line analysis into your plant."

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 slurries.

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

The *MAYA* laser analyser, a LIBS-based system developed by **Laser Distance Spectrometry**, has been installed by two leading fertilizer companies, the US phosphates producer Mosaic and Russian potash producer Uralkali, for process monitoring and control. This real-time elemental analyser has the following applications in phosphates 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 extraction, for example
- Determining the content of insoluble precipitates
- Controlling final product quality

MAYA has mainly been marketed as a conveyor belt analyser for the monitoring and control of ore, froth flotation and dense media separation The analyser has low detection limits and can simultaneously determine elements of interest, including

Fertilizer International 477 | March-April 2017

www.fertilizerinternational.com

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

PGNAA boosts phosphate plant efficiency at Vernal, Utah

Background

US phosphate producer **JR Simplot** has adopted prompt gamma neutron activation analysis (PGNAA) at its beneficiation plant in Vernal, Utah. Two PGNAA units supplied by San Diego-based manufacturer **SABIA Inc** analyse the elemental composition of the full slurry streams for both the plant's incoming feed and its final product. This allows Simplot to optimise Vernal's output by adjusting flotation circuits in near real-time.

Situation before PGNAA

Physical samples were analysed in the laboratory with about a 4-12 hour delay until results were received. This was highly problematic for the plant's continuous feed forward process control. By the time the lab results were available, the material had passed through their circuits and was well on its way to the processing plant. To help overcome this lab delay challenge, an order was placed with SABIA for two on-line PGNAA *X1-XP Slurry Analysers*, one for incoming feed material after the primary grinding circuit and the other for the final product

Flotation circuits

One of *SABIA's X1-XP Slurry Analysers* was installed around a 12-inch diameter pipe discharging into a flotation feed surge tank located ahead of the primary flotation desliming circuit. This analyser monitors the grade of incoming feed and validates feed forward control decisions. It does this by providing near real-time percentage P_2O_5 and MgO measurements. This valuable information allows operators to then adjust the primary flotation circuit to increase grade, by slowing down the rate of incoming feed, and also modify their reagent control accordingly.

To validate the final product, a second SABIA analyser was installed around an eight-inch pipe after the sizing and thickening stage. The MgO target threshold in the final concentrate after processing is <0.8%. MgO content above this level in the chemical plant feed causes difficulties when reacting and filtering the final product.

In the rock feed for the Vernal plant, phosphate minerals are liberated at 35-mesh (500 microns). The challenge is to liberate P_2O_5 from the rock while avoiding overgrinding and the generation of excess amounts of less than 75 micron material. If this happens, dolomite containing MgO becomes liberated, floating into and contaminating phosphate concentrates.

Main benefits of PGNAA On-Pipe Slurry Analysers

- SABIA On-Pipe Analysers allow control responses within 90 minutes
- Precise and accurate over a wide range of slurry compositions
- Ability to measure 100% of the slurry stream
- Operators can bring the mill up quickly and react to slurry concentration changes in near real-time
- In troubleshooting, earlier identification of problems saves time and money, whether at the cyclone, flotation cell or screening stage
- Eliminates dependence on the 4-12 hours turnaround time for lab results
- The lab now only validates results

"The plant operations personnel are now able to eliminate the 12 hour lag time they previously had to validate the process and call decisions," explains April Montera, SABIA's sales director. "Now if the phosphate level changes by 0.2%, or the magnesium level changes by 0.1%, the operators take note – and if the phosphate level changes by 0.5% the operators can now take action to bring the concentrate back on target." ■

light elements (C, Si, Mg, Al etc.), at high sensitivity and accuracy. It also does not require any special operating permits as no ionising radiation is emitted. According to its manufacturer, *MAYA* analysers have relatively low running costs, are easy to maintain and help eliminate the human error associated with conventional sampling and elemental analysis.

MAYA analysers provide direct on-line measurement of BPL, Mg, Fe, Al, insoluble phase and the metal impurity ratio (MER) of phosphate rock on a conveyor belt. Material on a small segment of the conveyor belt can be analysed and the results obtained are independent of surface composition, particle size or layer thickness.

