1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76

Number 472

May | June 2016

# INTERNATIONAL Fertilizer

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## IFA convenes in Moscow

## Nitrogen in the Former Soviet Union

## Morocco's phosphates growth dash

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76


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47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76

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NUMBER 472 MAY | JUNE 2016

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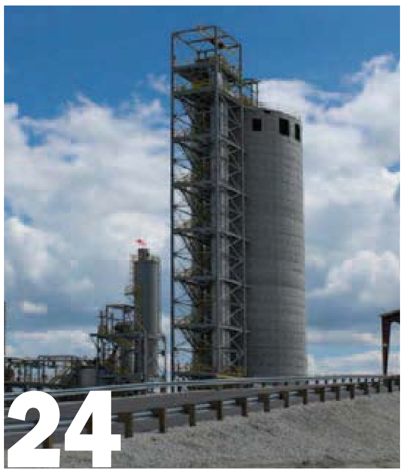
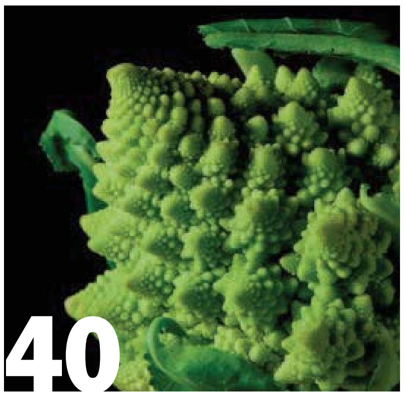



**New Wales sulphur melter**




**Brassica crops**

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## CONTENTS



## PHOSPHATES AND POTASH INSIGHT



## REGULARS

1 47 2 48 3 49 4 50 5 51 6 52 7 53 8 54 9 55 10 56 11 57 12 58 13 59 14 60 15 61 16 62 17 63 18 64 19 65 20 66 21 67 22 68 23 69 24 70 25 71 26 72 27 73 28 74 29 75 30 76 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46



# IFA convenes in Moscow


> **"With IFA's Russian members actively preparing for this meeting for several months, this is an IFA annual meeting not be missed!**

In this issue's editorial, we look ahead to the 84th International Fertilizer Industry Association (IFA) Annual Conference in Moscow, 30 May -1 June.

Warmly welcoming delegates to this year's conference, Abdulrahman Jawahery, IFA President, said: "With IFA's Russian members actively preparing for this meeting for several months, this is an IFA annual meeting not be missed! Our friends at Uralchem and Uralkali will host a reception and performance on the Monday evening, and EuroChem, PhosAgro and Acron are hosting another wonderful traditional Russian evening on Wednesday evening. I already extend to them a very hearty Spasibo!"

He continued: "We do ask that you take a break from networking to join us for the two joint sessions we are planning: IFA 2016 will begin on Monday with a panel on fertilizer demand and keynote speeches. On Wednesday afternoon, we will be holding our General Meeting and presenting the long-term fertilizer market outlook. IFA will also plan some further sessions to highlight some of our initiatives, which you may wish to join, and we will again be convening our industry's future leaders."

The conference begins on Monday 30 May with a session devoted to demand prospects at the global, regional and country level. The first speaker, **Xin Zhang** of Maryland University, will look at global nitrogen use efficiency trends. The outlook for agricultural commodity prices and farm incomes will then be covered by Rabobank's **Dirk Jan Kennes**. Next up, in a highly pertinent and topical presentation, **Vladimir Alexandrov** of McKinsey & Company will examine the economic and agricultural outlook for Russia and Ukraine. Continuing with the regional theme, Agroconsult's **André Souto Maior Pessoa** will explore Brazil and Argentina's economic and agricultural prospects. Finally, Fertilizers Europe's president, **Javier Goni del Cacho**, will wrap-up the session with an analysis of the draft EU fertilizer regulation. He will also discuss the regulation's likely impact on regional fertilizer demand.

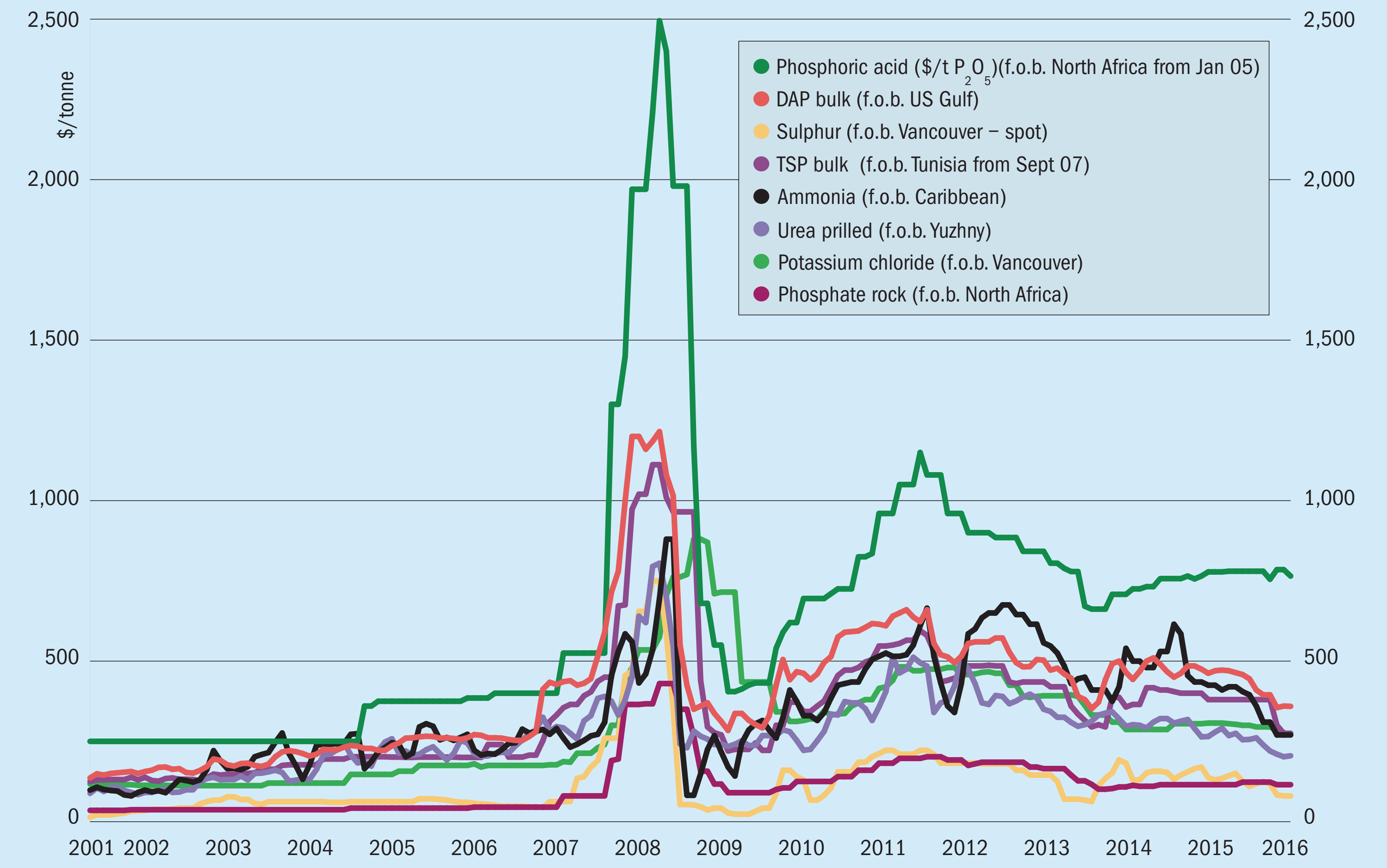
Monday morning finishes with two keynote presentations. **Dr JB Penn**, Deere & Company's chief economist, will reflect on global opportunities and challenges. The highly valuable contribution modern agriculture makes to society is the topic of the other keynote address by **Harald von Witzke**, emeritus professor at Berlin's Humboldt University.

Monday's conference programme ends with the presentation of the 2016 Norman Borlaug Award to Professor **Tekalign Mamo**, a distinguished soil scientist and Ethiopia's former agricultural minister. Professor Mamo received the award for his outstanding contribution to soil health and natural resources in Ethiopia. The award is especially deserved as Professor Mamo's work has directly benefitted more than 11 million of the country's smallholder farmers. In 2005, a watershed strategy spearheaded by Professor Mamo helped local communities rehabilitate more than 15 million hectares of degraded land across Ethiopia. Professor Mamo was also responsible for the Ethiopian Soil Information System (EthioSIS), the most advanced soil fertility mapping exercise on the African continent. "I am honoured to receive this award, and am proud Ethiopia's leadership in addressing soil health issues is being recognised internationally," commented Professor Mamo. "Much remains to be done to continue Ethiopia's transformation and lift even more people out of poverty. But an accolade such as this serves as encouragement to continue this important journey by fellow citizens and African colleagues."

On Wednesday 1 June, the conference's final day, delegates will have the opportunity to hear the very latest from IFA's demand and supply experts. **Patrick Heffer** and **Armelle Gruere** will present the medium-term outlook for world agriculture and fertilizer demand. **Michel Prud'Homme** will then end the conference with his presentation on the global supply of fertilizers and raw materials over the next four years.

# Market outlook

**Historical price trends** $/tonne




*Source: BCInsight*

## Market insight courtesy of Integer Research

### AMMONIA

Limited availability and the demand from spring applications saw a seasonal uptick in prices. The Yuzhny price climbed to $274/t f.o.b. in April bouncing back from what now looks like a floor price of $262/t f.o.b. in February. Prices were supported by limited Ukrainian supply. OPZ ran only one of its two ammonia units in April, for example, and Dnipro's surplus ammonia was all delivered to the domestic market. Cold and wet weather in the US caused a lag in seasonal demand in March. However, the Tampa price for May loadings increased by $10/t to $230/t cfr on the back of brisk spot business in Europe, India, Africa, China and the Middle East as seasonal demand there peaked.

### UREA

Global urea prices appeared to reach their floor in March. The Yuzhny prilled urea price fell to $199/t f.o.b. as a result of the collapse in energy prices and the continuing oversupply of urea to the market. Emerging US spring demand led to an uptick in global prices in April. This saw the Yuzhny export price increase by $6/t to $205/t f.o.b. Meanwhile, seasonal demand and limited supply in the Middle East resulted in an uptick in the Arab Gulf granular urea price, up by $10/t to $212/t f.o.b. Chinese suppliers remained firm on urea export price ideas due to a buoyant domestic market in April.

### PHOSPHATES

Trading in the global phosphates market so far this spring has generally been weak. After declines in February, prices did, however, stabilise at the end of April, at $330-340/t for DAP f.o.b. China and $340-345/t for MAP f.o.b. Baltic. DAP exports from China dropped two-fifths year-on-year in the first quarter. China's MAP exports were similarly down a third over the same period. There are signs that regional markets are diverging. In Russia PhosAgro reported a 10% increase in sales of feed and fertilizer phosphates in the first quarter. Phosphate sales from Acron's Russian operations have also risen. The relative buoyancy of Russian phosphate production and export volumes reflects the rouble's devaluation. Chinese producers, in contrast, are being burdened by higher electricity tariffs.

### POTASH

Potash prices lacked direction in April. The NW Europe benchmark price ranged from €250-260/t cif ($288-300/t) at the end of April, compared to Vancouver f.o.b. prices of $230-300/t. Granular prices in Brazil and the US are at an eight-year low. April Brazil cfr prices were down $125/t year-on-year to $225-235/t. In the US, oversupply in 2016 has nudged barge prices downwards with import tonnes being heard at $180/short ton f.o.b. Nola in April, equivalent to $194/t cfr Gulf.

Since the start of the year, attention in the potash market has been focussed on when – and at what level – the China contract price settlement will be agreed. Stock levels in China are uncharacteristically high, placing price negotiations firmly



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in the hands of buyers. In April, inventories in the country were approximately two million tonnes, around double the amount at which new contracts are typically concluded. Industry sources suggest an agreement is likely to be reached in June, although ideas on price levels, at $200-260/t cfr, are wide-ranging.

## SULPHUR

Global sulphur prices continued to soften through April, although there were signs of the market reaching a floor in early May. The main issue has been a lacklustre downstream phosphates market. Middle East prices dropped with Tasweeq in Qatar posting an April price of $78/t f.o.b. In the UAE, Adnoc rolled over its monthly price for the Indian market in May, a signal that producers expect a more stable month ahead. Middle East supply availability was limited in April, owing to healthy import demand from North Africa and China and maintenance turnarounds in Saudi Arabia. First quarter sulphur imports to China showed an increase of 21% year-on-year, totalling over 3 million tonnes. Imports from the UAE, South Korea and Canada increased, whist tonnages from Kazakhstan and Iran decreased. The impact of the wildfires affecting Fort McMurray, Alberta, in May is uncertain, although short-term disruption to the production and transport of sulphur from Western Canadian oilsands is expected.

**Market price summary** $/tonne – Early-May 2016

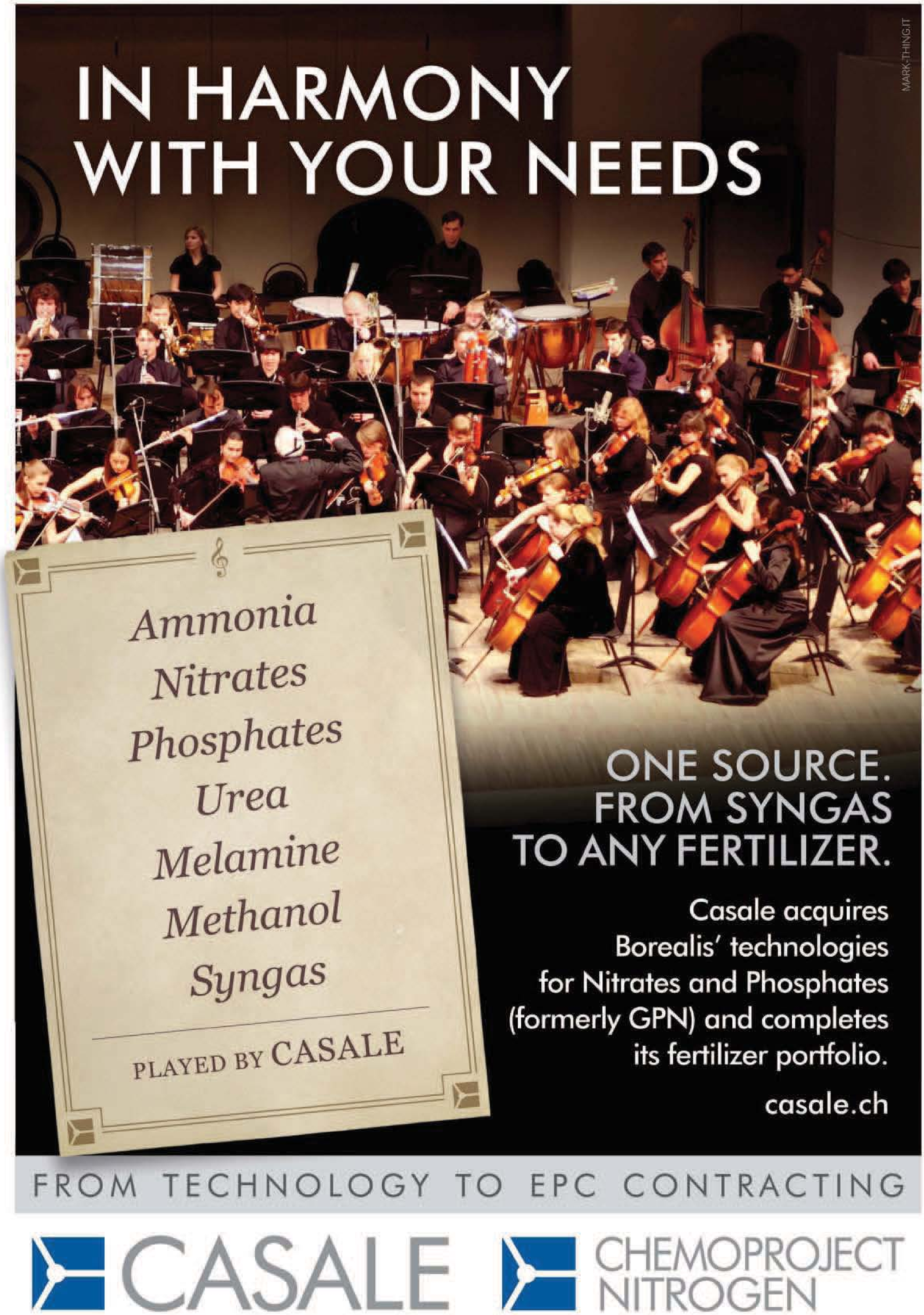
| **Nitrogen** | **Ammonia** | **Urea** | **Ammonium Sulphate** | **Phosphates** | **DAP** | **TSP** | **Phosphoric Acid** |
|---|---|---|---|---|---|---|---|
| f.o.b. Caribbean | 280 | n.m. | f.o.b. E. Europe 110-115 | f.o.b. US Gulf | 350-354 | n.m. | n.m. |
| f.o.b. Yuzhny | 270-280 | 202-205 | - | f.o.b. N. Africa | 345-370 | 275-295 | 630-900 |
| f.o.b. Middle East | 350-355 | 208-222** | - | cfr India | 342-348 | - | 715* |
| **Potash** | KCl Standard | $K_2SO_4$ | **Sulphuric Acid** | | **Sulphur** | | |
| f.o.b. Vancouver | 220-315 | - | cfr US Gulf | 30-40 | f.o.b. Vancouver | 70-80 | |
| f.o.b. Middle East | 215-320 | - | | | f.o.b. Arab Gulf | 80-85 | |
| f.o.b. Western Europe | - | €480-500 | | | cfr North Africa | 70-80 | |
| f.o.b. FSU | 210-305 | | | | cfr India | 95-100+ | |

*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 outlook:** Strong US and Indian demand is expected to support global prices through May and June, as is limited supply availability. The SAFCO II plant in Saudi Arabia is down for maintenance until June, and OPZ will continue to run only one of its two ammonia lines until July. Global ammonia demand is forecast to soften from July onwards, as peak seasonal demand in the US ends and additional capacity comes online. US ammonia capacity is expected to increase from the third quarter with the start-up of CF Industries' new Donaldsonville ammonia plant and Dyno Nobel's capacity expansion at Waggaman. These capacity additions, by displacing some US import demand for ammonia, could lead to further oversupply in the global market and more downward pressure on prices.
- **Urea outlook:** Persistent oversupply in the market means sentiment is relatively subdued, although seasonal demand is expected to provide support to global urea prices through May and June. Supply and demand is expected to remain imbalanced in the third quarter, however, which could lead to the Yuzhny urea price dropping below $200/t f.o.b. again. Several capacity expansions are due for completion this year. Indorama's new 1.4 million t/a capacity Eleme urea plant in Nigeria is due to be commissioned imminently, as are several projects in the US, with Petronas' SAMUR project in Malaysia expected to follow in the second half of 2016.
- **Phosphates outlook:** Processed phosphate producers were reported to be lowering prices as the main buying season in European and American markets came to a close in May. Consequently, the period of price stability that has prevailed since February's price falls may end with further softening. However, with the coming of the monsoon season in June, demand from India may support a floor in pricing. In the US market, meanwhile, buying activity is said to be on a hand-to-mouth basis. Further falls in processed phosphates prices could stimulate activity, helping to balance the market.
- **Potash outlook:** The picture for potash demand is mixed. Shipments to India may pick up, as the MOP subsidy has remained stable and monsoon forecasts have improved. Robust demand in SE Asia is expected on the back of higher palm oil prices. In Brazil, improved liquidity and greater soybean acreages may lead to slight year-on-year increases in 2016 shipments. The US market has disappointed so far this year, with wet weather hitting spring planting. However, an increase in planted acres, and lower nutrient levels from bumper corn harvests, may support US demand. On the supply side, K+S's Legacy mine in Saskatchewan is due to be commissioned over the summer with production of around 500,000 tonnes expected this year.
- **Sulphur outlook:** Sulphur prices are expected to be stable through May and June, although further softening in some regions is possible if demand and trade does not improve. A more balanced supply situation in the Middle East could add stability and provide potential for price improvement, although the arrival of new supply in coming months is likely to limit any potential market recovery. In North America, an increase in solid imports through Tampa to supply Mosaic's sulphur melter could lead to a decline in railed molten sulphur from Canada into the US. The impact of this on exports through Vancouver, and on railed volumes, remains a wildcard.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# Fertilizer Industry News

BRAZIL

## Anglo American sells phosphates assets to China Molybdenum

Anglo American plc has agreed to sell its Brazilian niobium and phosphates businesses to China Molybdenum Co Ltd for $1.5 billion.