The company's systems are already used for on-belt analysis in Florida to help identify and discard high MgO rock (>2% MgO pebble content). Using LIBS analysis to reject high MgO rock could potentially improve phosphate company profits by $5.9 million, calculates Laser Distance Spectrometry, based on a production level of 1.9-2.0 million tonnes and using certain pricing and technical assumptions.

Laser Distance Spectrometry has published several technical reports on LIBS phosphates applications. These include laboratory trial results for the measurement and monitoring of Fe and P_2O_5 in Russian phosphate rock on a conveyor. The company has also investigated the use of LIBS to measure the yield response of different flotation reagents dosages in phosphate slurry beneficiation in Israel.

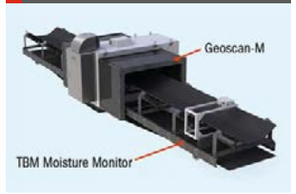
The installation of a MAYA analyser can pay for itself within 2-4 months, suggests Laser Distance Spectrometry, due to improvements in product quality and reductions in water, flotation agent and energy consumption.

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 technology has also been developed for slurry analysis by San Diego-headquartered **SABIA**. Two of the company's *Model X1-XP Slurry Analysers* have been successfully installed at J R Simplot's Vernal phosphate beneficiation plant in Utah (see box).

The Geoscan range of on-belt PGNAA analysers developed by another manufacturer, Australia's **Scantech,** are widely-used for the monitoring of bulk industrial materials such as cement, coal and minerals. 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. Units have been operating in the sector for more than 14 years with over 60 mining and processing installations worldwide, including iron ore, phosphate, manganese, zinc-lead, bauxite and copper operations.

Fig 1: **Scantech's Geoscan-M conveyor belt analyser**



Geoscan-M is installed as an enclosure around a conveyor belt (Figure 1). Its compact design uses only one metre of belt space, enabling it to be fitted between standard idlers. The analyser suits most belt sizes and loads with three models available for belt widths up to 2.4 metres and bed depths up to 0.53 metres.

In the *Geoscan-M* PGNAA analyser, neutrons are emitted from a Californium-252 source located underneath the belt. These are absorbed by elements present in the material being conveyed. Each element then emits a unique gamma ray spectrum which is picked up by a proprietary detector array placed above the conveyor. This spectrum is processed and reported as a multi-elemental analysis (Si, Al, Fe, Ti, K, Mn etc.) by *Geoscan*, typically every two minutes. Results are combined with a microwave measurement which detects, reports and corrects for moisture content.

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

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

"Our technology is proven and we have over a 1,000 analysers out there in the market," comments Scantech's Derek Griffiths. "We concentrate on the belt analysis of phosphates and currently have 16-17 analysers operating or on order at the moment at phosphates sites."

He continues: "These are used for run-of-mine analysis for ore grade, for beneficiation, for process control and for sulphuric acid addition. There are benefits and paybacks – these are tried and tested."

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

- **Measurement:** full cross section continuously, six monthly calibration
- **Penetration:** >0.5 metre
- **Sampling:** tonnage limited only by belt size and depth (~17 kt/h)
- **Analysis:** no matrix effects (Ca, Fe), unaffected by layering, particle-size, dust and belt speed
- **Maintenance:** low cost, non-contact ■

Fertilizer International 477 | March-April 2017 www.fertilizerinternational.com

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Applying evaporators & crystallisers to fertilizer production

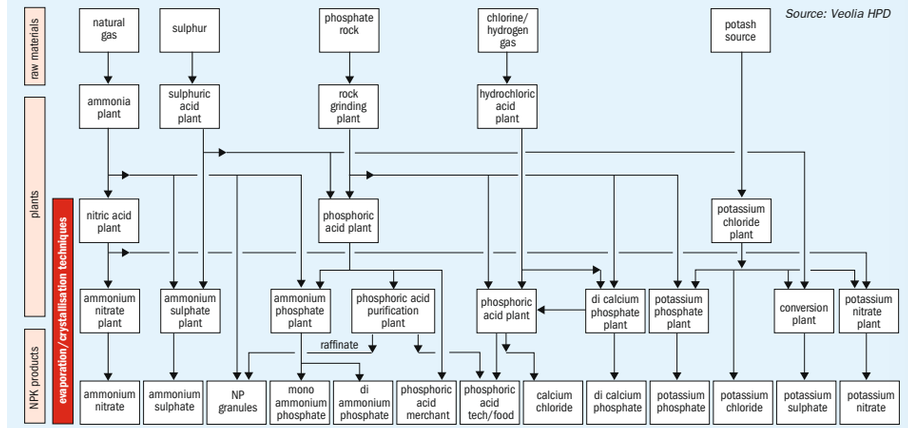
Véronique Bourgier, PhD, **Karen Schooley** and **Rob Lawson**, of Veolia Water Technologies HPD® Evaporation and Crystallization, explain the main applications of evaporators and crystallisers in the fertilizer industry – particularly in potash production. These include manufacturing fertilizers from raw materials, and the recovery of fertilizers as valuable by-products from waste streams or other processes.

Evaporation and crystallisation techniques have many applications in the fertiliser industry. Valuably, they allow fertilizers to be produced from primary raw materials or from the secondary by-products of another process, or, due to economic pressures, from waste streams.

The numerous applications of evaporation and crystallisation in the synthesis of N, P and K fertilizer products are shown in Figure 1. Demand for water-soluble fertilizer products is on the rise, driven by water scarcity and the adoption of more efficient fertilization practices. The diverse range of fertilizers produced using evaporation and crystallisation technologies include:

- **Ammonium sulphate:** Crystals can be made from pure ammonia and pure sulphuric acid by reactive crystallisation, or produced by evaporative crystallisation of a dilute ammonium sulphate stream (i.e. using a by-product from caprolactam production, coking, sulphuric acid gas scrubbing, nickel/cobalt production or recovery of waste nickel).
- **MAP/DAP:** Monoammonium phosphate (MAP) and diammonium phosphate (DAP) can be made via reactive crystallisation using technical-grade phosphoric acid and pure ammonia. Opportunities also exist to make these products using less expensive green phosphoric acid or raffinate.
- **Potash:** Cooling crystallisation is used extensively in solution mining to produce potassium chloride (KCl or potash), and in conventional mining to make higher grade KCl products. Many potash deposits contain sylvinite (a double salt of NaCl and KCl). Sodium chloride removal via crystallisation can make up a major portion of the processing plants used to recover valuable potash.
- **SOP:** Potassium sulphate (SOP) can be made via multiple approaches, often involving crystallisation steps. SOP demand is increasing due to its greater use on high-value crops such as tobacco or nuts (and its higher selling price relative to potassium chloride).
- **Nitrate fertilizers:** Evaporation is used to concentrate ammonium nitrate and to produce products such as potassium nitrate and calcium nitrate.
- **Phosphoric acid:** Evaporation is used to concentrate dilute phosphoric acid into a marketable product, or as raw material for phosphate fertilizer production.
- **Calcium chloride:** Calcium chloride waste streams generated from the phosphoric acid process can be concentrated using evaporation technology to generate a saleable product.

Fig 1: **Fertilizer production processes that involve evaporation or crystallisation**



Source: Veolia HPD

Table 1: **Fertilizer products that are typically made using evaporation and crystallisation processes**

Ammonium chloride, NH_4Cl	Di-ammonium phosphate(DAP), $(NH_4)_2HPO_4$
Ammonium nitrate, NH_4NO_3	Di-potassium phosphate (DKP), K_2HPO_4
Ammonium sulphate, $(NH_4)_2SO_4$	Mono-potassium phosphate (MKP), KH_2PO_4
Calcium nitrate, $Ca(NO_3)_2$	Mono-ammonium phosphate (MAP), $NH_4H_2PO_4$
Potassium chloride (MOP), KCl	Mono-ammonium diphosphate (MKDP), $KH_5(PO_4)_2$
Phosphoric acid, H_3PO_4	Magnesium sulphate monohydrate, $MgSO_4.H_2O$
Potassium nitrate, KNO_3	Urea, $CO(NH_2)_2$
Potassium sulphate (SOP), K_2SO_4	Urea phosphate, $CO(NH_2)_2.H_3PO_4$
Magnesium sulphate heptahydrate (Epsom salt), $MgSO_4.7H_2O$	