The purchase of the phosphates business will give China Molybdenum ownership of Anglo American's Chapadao mine, the Ouvidor beneficiation plant, two fertilizer complexes at Catalão and Cubatão, and the Coqueiros and Morro Preto phosphate deposits. Anglo American's Brazilian operations produced 1.3 million tonnes of phosphate concentrate and 1.1 million tonnes of phosphate fertilizers last year. Niobium and phosphates sales generated earnings (EBITDA) of $146 million for the company in 2015 from revenues of $544 million.

Anglo American announced the niobium and phosphate assets sell-off last December as part of a major restructuring exercise in the wake of the commodities slump (*Fertilizer International*, 470, p10). Reuters had named both Mosaic and Vale as potential buyers. The London-based private mining company X2 Resources was also linked to the sale at one point (*Fertilizer International*, 471 p12).

Anglo American will use the $1.5 billion proceeds of the sale to cut its debt levels. The mining giant is hoping to raise up to $4 billion this year by selling assets. Announcing the agreement with China Molybdenum on 28 April, Mark Cutifani, Anglo American's CEO, said: "The sale of our niobium and phosphates businesses is another positive step forward in the strategic reshaping of Anglo American that we set out in February. The proceeds from this transaction will enable us to continue to reduce our net debt towards our targeted level of less than $10 billion at the end of 2016."

The deal is conditional on Chinese regulatory approval and is expected to close in the second half of this year. The approval of China Molybdenum's shareholders is also required. This should be largely a formality as two major shareholders have already entered into a binding commitment over the sale. ■

UNITED STATES

## World's largest UAN plant starts production

CF Industries' new urea ammonium nitrate (UAN) plant at Donaldsonville, Louisiana, entered commercial production in March. This is a significant milestone for the company as it bring on-stream the largest single-train UAN production plant in the world.

The new plant increases Donaldsonville's annual UAN capacity from 2.4 million short tons to 4.2 million short tons. It has already produced more than 80,000 tons of UAN to date. A major commercial advantage for CF Industries is Donaldsonville's production flexibility. This enables the complex to switch its output between urea, UAN and Diesel Exhaust Fluid, according to market requirements.

Donaldsonville's new granular urea plant became operational in December. As a consequence, annual urea production should rise to around 2.2-3.2 million short tons this year, up from around 1.7 million short tons previously. The imminent completion of a new ammonia plant will make Donaldsonville the world's largest nitrogen facility, according to CF Industries. "The finish line for our Donaldsonville capacity expansion project is now in sight," said Tony Will, president and CEO of CF Industries. "The new UAN and granular urea plants are running consistently at or above nameplate capacities, and the new ammonia plant is within a few weeks of being mechanically complete."

Ammonia and urea expansions at CF Industries' Port Neal, Iowa plant are due for completion in the second quarter of 2016.

## Rentech Nitrogen completes sale of Pasadena plant

Rentech Nitrogen Partners has sold its 500,000 t/a ammonium sulphate (AS) plant in Pasadena, Texas, to Pasadena Commodities International. The new owner is an affiliate of Interoceanic Corp (IOC), the plant's long-standing AS distributor.

The purchase involves a $5 million cash payment together with an adjustment to working capital of around $6 million. The deal guarantees Rentech Nitrogen Partners a 50% share of any earnings (EBITDA) that Pasadena makes above $8 million for the next two years.

"We are pleased to be able to announce the successful conclusion of the lengthy process to divest Rentech Nitrogen's ownership in the Pasadena fertilizer facility," said Keith Forman, CEO of Rentech Nitrogen Partners. "The facility is being sold to an affiliate of IOC with whom we have had a relationship since our original acquisition of this facility over three years ago."

The sale of the plant was important as it allowed the completion of the merger between Rentech Nitrogen Partners and CVR Partners to go ahead in April.

INDIA

## India cuts phosphate subsidy rates

The Indian government has confirmed the country's nutrient-based subsidy (NBS) levels for 2016/17. For two of the main phosphate fertilizers, DAP and SSP, subsidy rates fell by 28% and 26% to INR 8,945/t and INR 2,343/t, respectively.

The maximum retail price for DAP is set to remain at INR 23,750/t ($356/t) with no imminent change expected. That means DAP importers should be able to achieve a margin of around $50/t based on current market prices, according to analysts CRU. The MOP subsidy rate was left almost unchanged, down only slightly to INR 9,282/t from INR 9,300/t last year. This was greeted with surprise as some industry sources had been predicting an MOP subsidy cut in the range of INR 1,500-1,800/t.

The Indian government also announced that the NBS will be reviewed on a half-yearly basis instead of annually for the first time. This provides the Indian government with the option to alter subsidy rates from October, if major shifts in global prices were to occur.

The 2016/17 Indian budget allocation for the urea subsidy was stable at INR 51,000 crore ($7.5 billion), up 1% up on last year. The budget allocation for phosphate and potash subsidies, in contrast, was reduced by 13% overall to INR 19,000 crore ($2.8 billion).

## Toyo Engineering wins Rajasthan urea plant contract

Japan's Toyo Engineering Corp has secured a $625 million contract from Chambal Fertilisers and Chemicals Limited

(CFCL) to construct a large-scale urea plant in Rajasthan. The project is scheduled for completion in 2019 and looks set to be the first new major urea plant to be built in India for 25 years.

The 4,000 t/d capacity urea plant will employ Toyo's *ACES21* urea synthesis technology, with KBR providing the technology for the 2,200 t/d capacity ammonia plant. Toyo subsidiary Toyo-India is the contractor for the project's engineering, procurement and construction work.

Toyo has been building fertilizer plants in India since 1962. The current project is the company's 15th Indian fertilizer venture and its second contract from CFCL. Toyo's previous CFCL project, the Gadepan-II complex, has been operational since 1999. It also uses Toyo and KBR technology with a production capacity of 2,620 t/d for urea and 1,520 t/d for ammonia.

## THE NETHERLANDS

### Shell and Uhde launch technology partnership

Shell Sulphur Solutions has entered into a technology partnership with Uhde Fertilizer Technology (UFT), a subsidiary of thyssenkrupp Industrial Solutions.

The partnership will allow Shell Thiogro's sulphur-enhanced urea technology, *Urea-ES*, to be incorporated into UFT's proprietary fluid bed urea granulation process. The partnership arrangement follows the successful trialling of *Urea-ES* at UFT's fluid bed granulation pilot plant in Leuna, Germany.

Shell launched *Urea-ES* in May last year. The technology disperses an emulsion of tiny, micron-size sulphur particles in urea melt prior to granulation. The new partnership is significant as it should enable some of the world's largest urea plants to start producing sulphur-enhanced urea fertilizers.

"We are pleased to be working with UFT, the foremost licensor of fluidised bed granulation plants in the world," commented Rafael Garcia, Shell Thiogro's global technology manager. "UFT's urea granulation expertise and Shell's sulphur know-how complement each other perfectly."

UFT director Matthias Potthoff added: "Fertiliser producers had been asking us about incorporating sulphur into their urea for a long time. From the first discussions with Shell Thiogro about a partnership… it was clear this would be a win-win relationship."

## EGYPT

### KBR wins contract for Kima 2 project restart

KBR has been awarded a contract to supply proprietary equipment for the Kima 2 ammonia plant being built by Chemical Industries Holding Co in Aswan, Egypt.

KBR also confirmed it will re-commence work on the ammonia technology license and basic engineering design contract for the much-delayed Kima 2 plant. This was awarded by Maire Tecnimont and dates back to December 2011. Construction of the 1,200 t/d ammonia and 1,575 t/d granular urea plant is now being fast-tracked, according to KBR, and should reach the 'provisional acceptance' stage in under three years.

John Derbyshire, president of KBR Technology & Consulting, said: "We are honoured that Kima has selected KBR. We look forward to working closely with our EPC partner Tecnimont to deliver a world-class ammonia plant."

The original 2011 price tag for the Kima 2 project was $540 million. But costs may now have risen to $592 million or more, according to analysts CRU, due to lengthy delays and the rescheduled 2018 completion date.

## AUSTRIA

### Borealis to renovate Linz fertilizer complex

Borealis is embarking on an €80 million revamp of its melamine and fertilizer production facilities in Linz, Austria, over the next four years. The investment will improve plant efficiency and environmental performance by funding the installation of state-of-the art process equipment. Borealis wants to boost the long-term competitiveness of the Linz site.

The upgrades will focus on the Linz Chemical Park and include modernisation of the site's railway, installation of state-of-the-art lighting and cooling water system improvements. Fertilizer storage facilities will also be renovated to reduce dust emissions and increase energy efficiency.

Linz is the largest fertilizer production site owned by Borealis in Europe. It produces a range of base chemicals and fertilizer products, including ammonia, nitric acid, urea, NPK and CAN fertilizers. Around 50,000 t/a of melamine is also produced at two plants in the Linz Chemical Park.

"Linz is already a role model for other Borealis fertilizer facilities when it comes to production reliability and performance," explained Mark Garrett, CEO of Borealis. "What is more, it is also a crucial component of our global growth strategy in fertilizers. This is a four-year investment programme which will result in enhanced competitiveness now and many years down the road."

## JORDAN

### APC starts construction on export terminal

The Arab Potash Company (APC) has started building a new JOD 118 million ($166 million) industrial port in Aqaba. The new terminal will increases Jordanian fertilizer export capacity and is being financed on a 50:50 basis by APC and the Jordan Phosphate Mines Company.

The start of construction was confirmed by APC's president and CEO Brent Heimann as part of statement on the company's 2015 results. APC reported a net profit of JOD 131 million ($185 million) last year. This was up 31% on 2014 despite falling sales volumes and revenues. Record potash production of 2.355 million tonnes last year, and a rise in APC's profit margin from 26% to 40%, were the main factors behind the profits boost, according to the company.

APC confirmed that it will be allocating JOD one billion ($1.4 billion) for the completion of major capital projects over the next two to three years. The investment will be used to increase potash production capacity by 245,000 t/a and granular potash production capacity by 250,000 t/a. The company also said it will proceed with a 33-megawatt solar electricity project and complete this within the next two years.

PHOTO: QUOD

*Location of the York Potash project in northern England.*

## UNITED KINGDOM

### York Potash DFS

Sirius Minerals released a definitive feasibility study (DFS) for its UK-based York Potash project on 17 March. This unveiled plans for a $3.56 billion polyhalite mine with an initial capacity of 10 million t/a.

The project will be financed in two stages, the first stage costing $1.63 billion and the second stage $1.93 billion. The mine's operating costs – estimated at $27.2/t – should deliver an "industry leading" cash margin of around 70-85%, according to Sirius Minerals.

The mine will begin production in 2021 and ramp-up to 10 million t/a by 2023 under the current timetable. Site preparation will take around 22 months and be followed by a 36 month construction period. The project should generate annual earnings (EBITDA) of between $1-3 billion, depending on sales volumes and product pricing. Subsequent expansion to 20 million t/a after 2023 would require additional capex of around $1.18 billion. The project's mineral transport system will have a design life of 50 years, although mine reserves are sufficient for more than 100 years.

Commenting on the DFS, Chris Fraser, Sirius Minerals' managing director and CEO, said the company was aiming to create a world-class fertilizer business in the UK: "It is expected to have a low operating cost structure, high margins and a very long asset life in one of the most business friendly, stable and dynamic economies in the world."

Sirius Minerals is continuing to work with its partners on the initial financing of the project. "This process is expected to take a number of months but certain parts of the early construction activity, such as highways upgrades, are commencing soon to facilitate an efficient start of the project," confirmed Fraser. ■

# People

## Marius Kloppers joins board of FLSmidth

**Marius Kloppers**, former CEO of BHP Billiton, has joined the board of FLSmidth. He brings to the Danish company considerable experience and expertise in the global mining industry. Kloppers joined the board because he believes FLSmidth has a unique opportunity helping mining companies adjust to the 'new normal' in global mining markets. Advantageously for FLSmidth, Kloppers predicts that the mining industry will need to increase spending on service agreements and high performance equipment if it is to achieve much-needed efficiency gains.

*Marius Kloppers*

## Khalid bin Abdulaziz Al-Faleh named Ma'aden chairman

Saudi Arabian Mining Company (Ma'aden) has made significant changes to its board, including the appointment of a new chairman, **Khalid bin Abdulaziz Al-Faleh**. Three new directors, **Abdullah bin Mohammed Al-Issa, Lubna bint Suliman Al-Olayan, Abdullah bin Ibrahim Al-saadan**, and the new chairman joined Ma'aden's board on 28 April. They replace non-executive directors Mansour Bin Saleh Al-Maiman, Mohammed Bin Abdullah Al-Kharashi, Sultan Bin Jamal Shawli, and Khalid Bin Hamad Al-Sanani who have stood down from the company. Two other independent board members, Abdullah bin Saif Al Saif and Abdul Aziz bin Abdullah Sugair, also resigned at the end of April due to special circumstances. They have been replaced by two new independent members, **Azzam bin Yaser Shalabi** and **Jean Shamo**.

## Derek Pannell becomes Agrium's chair

**Derek G Pannell** became chair of the board of directors of Agrium Inc on 4 May. He succeeds Victor Zaleschuk, Agrium's chair since 2012, who retired on the same day. Pannell has been an independent director at Agrium since 2008, and is a past president and CEO of Noranda Inc and Falconbridge Limited. Extra to his duties at Agrium, Pannell also chairs asset management company Brookfield Infrastructure Partners Limited. A Quebec-registered engineer, Pannell graduated from Imperial College and the Royal School of Mines in London and is a fellow of the Canadian Academy of Engineering.

## Gene Gauss becomes executive vice president at AJ Sackett

The AJ Sackett Company has appointed **Gene Gauss** to the position of executive vice president. Gauss joins the company's senior leadership team with responsibility for corporate sales, marketing and business operations, both for AJ Sackett and sister business Waconia Mfg. Gauss was previously vice president and fertilizer and nutrition director at the Wilbur Ellis Company, Denver, Colorado. His appointment was welcomed by Larry Taylor, chair of AJ Sackett and Waconia Mfg: "Gene brings extensive experience, industry knowledge and customer perspective… and contributes additional depth to our management team as we position for the future."

## Andrew Semple joins SinorChem

Sinor Chemical Industry Co Limited (SinorChem) has appointed **Andrew Semple** as its business manager for NBPT in North America, South America and the European Union. SinorChem is headquartered in Hangzhou City, Zhejjiang Province, China, and is a manufacturer of NBPT, an increasingly popular nitrogen stabiliser for urea. "I'm excited to join SinorChem," said Semple. "I believe SinorChem has the capabilities to help increase market adoption of these important nitrogen stabilisers." Semple was previously CEO of Eco Agro Resources, another NBPT producer. He also helped pioneer the use of nitrogen stabilisers during his time with Agrotain International, a firm acquired by Koch Agronomic Services in 2011. ■

# Calendar 2016

### MAY

**30 – 1 June**
84th IFA Annual Conference 2016, MOSCOW, Russia
Contact: IFA Conference Service
28, rue Marbeuf, 75008 Paris, France
Tel: +33 1 53 93 05 25
Email: conference@fertilizer.org
Web: www.fertilizer.org

### JUNE

**10-11**
40th AIChE Annual Clearwater Conference 2016, CLEARWATER, Florida, USA
Email: chair@aiche-cf.org
Web: www.aiche-cf.org

**23-24**
International Fertiliser Society (IFS) Meeting, BUDAPEST, Hungary
Contact: IFS Secretary
Tel: +44 1206 851819
Email: secretary@fertiliser-society.org

### SEPTEMBER

**6-8**
7th GPCA Fertilizer Convention, DUBAI, UAE
Contact: Ammara Shahiryar
Tel: + 9714 4510666
Email: ammara@gpca.org.ae

**25-27**
TFI World Fertilizer Conference, SAN DIEGO, California, USA
Contact: Linda McAbee
Tel: +1 202 515 2707
Email: lmcabee@tfi.org

### OCTOBER

**11-13**
29th AFA Int'l. Fertilizer Technology Conference & Exhibition, TUNIS, Tunisia
Contact: Arab Fertilizer Association, Cairo, Egypt
Tel: +20 2 24172347
Email: info@afa.com.rg

**25-27**
IFA Production and International Trade and IFA Crossroads Conferences, SINGAPORE
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

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# Selling nitrogen to the world

The Former Soviet Union (FSU) is a leading global supplier of ammonia, ammonium nitrate and urea. Many of the region's producers, by targeting markets such as Latin America and Western Europe, enjoy lucrative revenues from the international nitrogen export trade. The FSU looks set to maintain its leading position in ammonia and ammonium nitrate trading globally. The region's share of the urea export market, in contrast, is likely to decline due to higher capacity growth in other parts of the world.