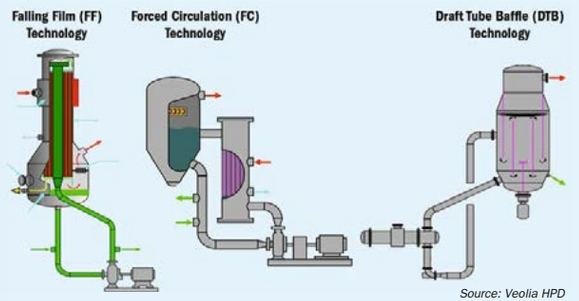
Source: Veolia HPD

Table 2: **Non-fertilizer by-products that are typically made using evaporation and crystallisation processes**

Calcium chloride, $CaCl_2$	Sodium chloride, NaCl	Magnesium chloride, $MgCl_2$

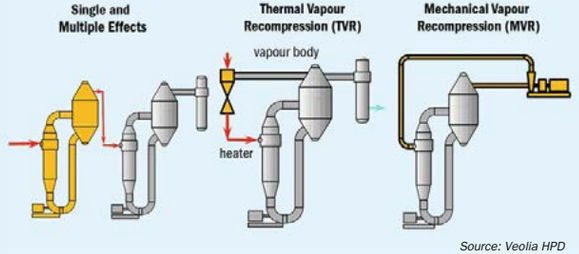
Source: Veolia HPD

Fig 2: **Three common types of evaporation or crystallisation equipment**



Source: Veolia HPD

Fig 3: **Three main configurations of evaporation or crystallisation equipment**



Source: Veolia HPD

Fertilizers manufactured using evaporation and crystallisation processes and the main by-products obtained are listed in Table 1 and Table 2, respectively.

Process options

Evaporation and crystallisation encompasses a range of different process options. These include standard evaporation, evaporative crystallisation, cooling crystallisation and reactive crystallisation. Process selection is influenced by the types of raw materials, the desired quality of the end-product, the physical behaviour of materials and project-specific criteria.

Evaporation and evaporative crystallisation: This involves the removal of solvent, typically water vapour, to concentrate the solute – which is usually the desired product. The objective is to increase the concentration of dissolved salts as water is evaporated. Examples of the use of evaporation in the fertilizer industry include phosphoric acid and calcium chloride concentration, and the preconcentration of dilute streams prior to crystallisation.

Cooling crystallisation: Certain compounds – those with relatively steep normal temperature-dependent solubility – are easily crystallised in cooling crystallisers. Crystallisation is initiated by cooling a hot

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

saturated solution until supersaturation is reached. The cooling is most often achieved by flashing the water vapour under vacuum. The main driving force for crystallisation is the cooling of the solute, but some concentration also occurs due to the removal of water vapour. This type of crystallisation is prevalent in potash production.

Reactive crystallisation: In this process, a crystalline product is formed by a chemical reaction when two species are mixed together. This type of crystallisation is used to make ammonium sulphate from ammonia (either gaseous or liquid) and sulphuric acid, or MAP/DAP by reacting ammonia with phosphoric acid. These types of crystallisers generally require relatively pure reactants, although there is increasing interest in using less pure, less costly compounds or waste streams in these applications.

Equipment types

The most common types of equipment adopted by the fertilizer industry (Figure 2) are as follows:

A **falling film evaporator** is typically used to concentrate a solution in non-scaling applications. It is often used to pre-concentrate a stream prior to a separate crystallisation process, and can turn highly soluble salts such as calcium chloride into high concentration solutions.

A **forced circulation crystalliser** is used for applications where it is easy to grow large crystals or where the particle size distribution of the product is not critical. Forced circulation crystallisers are often used for sodium chloride crystallisation in potash recovery from sylvinite deposits. This type of equipment is also known as a 'mixed suspension, mixed product removal' (MSMPR) crystalliser because the slurry is well-mixed and uniform throughout the system.

The use of **draft tube baffle (DTB)** or **HPD partitioned internal circulation (PIC™) crystallisers** is widespread in the fertilizer industry. This type of crystalliser is used in applications that require a

CASE STUDY 1

Potash from solution mining

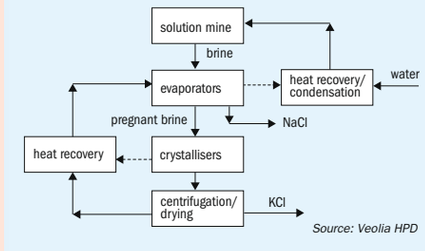
This case study is for a greenfield project in Saskatchewan, Canada. This will use solution mining to produce two million t/a of potash (KCl). The ore is mainly sylvinite (NaCl and KCl) but contains small amounts of carnallite ($KCl.MgCl_2.6H_2O$) and other minor impurities ($CaCl_2$, $CaSO_4$, NaBr, etc.).

Process description with water and energy optimisation

A block diagram of the solution mining process is shown in Figure 4. The ore is dissolved by injecting hot water underground. The brine solution produced is treated to recover pure, economically-valuable potassium chloride. Evaporation is used as an initial treatment step to remove sodium chloride. The use of an integrated thermo-compressor in the multiple effect evaporation system improves energy efficiency. NaCl removal takes place in a forced circulation crystalliser with an elutriation leg. The brine from the solution mine is saturated in calcium sulphate. This needs to be managed throughout the evaporator system to prevent scaling in the evaporator heaters.

The mother liquor obtained from the NaCl evaporator system is a hot solution nearly saturated in potassium chloride.

Fig 4: **Diagram of the solution mining process to produce KCl**



Source: Veolia HPD

PHOTO: VEOLIA HPD

Fig. 5: Veolia's KCl crystalliser being transported to the project site.

KCl is crystallised from this pregnant liquor in a multiple-stage, adiabatic cooled crystalliser system comprised of DTB crystallisers. Each stage operates at a progressively lower pressure/temperature and KCl precipitates as the liquor cools. Product purity and crystal size is controlled by adding water and adjusting process flows.

Solution mining initially requires large volumes of water to dissolve the ore and additional water is also required throughout the evaporation and crystallisation process. However, evaporated water is recovered and reused to minimise the amount of make-up water consumed during the solution mining process.

Complex supply logistics

Due to the size of the project, it was necessary to source equipment from multiple locations. Some vessels were pre-fabricated in China and shipped to Houston then trucked to Saskatchewan (Figure 5). The vessels transported were over 12 metres high, in excess of 50 metres long and weighed about 330 tonnes. It was desirable to minimise the amount of site construction work and do as much of the vessel fabrication in shops as possible. Equipment supply logistics were therefore complex and required careful coordination. ■

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

CASE STUDY 2

Potash from brine

A new crystallisation production system was required as part of a brownfield expansion of a Dead Sea brine plant in Israel. This was designed to increase potash capacity by 30%. The new system needed to be integrated into the existing plant and replace an older production line. The site also produces bromine and magnesium chloride from highly-concentrated brine feed.

PHOTO: VEOLIA HPD

Fig. 6: Veolia's PIC™ Draft Tube Baffle HPD® crystallisers.

Process description

The customer's original expansion plan was based on a four-stage train. However, after discussion, this was changed to a five-stage train using PIC™ (draft tube baffle), HPD® crystalliser technology (Figure 6). This design improved heat recovery and the additional cost was more than justified by the sizable savings in energy consumption. The bypass capabilities added to the system by the modified design would also help keep plant capacity at a stable rate.

Challenges and solutions

Veolia designed and built the system on a turnkey basis using HPD crystallisation technology. The design goal for a minimum nameplate capacity of 153 t/hr (1.3 million t/a) for potassium chloride crystal production was met with high system availability. To reach this goal, the production process needed to generate crystals of consistent size at high purity (> 98% KCl).