The size of the fertilizer sector in the Former Soviet Union (FSU) illustrates the region's enormous geographic spread, economic might and massive endowment in natural resources. The FSU produces more than 70 million tonnes of ammonia and fertilizer products annually, easily outstripping North American production. The nitrogen industry is the dominant force in FSU fertilizer manufacturing. Collective ammonia, urea and ammonium nitrate output is more than double the region's phosphate and potash production combined (Table 1).

## Exports hold the key

The FSU's large nitrogen capacity, coupled to relatively low levels of domestic demand, means that a significant proportion of nitrogen production is exported. This has allowed the FSU region to position itself as a leading global nitrogen supplier. The region commands a significant share of the world trade in nitrogen – equivalent to a quarter share for ammonia, a one-fifth share for urea and an impressive three-fifths share for ammonium nitrate[1].

Fertilizer exports from Russia, the largest regional producer, rose 17% year-on-year to 15 million tonnes on a nutrient basis in 2014, equivalent to 80% of the country's 18.7 million tonnes nitrogen, phosphate and potash output. Although potash is Russia's biggest fertilizer export, nitrogen accounts for almost two-fifths of the country's export volumes.

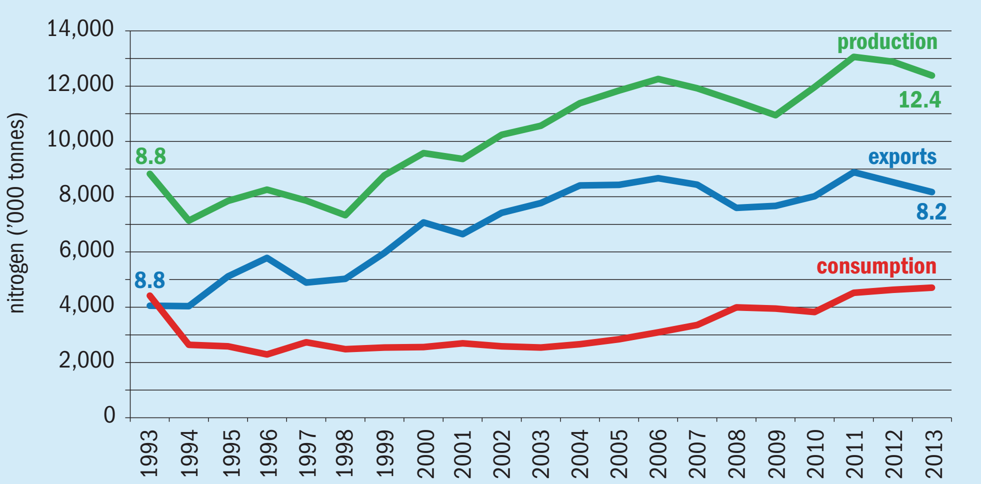
The large-scale export of nitrogen products from the FSU through the Baltic and Black Sea has a major influence on

Table 1: **Overview of FSU fertilizer market, 2013** ('000 tonnes)

| Country | Ammonia | Urea | Ammonium nitrate | DAP/MAP | KCl |
|---|---|---|---|---|---|
| Russia | 14,441 | 6,706 | 7,693 | 3,523 | 10,000 |
| Ukraine | 4,437 | 2,879 | 2,144 | 23 | 0 |
| Uzbekistan | 1,465 | 565 | 2,094 | 48 | 141 |
| Belarus | 1,026 | 1,219 | 0 | 106 | 7,072 |
| Lithuania | 900 | 438 | 588 | 781 | 0 |
| Turkmenistan | 315 | 340 | 272 | 0 | 0 |
| Georgia | 210 | 0 | 486 | 0 | 0 |
| Kazakhstan | 140 | 0 | 275 | 152 | 0 |
| Estonia | 95 | 150 | 0 | 0 | 0 |
| **FSU total** | **23,029** | **12,297** | **13,553** | **4,632** | **17,213** |
| **North American total** | **16,225** | **9,275** | **3,146** | **10,231** | **17,395** |

*Source: Simonova, 2014*

Fig 1: **FSU nitrogen production, consumption and exports, 1993-2013**




*Source: IFA*

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Table 2: **Nitrogen output of Russia's four largest producers, 2014**

| Site | Nitrogen production ('000 tonnes) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ammonia | Fertilizer products | | | | | |
| | | Urea | AN | UAN | CAN | NP | Product total |
| **EuroChem** | | | | | | | |
| Novomoskovskiy Azot (capacity) | 1,810 | 1,640 | 1,800 | 450 | 420 | - | - |
| Nevinnomysskiy Azot (capacity) | 1,160 | 930 | 1,420 | 1,020 | - | 460 | - |
| **Total** | **215** | **1,909** | **1,881** | **1,011** | **1,206** | **1,588** | **7,595** |
| **Uralchem** | | | | | | | |
| Azot Branch, OJSC Berezniki (capacity) | 1,150 | 530 | 1,350 | - | - | - | - |
| Minudobrenia, OJSC Perm (capacity) | 600 | 670 | - | - | - | - | - |
| MFP KCCW, OJSC Kirovo-Chepetsk (capacity) | 1,150 | - | 1,150 | - | - | 850 | - |
| **Total** | **777** | **1,110** | **2,940** | **-** | **-** | **522** | **4,572** |
| **Acron** | | | | | | | |
| Veliky Novgorad | 1,221 | 646 | 560 | 937 | - | - | 2,143 |
| Dorogobuzh | 526 | - | 874 | - | - | - | 874 |
| Hongri Acron | 75 | - | - | - | - | - | - |
| **Total** | **1,822** | **646** | **1,434** | **937** | **-** | **-** | **3,017** |
| **PhosAgro** | | | | | | | |
| Cherepovets | 1,155 | 966 | 291 | - | - | 121 | 1,378 |

*Source: company annual reports*

international price setting. The Black Sea f.ob. price, in particular, remains the leading global benchmark for many nitrogen products, including ammonia, urea, urea ammonium nitrate, ammonium nitrate and ammonium sulphate.

FSU nitrogen production has expanded by two-fifths in the last two decades to around 12.4 million tonnes by 2013. The region's nitrogen exports also doubled over this period, standing at 8.2 million tonnes in 2013 (Figure 1).

## Russian and Ukrainian dominance

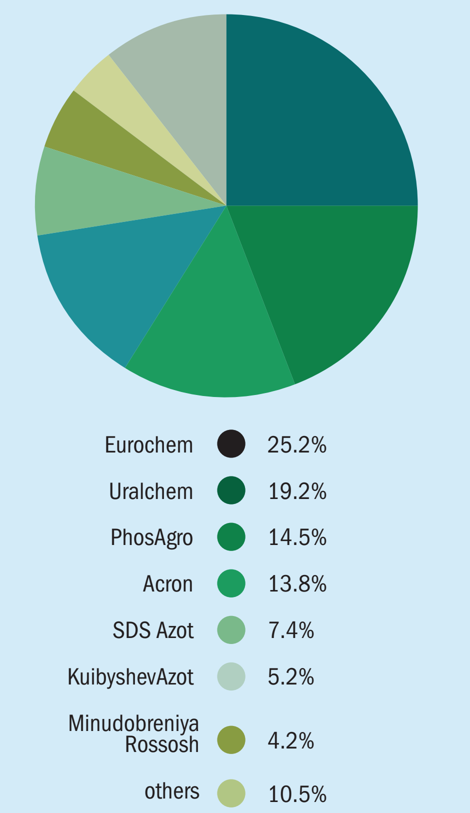
The FSU's disparate and diverse nitrogen industry encompasses many East European and Central Asian countries, although ammonia, ammonium nitrate (AN) and urea production is largely concentrated in just three states, Russia, Ukraine and Uzbekistan (Table 1). In Russia, four major producers, EuroChem, Uralchem, Acron and PhosAgro, are collectively responsible for over 70% of nitrogen fertilizer production.

EuroChem is currently Russia's leading nitrogen fertilizer manufacturer. The company's 25% share of the country's nitrogen production (Figure 2) helped it generate $2.9 billion in nitrogen sales in 2014. EuroChem possesses nine million t/a of nitrogen fertilizer capacity in total, although 2.4 million t/a of this is provided by its Antwerp calcium ammonium nitrate and ammonium nitrate plant. Its Russian operations benefit from integrated ammonia capacity and a captive upstream supply of natural gas from the 1.1 billion $m^3$ capacity Severneft Urengoy natural gas plant.

EuroChem's Nevinnomysskiy Azot site is the single largest producer of nitrogen fertilizers in Russia. The completion of an $80 million revamp in 2014 increased ammonia production capacity at Nevinnomysskiy by 117,000 t/a. EuroChem is currently investing $132 million in low-density ammonium nitrate production at Novomoskovskiy Azot. Reconfiguration of production at Novomoskovskiy has also allowed EuroChem to shift production to higher value calcium ammonium nitrate.

Uralchem is responsible for about a fifth of Russian nitrogen production (Figure 2) and is the country's leading ammonium nitrate producer, achieving a record output of almost three million tonnes in 2014 (Table 2). The company is also Russia's second largest producer of ammonia

Fig 2: **Russian nitrogen fertilizer output by company, 2015**




*Source: Azotecon*

Table 3: **Ukrainian nitrogen fertilizer production, 2014**

| Producer | Ammonia | Urea | AN | UAN | CAN | AS |
|---|---|---|---|---|---|---|
| Ostchem-Azot Cherkassy | 900 | 561 | 921 | 250 | - | - |
| DnieprAzot | 489 | 730 | - | - | - | - |
| OPZ | 915 | 604 | - | - | - | - |
| Ostchem-Rivneazot | 342 | - | 458 | - | 345 | - |
| Ostchem-Severodnetsk Azot | 205 | 150 | 158 | - | - | - |
| Ostchem-Stirol, Gorlovka | 135 | 107 | 125 | 53 | - | - |
| Coke ovens | - | - | - | - | - | 216 |
| **Total** | **2,986** | **2,152** | **1,662** | **303** | **345** | **216** |

*Source: Fertecon/Azotecon*

and urea. Demand for ammonium nitrate in Russia and neighbouring countries remains high and accounted for 60% of Uralchem's home market fertilizer sales of 1.4 million tonnes in 2014.

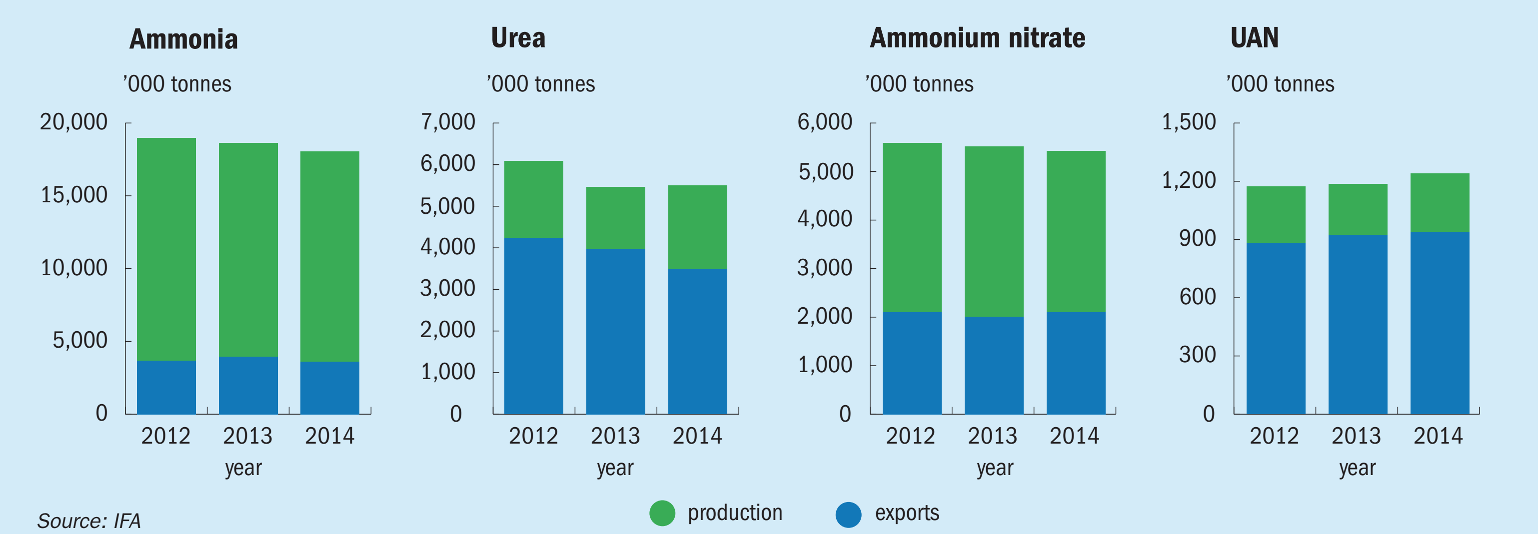
Acron's nitrogen fertilizer output rose to a record three million tonnes in 2014, helped by an upgrade at the Veliky Novgorod plant. This raised the plant's urea ammonium nitrate capacity to one million t/a, making Acron Russia's largest producer of this liquid fertilizer. Acron cut its urea output slightly to 645,000 tonnes in 2014, partly because it processed 417,000 tonnes internally to produce more urea ammonium nitrate and resins. Acron is planning to construct a new 700,000 t/a ammonia line at Veliky Novgorod.

PhosAgro increased its nitrogen production to 1.4 million tonnes in 2014 and is investing heavily in additional nitrogen capacity. The company hopes to become completely self-sufficient in ammonia by commissioning a 760,000 t/a ammonia plant at its Cherepovets site next year. PhosAgro also expects to launch a new 500,000 t/a granulated urea line at Cherepovets in 2017, and bring 300,000 t/a of new ammonium sulphate capacity on-stream.

Ukraine is another important player in the global nitrogen market, exporting urea and ammonia on a large-scale through Yuzhny on the Black Sea. The country was the world's fourth largest exporter of urea in 2013, exporting more than 90% of its urea output – roughly 7-8% of global trade – to Turkey, Italy, India, Brazil and other small markets in Latin America and Africa.

Unfortunately, Ukrainian-Russian relations remain at a very low ebb, and the last two years have been highly challenging period for Ukraine's nitrogen fertilizer industry. Two fertilizer plants operated by Group DF (Ostchem) in the country's east have been shut since May 2014 due to military conflict. Other Group DF plants have also suffered natural gas supply interruptions during 2015. These events have reduced fertilizer production volumes over the last two years (Table 3). Ukrainian urea produc-

**Fig 3: Nitrogen production exports in FSU, 2012-2014** ('000 tonnes N)




*Source: IFA*

tion was operating at around half capacity in 2014, for example, compared to the regional average operating rate of over 70%. The 700,000 tonnes of ammonia exported from Ukraine in 2014 was also around half the volume traded during the preceding two years (*Nitrogen+Syngas*, 338 p23).

## Domestic market

Russia, Ukraine and Kazakhstan are major cereal producers and occupy a dominant position in the global wheat export market. Their collective grain output increased by 7% to 181.3 million tonnes in 2014/15, according to the International Grain Council (IGC), reflecting attractive crop prices at the start of 2014 and favourable weather conditions. The IGC expects the grain harvest from these three FSU countries to fall back by 2% to 177.1 million tonnes in 2015/16, partly due to the effects of currency depreciation on input costs and finances. Land expansion is expected to be a key regional agricultural driver over the medium-term, with the cereal growing area expected to rise by 9% in Ukraine and 4% in Russia between 2014 and 2019.

The countries of the FSU collectively consumed close to 12 million t/a of nitrogen when demand was at its peak in the mid-1980s. However, after the Soviet Union's disintegration, domestic consumption in the region fell precipitously to around two million t/a in the early 2000s. Since then, FSU nitrogen consumption has partially recovered growing by almost 7% annually, albeit from a modest baseline[2].

This see-sawing in FSU demand, a consequence of major political and economic change in the region, is reflected in fertilizer application rates. Average nitrogen applications on arable land grew very strongly from 3.6 kg/ha to 50.5 kg/ha over the quarter century between 1961 and 1986, only to fall back to 10.4 kg/ha by 2002 following the collapse of the Soviet Union, before finally rebounding to 18.9 kg/ha by 2012 as the region's economy recovered[2]. FSU nitrogen application rates still remain relatively low by European standards though, being less than a fifth of average Western European application rates (130 kg/ha), for example (*Fertilizer International*, 471 p25).

Nitrogen contributed 1.5 million tonnes to the 2.4 million t/a of nutrients consumed by Russian agriculture in 2014. Demand from domestic crop growers amounted to just 13% of Russia's 18.7 million tonne NPK output for that year. Weak domestic demand and the corresponding reliance on international markets meant that over 70% of Russian nitrogen production (8.2 million tonnes) was exported in 2014[3].

Although Russian farmers benefit from discounted prices on certain key fertilizers, a lack of funding is limiting domestic fertilizer consumption, according to Uralchem: "Despite the existing mechanisms of state support for agriculture, many agricultural companies were limited in their ability to raise funds, with the situation aggravated by declining prices for agricultural products in international markets." Looking ahead, Uralchem predicts no "significant growth of agricultural output" in the FSU, and consequently expects regional fertilizer demand to remain stable or grow "by only a few percent annually".

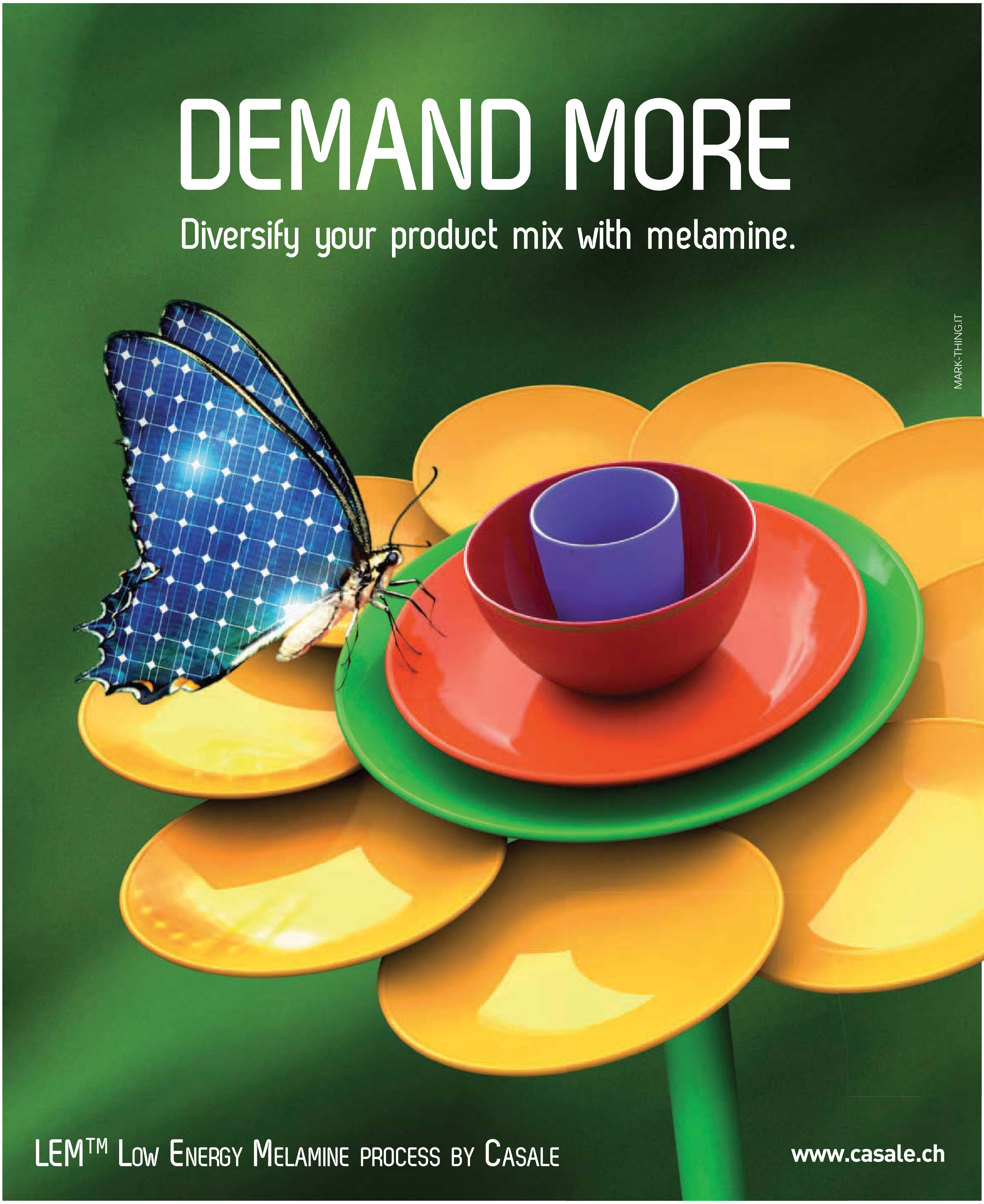
The latest demand outlook from the International Fertilizer Industry Association (IFA) reaches broadly similar conclusions. IFA expects growth in fertilizer demand in Eastern Europe and Central Asia to "remain modest (+2.0% p.a.) compared to recent history", with nitrogen demand increasing from around 4.4 million t/a in 2015/16 to 4.9 million t/a by 2019/20. It also singles out the "financial situation" as the major factor limiting the ability of the region's farmers to increase their fertilizer use over the medium-term.

Significant growth in domestic FSU nitrogen consumption is limited by a number of factors[2]:

- Agricultural supply exceeds domestic demand
- The potential for agricultural exports is also limited due to high transport costs to grain terminals
- Incentives for farmers to increase their agricultural output are therefore limited, even when price conditions are favourable
- The Russian wheat export duty introduced in February 2015, replacing the previous wheat export ban dating from 2010, also limits the ability of farmers to export

## Main export markets

FSU nitrogen production and exports have remained relatively static over the last three years (Figure 3). Urea production is particularly export-oriented with almost two-thirds of FSU output traded internationally (Figure 4). Around two-fifths of FSU ammonium nitrate production is also exported, although a significant proportion involves trade between FSU countries (Figure 5). Due to the increasing prevalence of integrated fertilizer production and domestic purchases, only one-fifth of FSU ammonia output enters the international market. However, the scale of regional production, particularly in Russia and Ukraine, permits the FSU to make a major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Diversify your product mix with melamine.
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**Fig 4: Urea production in FSU, 2014**

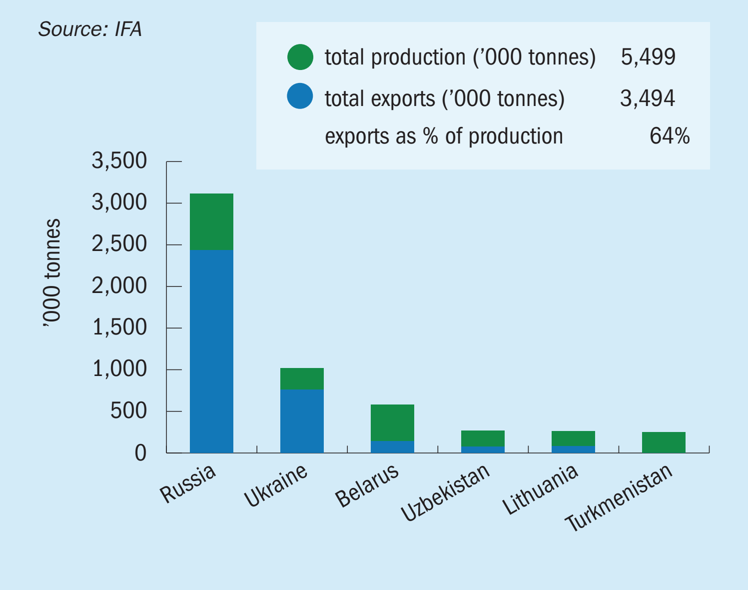



**Fig 5: Ammonium nitrate production in the FSU, 2014**

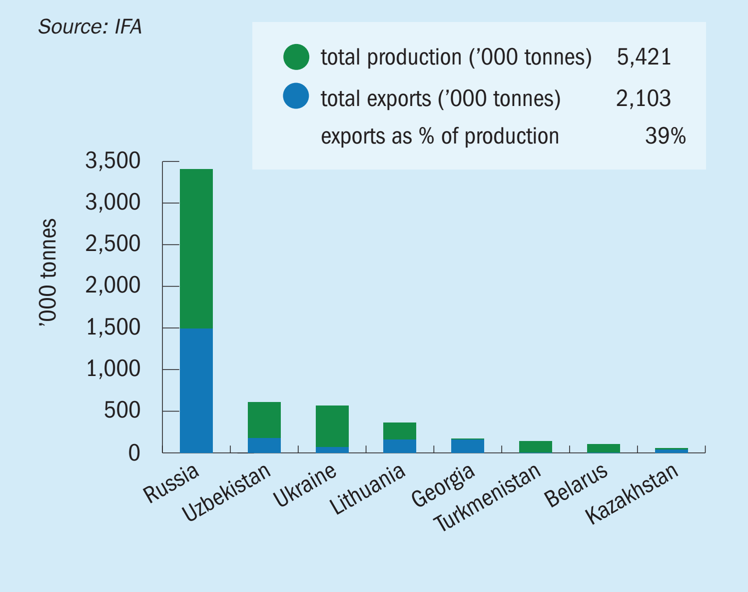
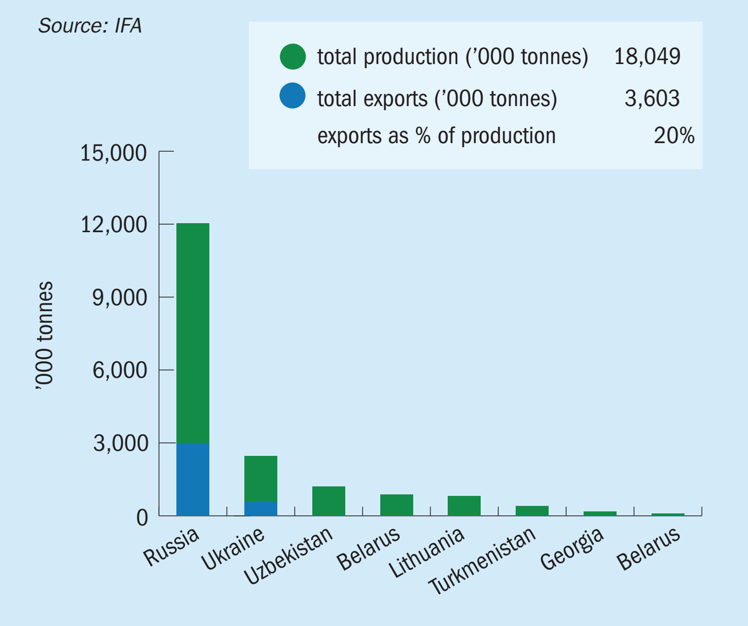



**Fig 6: Ammonia production in the FSU, 2014**




> **FSU urea production is particularly export-oriented.**

> **Russia remains the world's second biggest ammonia exporter.**

contribution to international trade (Figure 6). Russia remains the second biggest supplier in the global ammonia market. Its ammonia exports in 2014 (3.0 million tonnes nitrogen) were only exceeded by those of Trinidad (3.6 million tonnes nitrogen).

Western Europe and Latin America are the two most important international markets for FSU nitrogen products. FSU exports makes up roughly four-fifths of the Latin American import market for ammonium nitrate and two-fifths of the import demand for this product in Western Europe (Figure 7). The same two regional markets, Latin America and Western Europe, also rely on the FSU region for nearly a third of their urea imports (Figure 8). Urea from the FSU accounts for about 7% and 16% of world production and trade, respectively, according to the latest IFA figures. These also reveal that the FSU has a one-third share of global ammonium nitrate production but a two-thirds share of global trade.

One major obstacle for FSU nitrogen exporters is that access to premium US and EU markets is restricted by a range of different trade barriers, including anti-dumping rules, import duties and sanctions (Table 4). Despite these restrictions, the US still imported 3.7 million tonnes of fertilizers from the FSU in 2013. These included 1.6 million tonnes of urea ammonium nitrate, 870,000 tonnes of ammonia, 520,000 tonnes of urea and 130,000 tonnes of ammonium nitrate. But FSU nitrogen producers could find themselves backed-out of the US market as domestic production there ramps-up and displaces nitrogen fertilizer imports, particularly for urea and urea ammonium nitrate.

## Nitrogen outlook

FSU nitrogen production remains on a growth trajectory. The region should make a 10% contribution to the overall increase in world urea capacity over the next four years, with 4.4 million t/a of additional capacity expected from five major new plants between now and the end of the decade[4]. This includes Ammonii's new fertilizer complex in Russia's Tartarstan Republic (*Nitrogen+Syngas*, 338 p46) and National Chemical Group's twin one million t/a capacity Nakhodka I and Nakhodka I plants in the Primorsk region of Russia's Far East (Table 5). These additions, together with the commissioning of additional capacity at Cherepovets by PhosAgro, should increase Russia's urea capacity by over two-fifths to 11.5 million tonnes by 2019. Both KazAzot in Kazakh-

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Fig 7: **Ammonium nitrate exports: main destinations and market share, 2014**

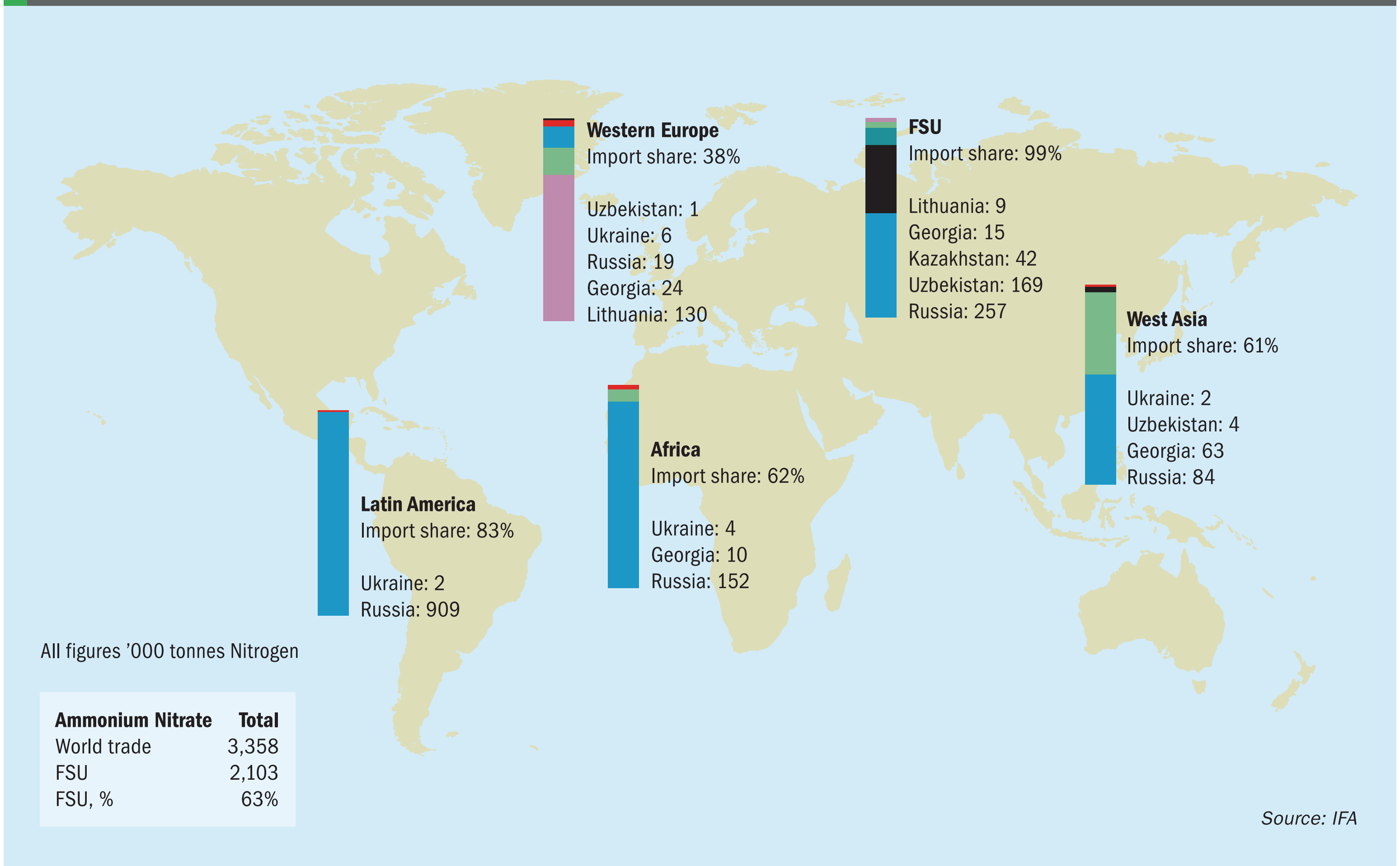


Fig 8: **FSU urea exports: main destinations and market share, 2014**

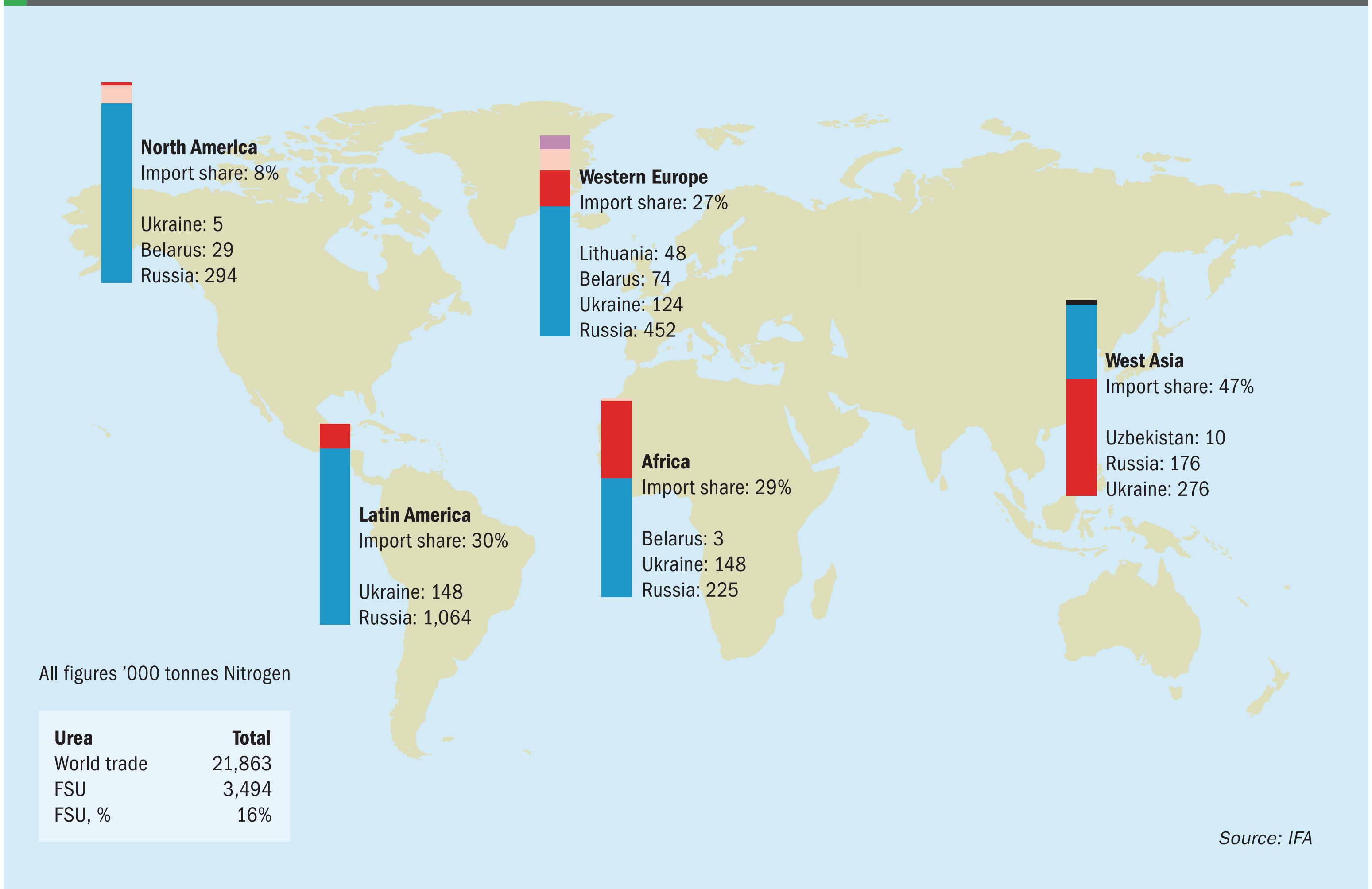

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Table 4: **Current trade barriers against FSU nitrogen exports**

| Market | Product | Exporter | Trade barrier | Tariff/cost |
|---|---|---|---|---|
| **US** | Urea | Russia, | Anti-dumping | 64.93% |
| | Urea | Ukraine | Anti-dumping | 64.93% |
| | Ammonium nitrate | Russia, | Anti-dumping | 156.29% |
| | Ammonium nitrate | Ukraine | Anti-dumping | 253.98% |
| **EU** | Ammonium nitrate | FSU | Anti-dumping | €32.82-47.07/t |
| | Ammonia | Russia | Import duty | 5.5% |
| **Brazil** | Ammonium nitrate | Russia | Anti-dumping | 32.1% |
| **Australia** | Ammonium nitrate | Russia | Minimum price | |