The location of the new crystalliser train was another project challenge. Field erection of large vessels was necessary due to clearance issues in accessing the proposed expansion area. Other difficulties were the limited communication windows, the regional climate and the extremely tight battery limits. ■

narrower crystal size distribution and a larger crystal size. Common applications include potash, ammonium sulphate and MAP/DAP fertilizer production, among others.

The **HPD Growth™ crystalliser** is an **Oslo type** or 'classified suspension, classified product removal' (CSCPR) crystalliser. It typically involves the circulation of a crystal slurry and the classification of crystals according to size using a fluidised bed. The classification advantages of an HPD Growth™ unit have been demonstrated in many applications. These applications include from high-purity to fertiliser-grade potassium chloride production and from by-product to high purity ammonium sulphate production.

Equipment configurations

There are many different ways to configure evaporation and crystallisation equipment (Figure 3) to ensure that project economics and process efficiency are both maximised. Among the design factors that must be considered are:

- Utility (steam, power and cooling water) availability and costs
- Capital equipment size and metallurgy
- Installation costs
- Process requirements
- Environmental constraints

In a **steam driven system**, steam is introduced into a heater to transfer the heat from the steam to a solution being concentrated in heater tubes. The vapour generated as a consequence of evaporation must be condensed in a water- or air-cooled condenser. The multiple effect process improves the energy efficiency by using the vapour that is generated as the heat source to evaporate additional water. This occurs at progressively lower pressure in each additional effect. This configuration greatly increases the steam economy, namely the amount of water evaporated per the amount of steam used. If high pressure steam is available, it is possible to reduce the steam consumption by using a thermo-compressor.

Mechanical vapour recompression (MVR) uses electrical energy to drive the evaporation in lieu of steam. The water evaporated is compressed using a mechanical vapour compressor. The resulting high-pressure vapour is then used in the heater to drive the evaporation. This results in much higher energy efficiency than a steam-driven system and is beneficial and practical option where steam or cooling sources are limited.

> **Evaporation and crystallisation plays a key role in emerging technologies.**

PHOTO: VEOLIA HPD

Fig. 7: Veolia's pilot scale forced ventilation evaporator.

A **multiple stage vacuum flash configuration** is often used for products that have an inverse solubility. These types of crystallisers use adiabatic cooling, i.e. the evaporation caused by the vacuum in the crystalliser cools the liquor and the product precipitates as a result of this cooling. This is a typical configuration used in KCl production.

Process challenges

To develop or validate design parameters, performing bench or pilot-scale tests is generally an imperative (Figures 7, 8). These should ideally be performed with the actual feed solution to be used in the full-scale commercial plant, or by using a synthetic substitute where this not available. The main process challenges in designing a commercial plant are:

Production of **high quality product salts**: Fertilizer products often need to meet specific crystal habit, size or purity requirements.

PHOTO: VEOLIA HPD

Fig. 8: Veolia's Lab evaporative crystalliser.

Adaptation to **environmental constraints**, e.g. limitations on liquid wastes or other discharges to the environment, limited energy supply or cooling media supply etc.

Valuable **product recovery** from waste streams or by-products.

Heat integration and water balance optimisation: Some production processes, such as potash from solution mining, have large recycle flows and place very high energy demands on the system. It is vital for such systems to have a highly-integrated heat balance.

Choice of **construction materials**: Because the feed or mother liquor is often at high temperature and contains high concentrations of corrosive compounds, a balance needs to be struck between the need for corrosion resistance and ensuring that the design remains cost-competitive.

Conclusions

Evaporation and crystallisation processes are prevalent in many commercial fertilizer production plants. New fertilizer production technologies continue to be developed in response to rising fertilizer demand and the decreasing availability of low-cost raw materials. Evaporation and crystallisation plays a key role in these emerging technologies. Research, bench-scale and pilot-scale testing and process development will also remain vital in bringing new applications to market. ■