*Source: Fertecon*

Table 5: **FSU urea projects, 2015-2019**

| Owner | Location | Capacity ('000 t/a) | Completion |
|---|---|---|---|
| Ammonii | Tartarstan Republic, Russia | 720 | 2015 |
| PhosAgro | Cherepovets, Russia | 500 | 2017 |
| SOCAR | Sumgayit, Azerbaijan | 660 | 2017 |
| National Chemical Group (NGhG) | Nakhodka I | 1,000 | 2019 |
| National Chemical Group (NGhG) | Nakhodka II | 1,000 | 2019 |

*Source: Prud'homme (2015)*

stan and NavoyAzot in Uzbekistan are reported to have postponed their greenfield urea projects until after 2019[4].

New additional urea production capacity is likely to be earmarked for export in IFA's view. Uralchem, however, still expects the FSU's share of the global urea export market to decline. Higher capacity growth in other parts of the world, comparatively high FSU costs – particularly from transport – and increased market competition are likely to disadvantage FSU urea producers in Uralchem's view.

Eight new ammonia units in Russia are also scheduled to add 6.5 million t/a to current production capabilities, helping raise FSU ammonia capacity to 34.3 million t/a by 2019. The majority of this extra ammonia capacity will be dedicated to downstream fertilizer production, although four of the new ammonia units will provide standalone capacity of 2.2 million t/a. These planned capacity additions should allow FSU producers to maintain their current position as leading world ammonia suppliers. Similarly, the FSU's primacy as a global ammonium nitrate supplier should also remain unchanged over the medium-term[2].

Russia currently ships ammonia through Yuzhny on the Black Sea and the Baltic ports of Ventspils and Sillamae. The scheduled completion of Eurochem's one million t/a Kingisepp ammonia plant in 2018, next to its existing Phosphorit fertilizer production site, should see the opening up of a new Baltic export route.

The recovery of Ukraine's nitrogen industry will largely depend on the end of conflict and successfully securing a continuing supply of natural gas from Russia, which in turn is linked to the broader health of political and economic relations between the two FSU neighbours. Ammonia export availability through the Black Sea is, however, expected to remain at around 3.0-3.5 million t/a over the next five years[4].

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1. Simonova, M., 2014. Fertilizer Situation in the Former Soviet Union. *Fertecon/TFI Fertilizer Outlook & Technology Conference*, Savannah, Georgia, 18-20 November 2014.
2. Penkov, M., 2015. FSU outlook for nitrogen demand, production and exports. *CRU Nitrogen + Syngas 2015 Conference*, Istanbul, Turkey, 23-26 February 2015.
3. Uralchem, 2014. *Uralchem Annual Report 2014*.
4. Prud'homme, M., 2015. Fertilizers and Raw Materials Global Supply 2015–2019. *83rd IFA Annual Conference*, Istanbul, Turkey, 25-27 May 2015.

# Mosaic's game-changing sulphur melter

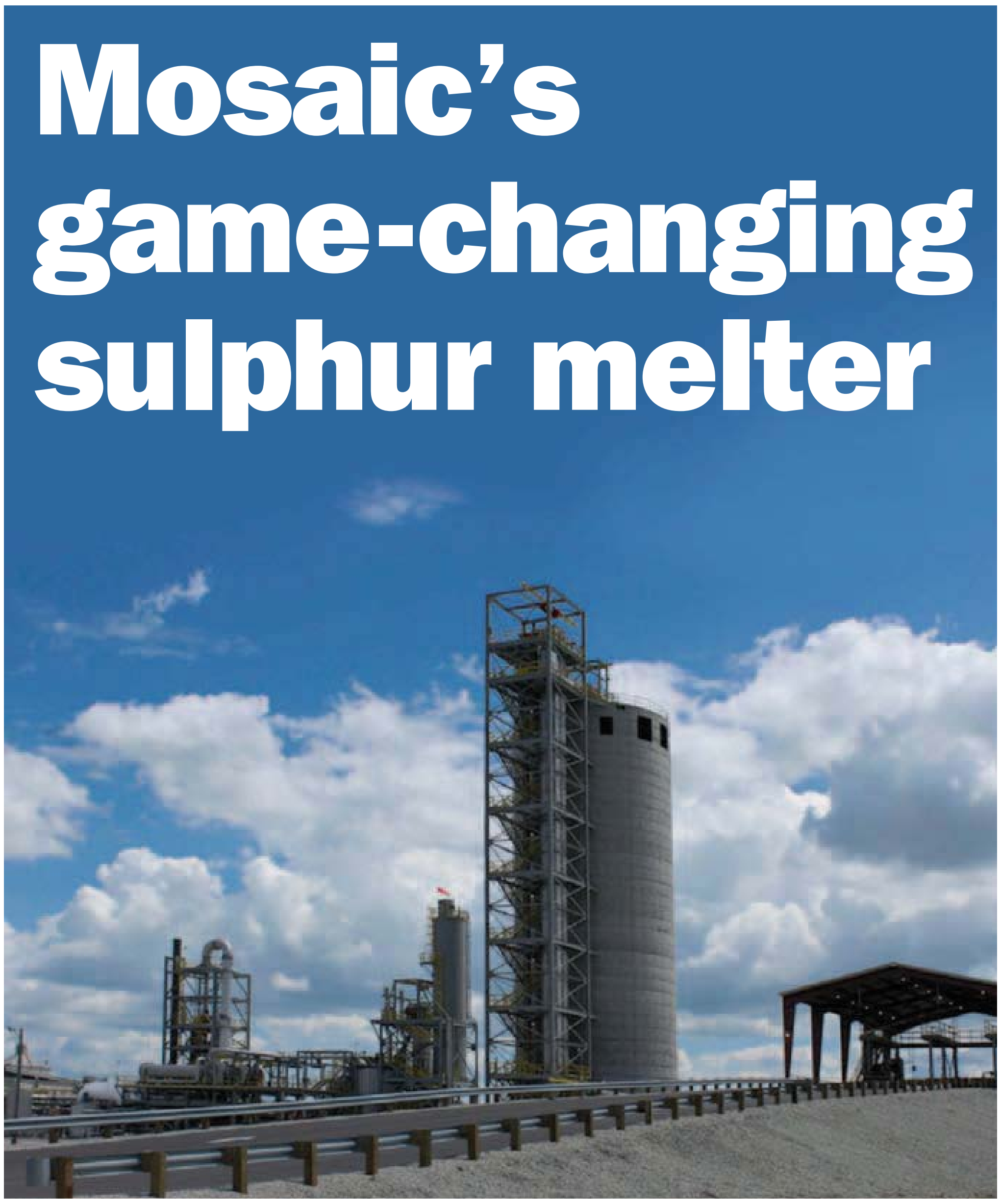


PHOTO: DEVCO

Left: New Wales sulphur melter.

The Mosaic Company's new sulphur melter will transform the North American sulphur market now that it is operational. We report on the technological innovation and partnerships behind the successful project to build a one million tonne capacity sulphur melting facility at Mosaic's New Wales complex in Central Florida.

The Mosaic Company, as the world's largest producer of finished phosphates, is unsurprisingly also the world's largest consumer of sulphur. Mosaic consumes 4.5 million tonnes annually, making sulphur an essential raw material for the company.

Traditionally, the company has exclusively sourced the molten sulphur it uses from North American sources, and configured its Florida-based manufacturing operations accordingly. But the long-term viability of relying solely on Canadian and US sulphur has started to look doubtful in recent times.

North American sulphur originates as a by-product of natural gas and petroleum refining and its availability has been strongly affected by the US 'shale gas revolution'. Looking ahead, North American sulphur supply is expected to tighten further as the prevalence of low-sulphur shale gas and oil production grows.

This has led Mosaic to look for sources of sulphur outside its home region to ensure future security of supply.

## Entering the solid sulphur market

Most of the world's sulphur, outside of North America, is traded as solid granules, an expanding market which Mosaic has been unable to access, at least until now. The recent completion of the highly-innovative and game-changing sulphur melting facility at the New Wales site does, however, change some of the long-standing, rules governing the US sulphur market. In particular, by providing Mosaic with the ability to source sulphur from overseas, it ends the company's reliance on molten sulphur, a change that is likely to weaken US demand for Canadian sulphur imports. The flexibility introduced by the melter, by opening up access to internationally-traded sulphur, should help bolster Mosaic's competitive position and help guarantee its future as a low-cost phosphate producer.

"Mosaic's one million t/a melter project will allow the company to participate in the solid sulphur market and access sulphur from a range of supply sources," agrees Meena Chauhan, sulphur research manager at London-based analysts Integer Research. "The US is traditionally a molten sulphur market, with Mosaic historically sourcing supply from domestic refineries as well as Canadian product which is transported via rail – around 1.7 million tonnes of sulphur were railed from Canada to the US market in 2015, for example."

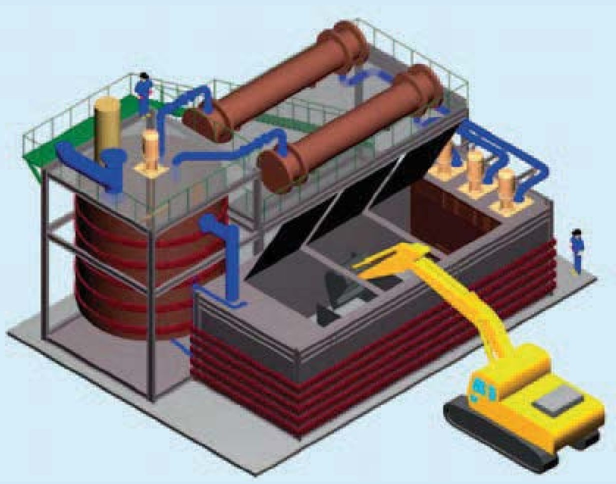
Having an in-house melter as a bargaining chip will also strengthen Mosaic's hand when it negotiates sulphur contracts with existing suppliers. By securing a lower price for procured sulphur, Mosaic could even recoup its $20 million investment in the melter within months rather than years. The melter will have paid for itself in just a single quarter, for example, if Mosaic was able to cut sulphur costs by $20/t, based on a quarterly consumption of 1.25 million tonnes (*Sulphur*, 362 p18).

## Design and construction innovation

Two commercial imperatives – ensuring a secure supply of raw materials and staying competitive – have been the main drivers behind the construction of the New Wales sulphur melter. But the advantages for Mosaic do not end there. Importantly, the melter's integral filtration system will substantially improve sulphur purity at the New Wales site, as Hermann Wittje, Mosaic's raw materials procurement director, explains. "Since our current sulphur supply comes from many varied sources, we have had little or no control over the quality of sulphur we receive," Wittje told *Sulfuric Acid Today*. "Having direct control of sulphur quality means opportunities to reduce the rate of catalyst bed fouling. This will be critical to our efforts to extend acid plant operating cycles to 36 months and beyond."

Not only will the new installation be the largest single-train sulphur melter in the world, it was constructed using a highly-compact and quick-to-build modular design which minimised on-site construction activity. The melter also has zero operational carbon emissions, as it consumes excess steam and electricity already generated on-site. Having access to on-site power also offers big operational savings by eliminating the costs of purchasing power from an external utility company. The availability of excess steam has also reduced the project's capital costs by avoiding the need to build a natural gas combustion unit and boiler.

**Fig 1: New Wales melter schematic. Rectangular pump tank, cylindrical melter mixing tank and tube-shaped heat exchangers.**



- Modular construction for easy shipment and onsite assembly.
- High availability due to ease of removing non-meltables.
- Sulphur system designed to drain into pump tank.
- Access hatches allow easy cleanout.
- Designed for efficient maintenance of equipment.

Source: Devco

## An incredible facility

Tulsa, Oklahoma-based engineering and construction firm Devco USA LLC was responsible for constructing the sulphur melting plant. The turnkey project was delivered by a team of Devco engineers and designers working with a number of key technology suppliers. Devco's overall remit included the installation of the melter alongside filters, an emissions scrubber, a truck unloader and silo and bucket elevators.

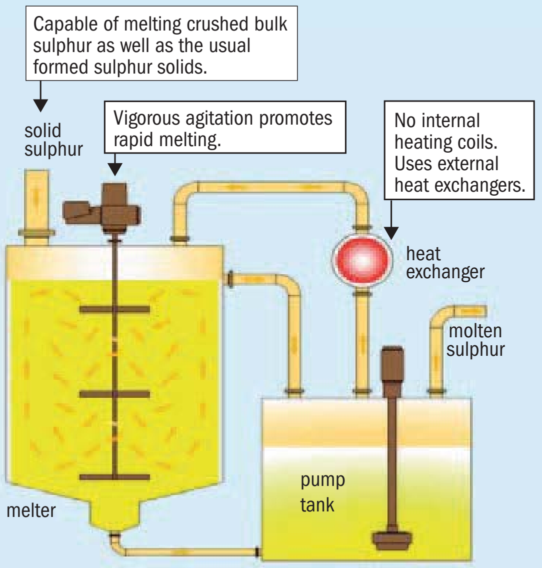
"We're on the material handling side, with very strong capabilities in civil, mechanical, structural engineering, electricals and automation," explains Mark Gilbreath, Devco's director of business development. "Our key suppliers were Crescent Technology [CTI Consulting], Twin Filter, MECS, Lightning Mixture, a very important part of this process, and Lewis Pumps.

As he explained to delegates at this year's Sulphur World Symposium in Vancouver, Canada, in April[1], Gilbreath helped steer the project from the start: "I was involved in the very initial conversations between Devco and Mosaic and I served as the executive sponsor for Devco. So I've been intimately involved in all aspects from working on the contract through commissioning and completion."

He is proud of what the project has achieved in just over a year. "The facility is fully operational. The project took about 14 months from groundbreaking through substantial completion. This is an incredible facility that we've been able to provide as a team with Mosaic."

Gilbreath singled out the melter's carbon neutrality as a notable feature and a project highlight. "We had steam available at the plant. This is a zero carbon footprint facility. We didn't have to add any energy for the production of sulphur so there's no extra energy consumed."

**Fig 2: Key components of the New Wales high capacity sulphur melter system, based on CTI consulting technology.**




- High volume sulphur melting units with capacities up to 4,000 t/d.
- External heat exchanger (HEX) gives high heat transfer coefficient, allowing high melting rates.
- High circulation rate through HEX for efficient heating and melting.
- All vessels and equipment are above ground.
- Vertical "in-tank" pumps.
- All molten sulphur is contained during unplanned shutdown.
- Customisable to meet specific customer requirements.

*Source: Devco*

## Dissolving sugar in a cup of tea

The melter and its main components, such as the pump tank, external heat exchangers and filters, occupy a relatively narrow and long strip of land on the New Wales site. The most visible structure is the 6,000 tonne capacity dry sulphur storage silo (photo, previous page). But the installation's centrepiece is the cylindrical seven-by-seven metre size high-capacity melter mixing tank which sits alongside a rectangular pump tank (Figure 1). The

*Filter units of modular design.* PHOTO: DEVCO

whole facility is elevated except for a large concrete vault. "If we're in a condition where we want to shut the melter down, all of the sulphur can be drained by gravity into that pit," explains Gilbreath.

One of the most innovative aspects of the New Wales melter is the use of three external heat exchangers. The main advantage offered by these 2 x 20 metre size objects is they make placing steam coils inside the melter unnecessary, as Gilbreath makes clear. "The melter mixing tank has no internal steam coils. The opportunity to get that steam out the melter tank is an incredible innovation. All of our heat is added to this system by external heat exchangers. They're low pressure with steam on the outside and molten sulphur on the inside, and a very effective way to get heat into the melter."

Gilbreath explains how the melting process works (Figure 2). "This system works well. It's hard to imagine how you can melt one million tonnes of sulphur a year in a vessel that's only seven metres in diameter and about seven metres tall. We bring in dry sulphur in the top of the melter vessel on one side and then bring in molten sulphur from the external heat exchangers on the other side. It's very important to get a good mixture, good agitation in the vessel."

One reason why external heat exchangers are able to work more efficiently is because they allow molten sulphur to circulate at a much higher velocity in comparison to the speed of movement of sulphur around steam coils in a tank. Gilbreath likens the use of external heat exchangers and the melting process to dissolving sugar. "Why don't we have steam coils? Think about mixing sugar in your tea and how efficient that is, versus just trying to put sugar into a cup and melting it dry."

## Easy to control and maintenance-friendly

The melter has already been operating at a sulphur consumption rate of 200 short tons per hour, well above its 155 short tons/hour design capacity. Its innovative design makes the melting process surprisingly simple to control, says Gilbreath. "Traditionally, you try and control the heat in a melter by the steam going into the coils. We control this by monitoring and regulating the dry flow of sulphur into the vessel – so there's a constant heat exchange with molten sulphur. It's much easier to control dry sulphur coming in than to control steam heat in coils."

Gilbreath also makes clear that the melter does not need to operate at high throughput all the time. "One of the advantages of this system is that it can be turned down substantially. There's still sulphur in the system but throughput can be turned down to zero – which is a great feature."

The melter has also been designed for ease of maintenance. Any constituents of the sulphur feed which do not melt – 'non-meltables' – settle in the conical base of the melter mixing tank and drain into the adjacent pump tank. Access hatches on top of the pump tank enable cleanout to take place during continuous operation. "There's always a few things in sulphur that settle out," comments Gilbreath. "Instead of having to open up that melter – as is traditionally done – and have a major shutdown, we're able to keep the melter vessel intact and clean out solids in the pump tank."

> **"The project took 14 months from groundbreaking to completion. It's an amazing facility.**

The heat exchange system is also maintenance-friendly. One of the melter's three external heat exchangers is a surplus 'redundant' unit that can be taken offline for maintenance without interrupting operations.

## Modular construction: the circus comes to town

The rapid completion of the New Wales melter facility would not have been possible without modular construction, says Gilbreath. "We broke ground in November 2014, we had substantial completion 14 months later at the end of 2015, with start-up and commissioning into the early first quarter of 2016. The only way we were able to do this so fast is through modular construction."

Modular construction has a number of known advantages, including:

- Controlled construction environment
- Reduced labour cost exposure compared to field construction
- Simpler foundation design
- Superior material control
- Reduced risk of schedule slippages

For the New Wales melter project, the main candidates for modularisation and off-site assembly were the control units, process equipment, utilities and pipe racks. Devco used a fabrication shop in Tulsa, Oklahoma, to assemble components into skids/modules. These were pre-wired and pre-tubed ready for final fit-ups on-site at New Wales. The pump tank was also fabricated in Tulsa, as were the filtration units (photo, left). The melter mixer tank, in contrast, was fabricated locally in Florida within 20 miles of the construction site.

The common building block for the project was a 14 x 14 x 40 foot container. "We try to put as much on that skid as possible inside the factory, all the piping, all the mechanical components," comments Gilbreath. "If we can put electrical control, at least the conduits, on the skid before it arrives at the site, we try to do that."

This approach to construction does demand good communication, though, advises Gilbreath. "Modular construction requires a lot of close communication between the constructor and the customer to explain where all the material is. And one day the circus comes to town and all the modules begin to arrive and then we have to go very quickly to get them all installed."

Unusually high rainfall during the summer of 2015 demonstrated the advantages of pre-assembly in an off-site fabrication shop. "We had morning rains for a period of about six weeks," comments Gilbreath. "A lot of the actual construction was being done inside a covered building in Tulsa – so modular construction helped us make the schedule in New Wales."

## Logistics and economics

Mosaic's Florida-based operations consume 3.8 million tonnes of sulphur annually, some 84% of the company's total sulphur demand. Although Mosaic originally considered locating the melter at the Port of Tampa, the New Wales site was finally selected as the most attractive and practical location for a number of reasons, as Mosaic's Hermann Wittje makes clear[1]. "We chose New Wales because it's our single largest consuming facility. It has plenty of available land, we've got readily-available captive steam and utilities already present. It's already a large industrial brownfield site so that makes permitting much easier."

Accessing Gulf coast ports from the New Wales site in Central Florida is also relatively straightforward. "We're in very close proximity to viable deep water ports. We're only 26 miles away from Port Red Wing one of the two facilities that we're using and 46 miles from the other, Port Manatee," comments Wittje.

Port Red Wing, located in the Port of Tampa, is a 9.9 m (32 ft) draught, 8,000 tonne per day port with 80,000 tonnes of storage currently. Port Manatee, which also has the ability to unload cargo at 8,000 tonne per day, is located in Tampa Bay, 20 miles south of Port Red Wing. Its deeper 12.2 m (40 ft) draught allows the berthing of Panamex vessels, making lower freight rates possible. Mosaic expects storage capacity at Port Manatee to rise to 80,000 tonnes or more.

The commercial imperatives for the melter project are pretty clear in Wittje's view. "We need supply security. This melter ends up giving us the security comfort of being able to source sulphur not just from North America but from elsewhere. We're the largest sulphur consumer in the world. We can take formed sulphur in now at various ports – that's an avenue we haven't had economical access to in the past."

The opportunity to 'backhaul' and distribute finished products from New Wales via the empty trucks and ships used to deliver sulphur also means that the transport economics and logistics work well, says Wittje. "We end up moving sulphur from these ports into Central Florida and then load-up finished products to go back to the port for export – or move it across the Gulf and up the Mississippi river system into our key Corn Belt area."

## New trade routes

The start-up of the melter should herald the emergence of new trade routes, most notably the shipment of sulphur from both the UAE and Kazakhstan to the US Gulf. Mosaic has already purchased a total of 59,000 tonnes of Kazakh- and UAE-supplied sulphur for melter commissioning runs.

Changes in Mosaic's sulphur procurement could also force US Gulf sulphur producers to export more solid sulphur to Brazil or other markets such as Morocco (*Sulphur*, 362 p18). One scenario that is looking increasingly likely, according to analysts Fertecon, is that US Gulf sulphur exports to Brazil could displace current Kazakh supply to the country and see this re-routed to Mosaic in the US instead.

The displacement of Canadian sulphur imports will, however, be one of the most noticeable consequences of the melter's start-up, according to Integer Research.

"One of the key trade changes we expect is for US imports of Canadian molten sulphur to decrease as solid sulphur imports to Tampa increase from offshore suppliers such as the Middle East and the Former Soviet Union," says Integer's Meena Chauhan. "We have already seen cargoes being shipped from Kazakhstan as part of the plant commissioning."

She continues: "Tonnages from this trade route are expected to increase, as is trade from countries such as the UAE due to the uptick in excess sulphur available for export. However, the melter's utilisation rate has been below capacity so far in 2016, due to the current slowdown in the downstream processed phosphates market and ample sulphur stocks."

The full impact of the melter on trade has yet to materialise, concludes Chauhan: "January 2016 data released by the USGS shows sulphur imports from Canada remained stable at around 140,000 tonnes for the month, a level seen throughout the majority of 2015."

Due to falls in bulk sea freight rates, Fertecon thinks it is possible for sulphur to be shipped from the UAE at a lower cost than rail deliveries of liquid sulphur from Canada. Mosaic itself reports that sulphur freights costs from Alberta, Canada are over $100/t versus $15-20/t for FSU sulphur and $20-25/t for sulphur from the Middle-East[1]. At some point, high logistics costs to Tampa, combined with fewer molten rail cars, could even make it uneconomic to import sulphur from Canada into the US, in Fertecon's view. ■

## References

1. Wittje, H. & Gilbreath, M., 2016. Mosaic New Wales Sulphur Melter. *TSI Sulphur World Symposium 2016*, 11-13 April 2016, Vancouver Canada.

*Brazil is the World's second largest producer of soybeans.*

PHOTO: ALF RIBEIRO/SHUTTERSTOCK.COM

# Brazil: global agriculture's powerhouse

Brazil's massive agricultural industry makes the country a pivotal market for fertilizers. We look at the country's large, diverse and rapidly-growing farming sector and assess future nutrient demand.

A sharp economic downturn and political uncertainty made 2015 a difficult year for Brazil's farmers. Fertilizer purchases were particularly affected with total deliveries down by 6% to 30.2 million tonnes and imports falling by 12% year-on-year to 21.1 million tonnes. Domestic fertilizer production did hold up, however, growing by 3% to 9.1 million tonnes in 2015.

The lack of farm credit in Brazil was a pivotal factor behind last year's fall in fertilizer consumption. Finance from agricultural wholesalers and private banks has become increasingly important to the country's farmers in recent years, as production costs have risen, with these two sources accounting for half of total agricultural funding in 2014/15. Last year was different, however, as farmers resorted to using more of their own money or turned to trading companies for funding[1].

Analysts at CRU have also identified the lack of credit in Brazil as one of the main factors behind last year's downturn in fertilizer demand. An increased reliance on bartering, together with changes in the barter ratio, is affecting farm financing in their view. Encouragingly, the barter ratio (the number of 60 kilo soybean bags per tonne of phosphate fertilizer) was above 25 at the start of 2015 but has since slid to below 20.

Credit has been vital in propelling Brazilian agricultural production and export growth by counteracting the country's "structural and institutional headwinds", as Rabobank recently explained[2]: "The combination of poor logistics, high taxes and institutionalised bureaucracy – referred to locally as *Custo Brasil* – has been offset by… a system of official rural credit which is extensively supplemented with finance from input suppliers, trading companies and private sector banks."

Last year's drop in Brazilian fertilizer consumption was also linked to a fall back in average farm profitability[1]. This slipped to BRL 730/ha in 2015/16, a downward correction following the precipitous rise from BRL 191/ha to BRL 901/ha during the preceding six years. Average farm production costs in Brazil have also risen inexorably, from BRL 1,282/ha in 2009/10 to BRL 2,220/ha in 2015/16. Fertilizers costs, although declining as a proportion of total costs, increased from BRL 365/ha to BRL 532/ha over this period.

## Agricultural superpower

Despite its recent troubles, Brazil position as an agricultural superpower looks assured. The country is the world's largest exporter of sugar, ethanol, soybeans, orange juice, coffee, poultry and beef (Table 1) and, overall, is the third largest agricultural exporter globally after the United States and the European Union[2]. Brazil should maintain its role as a "leading supplier to international food and agriculture markets over the next decade", according to the OECD, and be able to balance this with feeding its growing and increasingly wealthy population[3].

Brazil emergence as Latin America's leading agricultural economy is a consequence of its vast endowment in land and its burgeoning population, both by far the largest in the region. Although agriculture accounts for less than 6% of Brazil's GDP, the sector makes a major contribution to the country's foreign earnings and trade balance. Agriculture and agribusiness exports totalled over $86 billion in 2013, for example, some 36% of the country's total exports that year. Total agricultural output has also more than doubled in volume in the last 25 years, and livestock production almost trebled over the same period.

Although the domestic market absorbs much of farm output, increased production of export-oriented products, especially soybeans, sugar and poultry, has been the main engine of Brazilian agricultural growth. Brazil exports large volumes of agricultural produce to the European Union, China, the United States, Japan, Russian and Saudi Arabia. China replaced the EU as the country's single biggest export market in 2013[3].

Brazil's farms employ just over one in ten of the country's workforce. This relatively low level of agricultural employment reflects the prevalence of highly-mechanised, large-scale production of grains and oilseeds and extensive livestock rearing[2]. Holdings above 1,000 hectares in size, for example, account for just 1% of farm numbers but cover 44% of Brazil's farmland[4].


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Table 1: **Brazil's global agricultural production and export share and ranking**

| 2014 | Production global share | Production global rank | Export global share | Export global rank | Main market |
|---|---|---|---|---|---|
| Sugar | 22% | 1 | 46% | 1 | China |
| Ethanol | 27% | 2 | 55% | 1 | USA |
| Soybeans | 30% | 2 | 39% | 1 | China |
| Soybean Meal | 15% | 4 | 22% | 2 | Europe |
| Corn | 8% | 3 | 8% | 2 | Japan |
| Rice | 2% | 9 | 2% | 8 | Venezuela |
| Orange Juice | 55% | 1 | 77% | 1 | Europe |
| Coffee | 36% | 1 | 29% | 1 | USA |
| Cotton | 6% | 5 | 11% | 5 | South Korea |
| Pork | 3% | 4 | 8% | 4 | Russia |
| Poultry | 15% | 3 | 34% | 1 | Saudi Arabia |
| Beef | 16% | 2 | 19% | 1 | Russia |

*Source: USDA/Mosaic*

Climatic variations across Brazil, by enabling the cultivation of both temperate and tropical produce, have helped the country develop a diverse agricultural sector. Most of Brazil's grains, oilseeds and other export crops are produced in the south and centre-west regions of the country. These regions benefit from higher rainfall, better soils and more developed infrastructure. The farms in both regions also use inputs more intensively and are generally better technologically equipped than farms in other parts of Brazil[3]. Soybean production is, however, on the rise in Maranhão, Tocantins, Piauí and Bahia, the so-called MaToPiBa states in Brazil's north[3].

## Land expansions fuel fertilizer demand

Brazil's prominence in key global agricultural markets has cemented its status as the fourth largest fertilizer consumer in the world, accounting for around 6% of total world demand. The country consumed a record 14.1 million tonnes of nutrients in 2014 and, due to the prevalence of soybean growing, demand for potash and phosphate is unusually high by international standards. Brazil's farmers applied 5.4 million tonnes of potash (38%) and 4.8 million tonnes of phosphate (34%) last year versus 3.9 million tonnes of nitrogen (28%). As a proportion of use, Brazilian potash application is more than double the world average (16%) and, conversely, its application of nitrogen is less than half the global norm (61%)[1].

Mato Grosso state is currently the largest consumer of fertilizers, followed by Rio Grande do Sul and Paranà. Annual consumption in northern states is also said to be expanding at close to 8%.

Brazil's impressive agricultural growth in recent decades has come from land expansions, particularly in the country's centre-west and northern regions, and from increased agricultural productivity (yield gains). The cultivation of crops on relatively infertile pasture previously used for cattle ranching is a major factor underpinning Brazilian fertilizer demand. Central Brazil, in particular, contains substantial areas of degraded grassland with potential for additional crop production.

Further expansions in arable land are likely to underpin strong fertilizer demand over the medium term. That is certainly the view of leading analysts, such as Michael Rahm of the Mosaic Company[4].

"There's no question Brazil is an agricultural powerhouse," Rahm said recently. "They have a very large, diverse and rapidly-growing agricultural sector – and that's largely due to abundant land area and a favourable climate. Soybeans and second crop corn have been the main engines of growth in Brazil, accounting for about 97% of the growth in grain and oilseed production."

He added: "Brazil achieves world-class yields but the growth in production is coming largely from land being brought into production. What makes you optimistic about Brazil is that there are still large quantities of land available to be brought into production."

Brazil's longer term prospects remain positive, in Rahm's view, despite the country's current political predicaments and economic set-backs.

"Brazil is undoubtedly facing headwinds today in terms of credit availability, slowdown of the economy, exchange rate volatility, economic and political uncertainties, corruption scandals and so on. But when you look at currency weakness and relatively high crop prices, these are expected to sustain the long-term growth trends we've seen in Brazil."

## Soybeans and second crop corn

Despite Brazil's very large and diverse farming sector, agricultural growth has almost exclusively been powered by corn and soybean cultivation.

"In the last 15 years, grain and oilseed production has grown about 5.6% per year," comments Rahm. "When you look at where that growth is coming from, soybeans and second crop [Safrinha] corn account for 97% of that growth."

These increases in grain and oilseed production have come from two factors: the harvesting of an additional 20.9 million hectares and an increase in average yields to above 3.5 t/ha. Significantly, soybean growing area has doubled since 2000 from less than 15 million hectares to over 30 million hectares currently. Soybeans have been responsible for 84% of Brazilian crop expansion over this period with corn contributing a further 11% (2.3 million ha).

About 90% of the global growth in soybean production achieved in recent years has been delivered by improving yields. This is not the case in Brazil, however, as – although the country achieves world-class soybean yields – four-fifths of soybean production growth has come from land expansion alone.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76

Table 2: **Agricultural land use and availability in Brazil**

| Land use | Area (million hectares) |
|---|---|
| **1. Available land:** pasture that could be converted to crops | 200 |
| **2. Available land:** not in pasture or planted to crops | 60 |
| Soybeans | 31.9 |
| Corn | 15.7 |
| Sugarcane | 9.0 |
| Reforestation | 5.7 |
| Edible beans | 3.1 |
| Rice | 2.3 |
| Coffee | 2.4 |
| Wheat | 2.5 |
| Other | 7.3 |
| **3. Total planted area** | 79.7 |
| **Total arable (1+2+3)** | 340 |
| **Total land area** | 850 |

*Source: Mosaic/Conab/IBGE*

Table 3: **Soybean fertilizer application rates for Brazil versus selected countries***

| Country | Area (million hectares) | NPK use (million tonnes) | NPK rate (kg/ha) | Average soybean yield (t/ha) |
|---|---|---|---|---|
| Brazil | 23.5 | 3.30 | 140 | 2.94 |
| US | 30.9 | 1.12 | 37 | 2.96 |
| Argentina | 18.6 | 0.41 | 22 | 2.93 |
| China | 9.2 | 0.78 | 85 | 1.63 |

**2010 data* *Source: Mosaic/USDA/IFA*

The availability of hundreds of millions of hectares of land (Table 2) is one of the most promising features of Brazilian agriculture, as Michael Rahm explains: "There's probably 60 million hectares of arable land, not in pasture or planted to crops today, that could be brought into production. And there's still about 200 million hectares of land in Brazil that are still in pasture – so certainly some of that can come into production."