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Advertisers' index

Advertiser	Page	Contact	Fax / Email
ArrMaz Custom Chemicals	17	Mr Chris Day	cday@arrmaz.com
AUMUND Fordertechnik	21	Dr N Velten	velten@aumund.de
Casale	23-33	Ms Rosella Gazzaniga	41 91 960 7291
Desmet Ballestra SpA	49	Mrs Cinza Gandini	39 02 5802 8548
ECOPHOS	11	Mr Laurent Palierne	laurent.palieme@ecophos.com
Maschinefabrik Gustav Eirich GmbH	13		www.eirich.de
EMT Manufacturer of Blending Bagging & Transport Equipment	61	Mr Gustaaf Zeeman	emt@emt.tech
Evergrow For Speciality Fertilizers Company	9	Mr Ahmed Galal	202 35371089/90
Hebei Monband Water Soluble Fertilizer Co., Ltd	IFC	Ms Tracy Gao	tracygao@jitainy.com
Integer Research	39		www.integer-research.com
Jacobs / Chemetics	7	Mr Andrew Barr	Andrew.barr@jacobs.com
Koch Agronomic Services	5	kascustomerservices@kochind.com Kochagronomicservices.com	1 866 863 5550
Köppern GmbH & Co. KG	51	Mr Stefan Bremer	s.bremer@koeppern.de
Ludman Industries	37	Mr James Lenahan	jlenahan@ludman.net
Neelam Aqua & Speciality Chem (P) Ltd	OBC	Mr Mithlesh Kumar Mathur	91 141-2460081
Phosphates 2017 Conference	IBC	Ms Hayley Ward	Hayley.ward@crugroup.com
Prayon Technologies s.a.	42	Mr Marc Collin	mcollin@prayon.be
Solex Thermal Science Inc	47	Ms Shannon Nowek	1 403 254 3501
Solvay Technology Solutions	19	Mr Ron Sausa	ronald.sausa@solvay.com
Stamicarbon	35	Ms Spies, Chantal	31 46 4237001
Weir Minerals Lewis Pumps	58	Mr Ken Black	1 314 843 7964
Yargus Manufacturing, Inc.	55	Mr Larry Yargus	1 217 826 8551

Next issue: May/June 2017

Distribution at:

IFA Annual Conference, Marrakech, Morocco
Clearwater 2017, Florida, USA
Int'l Fertiliser Society Technical Conference, London, UK

Closing date for advertisement space booking is 2 May 2017
For further information and to book advertisement space contact:
Tina Firman, Publishing Director: tina.firman@bcinsight.com
Tel: +44 (0)20 7793 2567 Fax: +44 (0)20 7793 2577

Editor:
SIMON INGLETHORPE
simon.inglethorpe@bcinsight.com
Contributor:
OLIVER HATFIELD
publications@integer-research.com
Publishing Director:
TINA FIRMAN
tina.firman@bcinsight.com
Subscription rates:
GBP 300; USD 550; EUR 450
Subscription claims:
Claims for non receipt of issue must be made within 3 months of the issue publication date.
Subscriptions Manager / enquiries:
MARIETTA BESCHORNER
Tel +44 (0)20 7793 2569
Fax +44 (0)20 7793 2577
marietta.beschorner@bcinsight.com
Cheques payable to BCInsight Ltd
Advertising enquiries:
TINA FIRMAN
tina.firman@bcinsight.com
Tel: +44 (0)20 7793 2567
Agents:
Japan: (also subscription enquiries)
KOICHI OGAWA
O.T.O. Research Corporation
Takeuchi Building
1-34-12 Takadanobaba
Shinjuku-Ku, Tokyo 169, Japan
Tel: +81 3 3208 7821
Fax: +81 3 3200 2889
Previous articles from *Fertilizer International* and *PK Insight* from 1997 to the present are available digitally in PDF format. To make a purchase, or for a list of available articles, please see:
www.bcinsight.com

ISSN: 0015-0304
Design and production:
JOHN CREEK, DANI HART

Mixed Sources
Product group from well-managed forests and other controlled sources
www.fsc.org Cert no. SA-COC-001794
© 1996 Forest Stewardship Council

Printed in England by:
Buxton Press Ltd
Palace Road, Buxton, Derbyshire, SK17 6AE

BCInsight

Published by: BCInsight Ltd
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Don't forget the next issue of Fertilizer International May/June 2017

FERTILIZER INTERNATIONAL
ISSUE 477
MARCH-APRIL 2017

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com