## Soils require large application rates

Brazilian agricultural land is often nutrient-poor with soils of low or very low fertility covering large swathes of the country. Because of this, an average NPK application of 140 kg/ha is necessary to achieve Brazil's world-class soybean yields, compared to average application rates of just 37 kg/ha in the United States and 22 kg/ha in Argentina (Table 3).

Mosaic calculates that an extra 0.5 tonnes of fertilizer products, such as MOP, MAP and urea, are required for every additional hectare of Brazilian land brought into production, assuming an average crop yield of 3.75 t/ha. Soybean cultivation requires particularly large amounts of P and K.

"For every hectare that's brought into production, there's about half a tonne of NPK that goes down onto crops and, in the case of soybeans, that's mostly phosphate and potash," comments Rahm. "When you look at the nutrient mix, P and K account for 34% and 38% of total nutrient use and that's unusually high due to the fact that Brazil produces so many oilseeds that require P and K."

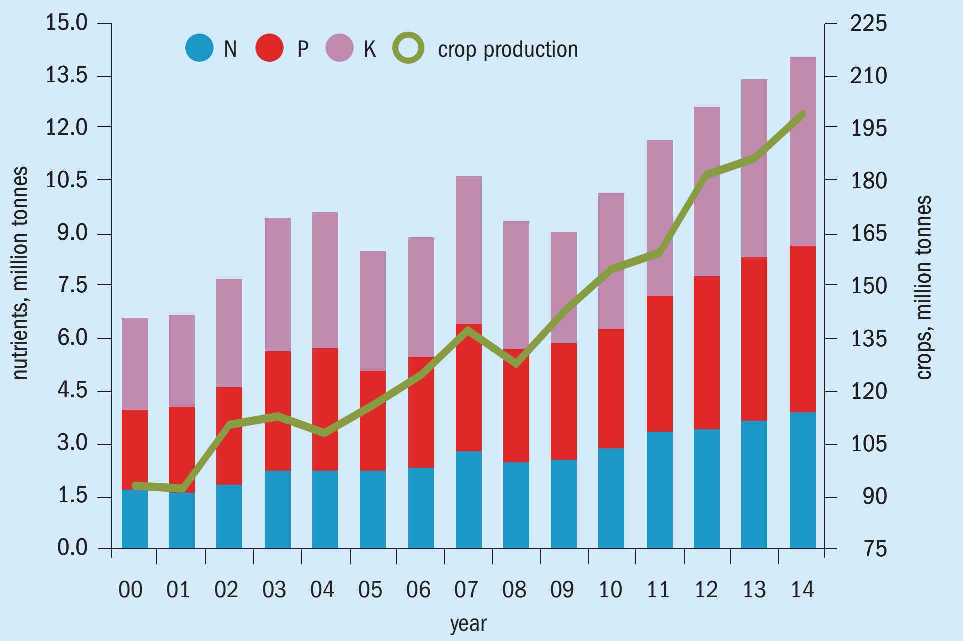
## A growing market

Bulk blended products make up three-quarters of Brazil fertilizer deliveries. Products such as urea, AS, SSP, TSP and MOP are combined to provide farmers with formulations tailored to their crop growing and soil types. A combination of urea and MOP, 30N-0P-20K, is a particularly popular fertilizer blend for corn in Mato Grosso state, for example. Fertilizers are mainly transported by truck (95%) rather than rail (5%) in Brazil and are usually supplied as either one tonne (55%) or 50-kilo (40%) bags. Fertilizer consumption also follows a seasonal pattern with 60-65% of demand falling in the second half of the year.

The 5.6% annual growth in grain and oilseed production since 2000 has been matched by an almost identical growth rate in NPK nutrient shipments (Figure 1). This is not surprising in Rahm's view. "There's no alchemy taking place in soils. You're growing a crop, that crop needs nutrients, and in the case of Brazil – where the soils are not very rich in nutrients – you see a very tight correlation with fertilizer use."

The pace of growth in Brazilian fertilizer product consumption, has accelerated in recent years, increasing by more than two-fifths to 32.2 million tonnes between 2009 and 2014, before falling back to 30.2 million tonnes last year. Large rises in urea, MAP and MOP deliveries are behind much of this growth – the use of each of these products has more than doubled since 2000 – with further significant rises

Fig 1: **Brazil N+P+K consumption and crop production** 2000-2014

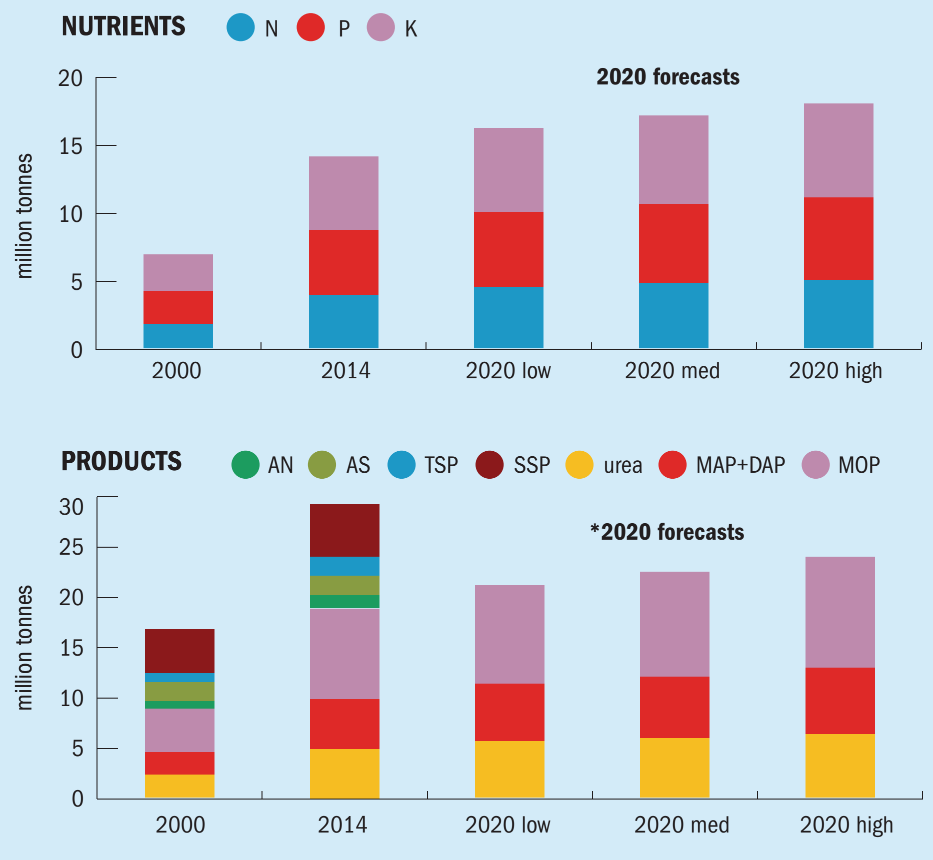



*Source: ANDA and USDA*

1 47 2 48 3 49 4 50 5 51 6 52 7 53 8 54 9 55 10 56 11 57 12 58 13 59 14 60 15 61 16 62 17 63 18 64 19 65 20 66 21 67 22 68 23 69 24 70 25 71 26 72 27 73 28 74 29 75 30 76 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46



Fig 2: **Brazilian fertilizer consumption, forecast for three different growth scenarios**




*Source: Mosaic/ANDA*

expected by 2020 (Figure 2).

SSP remains the most popular choice of phosphate fertilizer in Brazil, with 2014 deliveries of 5.23 million tonnes larger than the combined deliveries for MAP (4.21 million tonnes) and DAP (0.74 million tonnes). However, SSP's share of the Brazilian phosphate market is on the decline and, when calculated on a $P_2O_5$ basis, has fallen from roughly a third (35%) in 2000 to a fifth (22%) currently. This trend is expected to continue in future as Brazil's farmers shift to higher analysis NPK, DAP and MAP products.

## Future demand and import reliance

Brazilian nutrient demand is projected to grow from 14 million tonnes in 2014 to between 16-18 million tonnes by 2020, assuming 2-4% annual growth in grain production over this period. Fertilizer consumption on a product basis would rise to 36.7-40.8 million tonnes by 2020 under this demand scenario, up from 32.2 million tonnes in 2014.

These figures are based on a recent analysis by Mosaic. A separate forecast by ANDA, Brazil's national fertilizer association, is more conservative and predicts nutrient demand will grow to 15.0 million tonnes by 2020, equivalent to fertilizer consumption of 35.5 million tonnes (Table 4).

Brazil's overall dependency on fertilizer imports has grown from about 60% in 2000 to around 75% currently, as rising demand has continued to outstrip domestic fertilizer production. Imports currently account for over 95% of the potash market, 80% of the nitrogen market and 60% of the phosphate market in Brazil. Imports have risen particularly sharply since the start of the decade. "Those import shares, despite a lot of talk five of six years ago about Brazil trying to become nutrient independent, have increased as demand has increased,"comments Michael Rahm.

The completion of a number of major-Brazilian fertilizer projects under-development currently could, however, see import dependency decline appreciably for urea by 2020, and ease back slightly for MAP and DAP (Table 5).

"Petrobras has [several] large-scale nitrogen projects under development. Tres Lagoas is the largest, more than 80% complete and is expected to start-up some time in 2017," comments Michael Rahm."The major phosphate producers, Anglo, Vale, Galvani, also have a number of projects that are expected to come online in the near future."

Brazil's reliance on MOP imports, however, looks set to increase over the medium-term. Vale's 1.3 million t/a Carnalita potash project is unlikely to enter production before 2020, as finance is not in place and board-level approval is still awaited (Table 6). Brazil could even be left without a domestic supply of potash by the end of the decade, as reserves at Vale's Taquari-Vassouras operation in Sergipe state, Brazil's single existing potash mine, are expected to become exhausted by 2020.

Despite planned improvements to domestic fertilizer supply, Brazil is likely to remain a major MOP, MAP and urea importer for the foreseeable future, if agricultural production continues to expand at several percent per year over the medium-term, as expected.

## Distribution and infrastructure

Fertilizer distribution in Brazil is increasingly under the control of a small number of large distributors, following a series of mergers and acquisitions, with further takeovers and consolidation expected in future. The number

Table 4: **Grain production and fertilizer demand scenarios for Brazil**

| Annual growth in grain production | 2020 grain production (million tonnes) | 2020 NPK nutrient consumption (million tonnes) | 2020 fertilizer product consumption (million tonnes) |
|---|---|---|---|
| **ANDA forecast** | | | |
| 1.4% | 216 | 15.0 | 35.5 |
| **Mosaic's demand scenarios** | | | |
| 2% | 224 | 16.1 | 36.7 |
| 3% | 237 | 17.0 | 38.7 |
| 4% | 251 | 18.0 | 40.8 |

*Source: Mosaic/ANDA*

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Table 5: **Fertilizer import trends for Brazil, medium demand scenario**

| | Domestic supply (million tonnes) | | Imports (million tonnes) | | Import share, % | |
|---|---|---|---|---|---|---|
| | **2014** | **2020** | **2014** | **2020** | **2014** | **2020** |
| Urea | 0.8 | 2.0 | 4.0 | 3.9 | 83 | 66 |
| DAP/MAP | 1.2 | 2.2 | 3.8 | 4.0 | 76 | 71 |
| MOP | 0.5 | 9.1 | 9.1 | 10.2 | 95 | 98 |

*Source: Mosaic/ANDA*

of importers fell from 98 to 77 between 2006 and 2014 and the market share of the top four importers, Yara, Mosaic/ADM, Fertipar and Heringer, increased from 57% to 70% over this period.

Access to the Brazilian market has become a strategic issue for major fertilizer producers and explains the importance placed on securing a distribution foothold in the country. Notable Brazilian acquisitions include Mosaic's purchase of ADM in 2014. Yara also took a 60% equity stake in Galvani in 2014, following its buy-out of ODF Holdings in 2013 and Bunge in 2012. In addition, OCP and PotashCorp have both acquired a 10% equity stake in Heringer in the last two years.

Fertilizer logistics should improve in future as Brazil upgrades and expands its transport infrastructure. Around $435 billion is due to be invested in a plethora of road, rail and port projects over the next two to three years[4]. These investments should improve fertilizer availability throughout the country and reduce the cost of exporting grain and oilseeds.

The $14.5 billion of road investment in the Cerrado should help cut the cost of logistics in central Brazil's main grain-producing and input-consuming region. Spending on highways in the fast-growing MaToPiBa (Maranhão, Tocantins, Piauí and Bahia) region in Brazil's north should also cut transport costs for both fertilizers and grain exports. Around $270 million has also been earmarked for port projects, seven of which are in the country's north[4].

Summing up distribution and other trends in Brazil's fertilizer market, Michael

Table 6: **Brazil's fertilizer project slate**

| Company | Project | Products | Capacity, '000 t/a | Start-up date |
|---|---|---|---|---|
| **Major phosphate projects** | | | | |
| Anglo | Catalao (Ouvidor) | Phosphate rock | 1,200 | after 2020 |
| | | Phosphoric acid | 400 | 2018 |
| | | MAP | 520 | 2018 |
| | | TSP | 240 | 2018 |
| Galvani | Salitre | Phosphate rock | 1,200 | 2018 |
| | | Phosphoric acid | 200 | 2018 |
| | | MAP/NPK | 350 | 2018 |
| Galvani | Santa Quiteria | Phosphate rock | 800 | 2019 |
| | | Phosphoric acid | 240 | 2019 |
| | | MAP/NPK | 290 | 2019 |
| Vale | Salitre Patrocinio | Phosphate rock | 1,100 | 2019 |
| | | Phosphoric acid | 560 | after 2020 |
| | | MAP | 780 | after 2020 |
| | | TSP | 330 | after 2020 |
| **Major nitrogen projects** | | | | |
| Petrobras | TresLagoas | Ammonia | 730 | 2017 |
| | | Urea | 1,200 | 2017 |
| Petrobras | Linhares | Urea | 700 | after 2020 |
| Petrobras | Uberaba | Ammonia | 500 | 2017 |
| **Major potash projects** | | | | |
| Vale | Carnalita | MOP | 1,300 | after 2020 |

*Source:IFA/Mosaic*

Rahm makes the following points: "Brazil is moving from low analysis to high analysis products. So SSP, though still a very important product in Brazil, is playing a lesser role in terms of overall phosphate use. In terms of how fertilizers are distributed, the market's moving from 50 kilo bags to one tonne bags and a little bit of bulk distribution – we expect those trends will continue. Finally, geographically we're seeing the biggest amount of growth in the north/northwest parts of the country."

## Encouraging signs for 2016

Encouragingly, although the Brazilian economy shrank 3.8% in 2015 – the country's worst economic performance in 25 years – agriculture still grew by 1.8% and was the only sector of the economy to expand. Growth was mainly attributable to increased soybean (11.9%) and corn production (7.3%) last year.

There are also early signs of a 2016 pick-up in Brazilian fertilizer demand. ANDA figures confirm 4.25 million tonnes of fertilizers were delivered in January-February, up 11% on the 3.83 million tonnes delivered during the same period last year, and slightly exceeding equivalent 2014 deliveries. This recovery has come almost exclusively from increased potash and nitrogen demand whilst phosphate consumption has remained flat. January/February 2016 fertilizer imports of 3.03 million tonnes were also up 15% on last year.

Brazilian farm fundamentals continue to look strong as well. At the start of February, Brazil's soybean price (BRL 33/bushel), for example, was just 6% below its September 2012 all-time high. This means Brazil's farmers can achieve good margins, if they can access credit. High margins should provide a strong incentive to take more land out of pasture, plant more soybeans and apply more fertilizers. Growers planted 4% more land to soybeans in the current season. It is therefore unsurprising that Brazil is heading towards a record 100 million tonne harvest this year. "When the incentives are there, Brazilian farmers plant soybeans," concludes Michael Rahm.

However, the decline in value of Brazil's currency, whilst making Brazilian agricultural exports more lucrative and competitive, does have a downside, as it increases production costs and makes imported fertilizers less affordable.

Brazil's agricultural fortunes are also closely-linked with China's economic performance. China accounts for about 70% of Brazil's soybean exports. The so-called 'Brazil-to-China soybean pipeline' has been particularly critical for export growth in recent years, as Michael Rahm explains: "When you look at what's driving growth in Brazil, people talk about the Brazil-to-China soybean pipeline. That certainly has grown dramatically over the last 15 years, and is expected to continue to grow despite the fact that there have been slowdowns and changes taking place at both ends of this pipeline." ■

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PHOTO: JON SULLIVAN / WIKIMEDIA COMMONS

# A sprouting fertilizer market

Brassica are widely grown for their valuable roots, stems, leaves, flowers, buds and seeds and include some of the world's most dominant food crops. We review the nutrient needs of this unusually diverse plant family, including cabbages, broccoli and cauliflowers.

*The Romanesco superficially resembles a cauliflower, but it has a visually striking fractal form.*

Fig 1: **World brassica production by crop, 2002-2012**


* Includes Chinese cabbage, mustard cabbage, pak choi, white cabbage, red cabbage, savoy cabbage, Brussels sprouts, collards, kale and kohlrabi.

*Source: FAOSTAT*

> **"Getting crop nutrition right is an essential prerequisite for harvesting high-quality brassica.**

The plant genus *Brassica*, part of the mustard family, includes some of the world's most widely-cultivated food crops. Commonly consumed vegetables such as broccoli, Brussels sprouts, cabbages, cauliflower, kohlrabi, pak choi (Chinese cabbage), radishes and turnips are all types of brassica. Other brassica, notably rapeseed and mustard seed, are grown on a large-scale globally as a rich source of vegetable oil and protein.

Brassica are native to Western Europe, the Mediterranean and temperate regions of Asia, and are informally known as cruciferous plants because of the easily identifiable cross-like arrangement of their petals. The other common name for brassica, cole plants, derives from the Latin *caulis*, meaning stem or stalk.

## Production

Brassica are cultivated for their roots (turnips, radishes), stems (kohlrabi), leaves (cabbages), flowers (cauliflowers, broccoli), buds (Brussels sprouts, cabbage)

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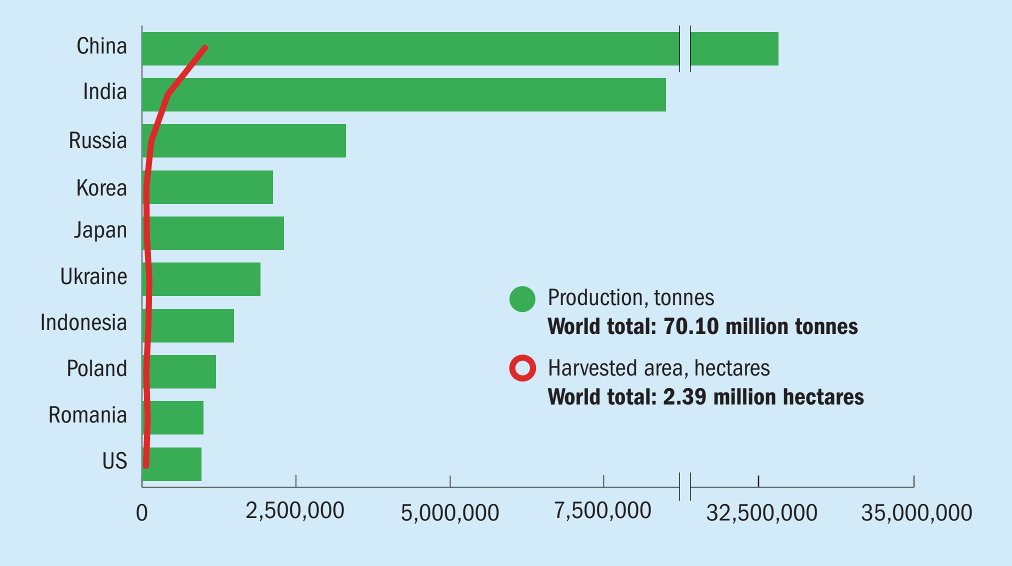
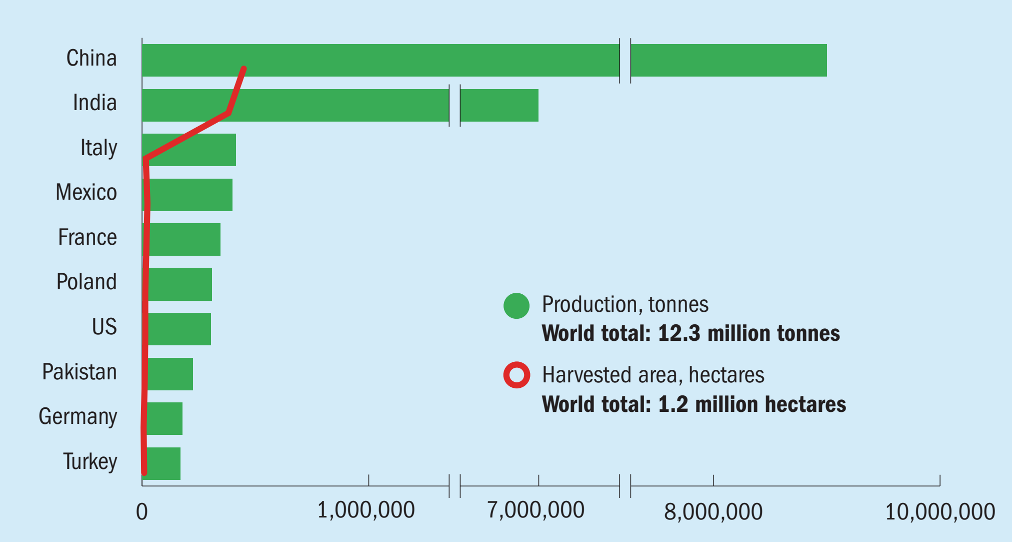
Fig 2: **Top ten cabbage producing countries, 2012**




*Source: FAOSTAT*

Fig 3: **Top ten cauliflower and broccoli producing countries, 2012**




*Source: FAOSTAT*

and seeds (mustard seed, rapeseed). Cabbages, pak choi, Brussels sprouts, kale and kohlrabi are the most commonly grown types with around 70 million tonnes produced annually from cultivation on 2.4 million hectares of land (Figures 1 and 2).

China is the world's biggest cabbage producer with almost a half share (32.8 million t/a) of world production. Indian production at 8.5 million t/a is also substantial. Russia, Japan, Korea, Ukraine, Indonesia and Poland are also major cabbage growing nations, each producing in excess of a million tonnes annually (Figure 2).

Around 21 million tonnes of cauliflower and broccoli are harvested from 1.2 million hectares globally (Figure 3). China and India are the world's two biggest growers, with harvests of 9.5 million t/a and 7.0 million t/a respectively, and are jointly responsible over three-quarters of global production. Italy, Mexico, France, Poland and the US are also sizable growers, each producing 0.3-0.4 million tonnes of cauliflower and broccoli annually (Figure 3).

## Growing conditions

Cabbages, cauliflower, broccoli and Brussels sprouts are all cool season crops well-adapted to the temperate oceanic climate common to parts of Europe, North America, South America, Australia and New Zealand. Cabbages are moderately tolerant to frost and will grow above 7°C but prefer a temperature range of 15-18°C. They need a constant supply of water and prefer aerated soils. Irrigation is generally necessary for their cultivation on light soils

Table 1: **Brassica: plant yields and nutrient removal**

| | Marketable yield (t/ha) | Harvest residue (t/ha) | Total fresh matter (t/ha) | Nutrient removal per tonne of fresh matter (kg/t) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | N | P | K | Ca | Mg |
| Broccoli | 20 | 70 | 90 | 3.7 | 0.46 | 4.0 | 2.22 | 0.28 |
| Brussels sprouts | 25 | 65 | 90 | 4.7 | 0.67 | 5.1 | - | 0.25 |
| Cauliflower | 40 | 60 | 100 | 3.2 | 0.48 | 3.3 | 1.52 | 0.14 |
| Chinese cabbage | 70 | 50 | 120 | 1.6 | 0.36 | 2.7 | 1.13 | 0.10 |
| Kale | 20 | 25 | 45 | 4.6 | 0.69 | 5.1 | - | 0.25 |
| Kohlrabi | 45 | 15 | 60 | 3.0 | 0.45 | 3.5 | - | 0.18 |
| Red cabbage | 50 | 40 | 90 | 2.6 | 0.37 | 3.2 | - | 0.19 |
| Savoy cabbage | 40 | 40 | 80 | 3.8 | 0.50 | 3.6 | - | 0.22 |
| White cabbage | 80 | 40 | 120 | 2.3 | 0.33 | 2.7 | 2.43 | 0.18 |

*Source: Yara*

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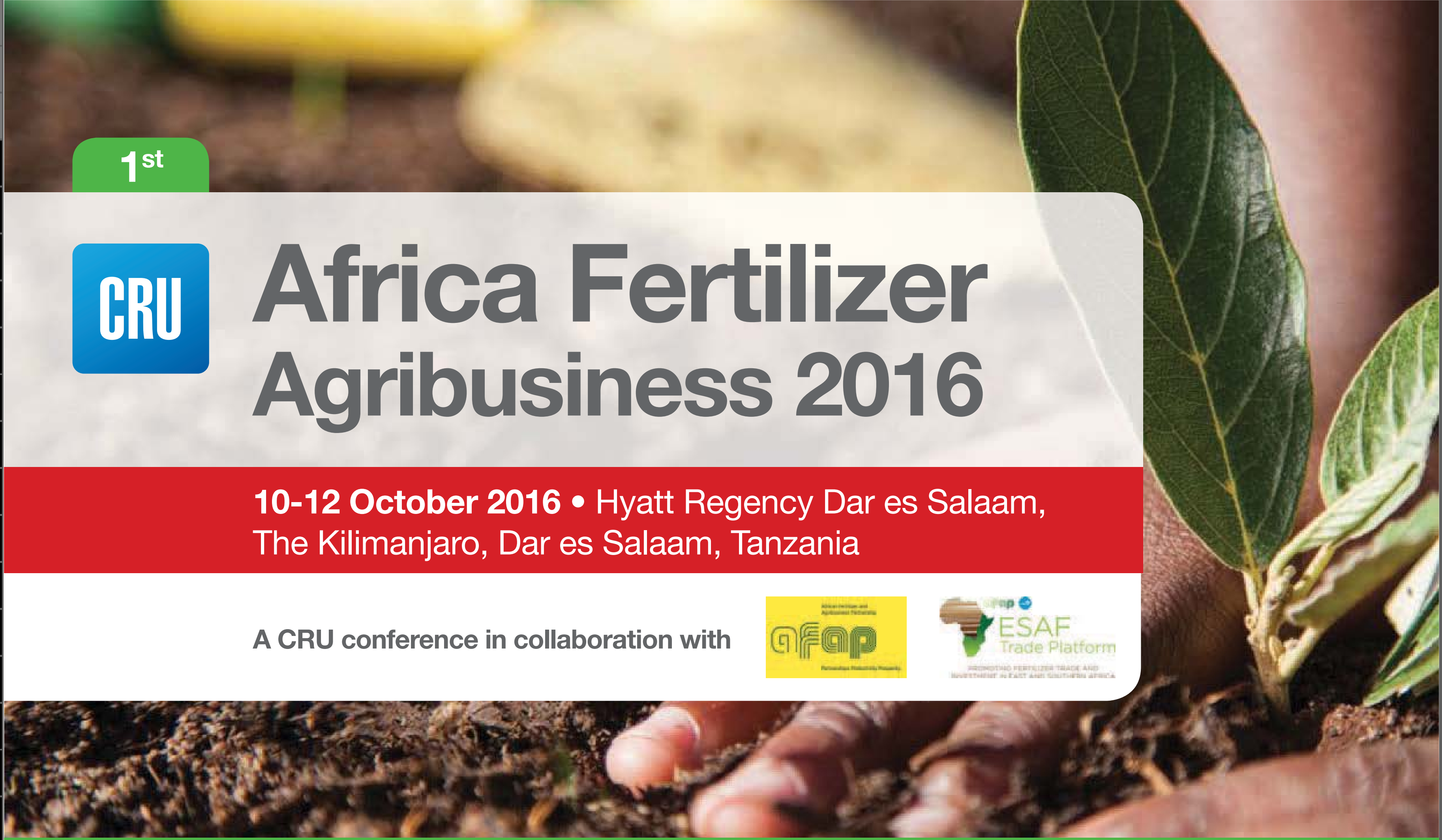
Table 2: **Role of nutrients in brassica (cauliflower) and signs of deficiency**

| Nutrient | Role | Symptoms of deficiency | Factors contributing to deficiency |
|---|---|---|---|
| Nitrogen | • High and early yields<br>• Good leaf size<br>• Market quality | • Yellowing of the older leaves<br>• Red discoloration at older leaf margins | • Low or high pH soils<br>• Sandy or light soils<br>• Low organic matter<br>• Drought conditions<br>• High rainfall or heavy irrigation<br>• High levels of un-decomposed manure or straw |
| Phosphorus | • Early growth and root development Promotes vigour in shorter season crops<br>• Improves marketable yield | • Older leaves become pale blue-green with purple discoloration<br>• Underside of leaves turns red | • Acid or very alkaline (calcareous) soils<br>• Low organic matter<br>• Cold or wet conditions<br>• Crops with a poorly developed root system<br>• Soils with low P reserves or high P capacity<br>• Iron-rich soils |
| Potassium | • Resistance to cold and drought<br>• Better yields and head weight<br>• A consistent, early marketable crop | • Leaf margins initially turn yellow to light brown and then dark brown later<br>• Leaf margins become weathered and curl as deficiency worsens | • Acid soils (low pH)<br>• Sandy or light soils<br>• Drought conditions<br>• High rainfall or heavy irrigation.<br>• Heavy clay soils<br>• Soils with low K reserves<br>• Mg-rich soils |
| Calcium | • Good root development<br>• Key role in crop quality<br>• Tolerance to stress<br>• Improved shelf life | • Necrotic leaf margins<br>• Young leaves display 'claw-like' deformations<br>• The curd dies off | • Acid soils<br>• Sandy or light soils<br>• Acid peat soils<br>• Na- and Al-rich soils<br>• Drought conditions |
| Magnesium | • Photosynthesis<br>• Growth and yield<br>• Storage life | • Older leaves show chlorosis between veins<br>• Necrotic spots between veins when severely deficient<br>• Old leaves drop prematurely | • Sandy soils<br>• Acid soils<br>• K-rich soils<br>• High K-applications on soils<br>• Cold wet periods |
| Sulphur | • Head development<br>• Stress tolerance<br>• Major role in crop quality<br>• Storage life | • Chlorosis in young leaves then older leaves as deficiency increases<br>• Leaves are stiff, curled inwards and typically show red discoloration<br>• Seedlings die when severely deficient | • Acid soils<br>• Light, sandy soils<br>• Low organic matter<br>• Poorly-aerated, waterlogged soils<br>• Low industrial sulphur emissions |
| **Micronutrients** | | | |
| Boron | • Improves crop strength<br>• Reduces effects of tip burn, hollow heart and club root<br>• Better crop quality and yield | • Small, stiff young leaves with red or brown margins<br>• Older leaves curl and may show red discoloration or chlorosis<br>• Curds delayed or light brown in colour<br>• Taste is bitter<br>• High yield losses | • Sandy or alkaline or low organic matter soils<br>• High N or Ca levels<br>• Cold, wet weather or drought |
| Manganese | • Boosts growth<br>• Good crop quality, high sugar and vitamin C | • Leaves smaller than normal<br>• Young leaves have green veins and eventually turn yellow | • Sandy or organic or fluffy soils<br>• High pH<br>• Cold, wet weather |
| Iron | • Early leaf development and crop productivity | • Younger leaf lamina become chlorotic but veins remain green<br>• Growth of roots and overhead plant parts stunted | • High pH<br>• High soil Cu, Cd, Ni or P content<br>• Water logging |
| Copper | • Needed for blue pigment (plastocyanin) in broccoli florets | • Chlorosis on mature leaves Possible link to heart necrosis | • Organic or chalky or sandy soils<br>• Reclaimed heathland<br>• High N applications |
| Molybdenum | • Better yields, particularly with broccoli and cauliflower<br>• Inner quality (sugar and vitamin C content)<br>• Shelf life | • Symptoms show in younger leaves first<br>• Distorted small leaves with chlorotic margins<br>• 'Whiptail' | • Acid soils<br>• Low soil organic matter |

*Source: Haifa/Yara*



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in warmer climates. Seedlings are usually greenhouse grown and transplanted later as plugs into the field. Cabbage leaves are prone to tip burn at high temperature, and plants may bolt and cabbage heads split above 27°C.

Cauliflowers are more temperature-sensitive than cabbages and are grown best at between 18-20°C. Winter cauliflower tolerate short periods of frost down to -10°C but only start to develop a head (curd) when temperatures reach 4°C. Leaf growth in cauliflower is important as it needs to be sufficient to cover and protect the head and ensure a good blanched white colour is obtained.

Broccoli is a hardy brassica able to flourish over a wide temperature range (4-35°C) although cultivation at 16-18°C is ideal. The best quality sprouts are obtained in cool, sunny, autumn or winter conditions. Sprouts can withstand heavy frost and harvesting in winter is favoured as it produces a crop with a tighter 'button' and a milder flavour. Growing under irrigated conditions is common.

Leafy brassica (collard greens, kale, spring greens) thrive under cool, moist conditions but are commonly grown at higher temperatures to allow fast-cropping. Such brassica can be harvested on a 4-5 week growing cycle yielding as many as 7-9 crops annually by regularly cutting low growth.

Table 3: **Average NPK requirement of brassica**

| Brassica type | NPK requirement (kg/ha) | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| Broccoli | 140-300 | 60-140 | 75-240 |
| Brussels sprouts | 160-250 | 60-140 | 125-370 |
| Cabbage | 120-350 | 50-140 | 60-300 |
| Cauliflower | 140-300 | 50-140 | 110-300 |
| Chinese cabbage | 110-250 | 60-115 | 120-230 |
| Kohlrabi | 120-200 | 60-80 | 180-210 |
| Radish | 25-100 | 20-60 | 80-180 |
| Swede | 50-140 | 50-105 | 150-180 |
| Turnip | 50-110 | 50-60 | 150 |

*Source: Tessenderlo*

## Nutrient removal

Brassica are grown as food crops for their roots, stems, flowers, buds or seeds. The marketable yield – the proportion harvested relative to the crop residue – is a particularly important control on nutrient removal. When broccoli and Brussels sprouts are harvested, for example, only 20-30% of the total fresh weight of the plant is recovered as edible produce (Table 1). Whereas for cabbages and kohlrabi between a half and three-quarters of the plant is removed at harvest.

The role of nutrients in brassica development, their influence on the quality and yield of produce, together with the main signs of nutrient deficiency are summarised in Table 2. Optimising both growth and yield in brassica crops requires the availability of nitrogen in large quantities. Good nitrogen supplies are particularly important for wrap or guard leaves. Applying the optimum amount of nitrogen also ensures good leaf/curd ratios and the production of high-quality, compact curds. Although it varies with brassica type, around 1.6-4.7 kg of nitrogen is removed from the field per tonne of crop (Table 1). Nitrogen demand is especially high during periods of intensive leaf production.

Brassica also consume potassium in relatively large amounts and removal often exceeds that of nitrogen (Table 1). Potassium boosts brassica head weight and yield, reduces crop variability and maintains head and curd compactness. Uptake varies between 2.7 kg/t and 5.1 kg/t and is greatest for those brassica with a high marketable yield such as cabbages. Phosphorus is required by brassica throughout the growing season, although its main role is ensuring good root growth and helping plants become established during early development. Brassica typically remove P at between 0.33-0.69 kg/t.

Calcium is another nutrient consumed in relatively large quantities. Although uptake is largely for leaf growth, the relatively small amounts of calcium present in harvested heads, buttons or leaves play an important role in crop quality and storage. Calcium uptake from the field is around 2.2-2.3 kg/t for broccoli and cabbage and generally peaks at the start of head formation. The amount of magnesium required by brassica, in contrast, is relatively low at between 0.10-0.28 kg/t.

## Fertilizer recommendations

Brassica crops require substantial amounts of nutrients, with cabbage, cauliflower and broccoli having the highest NPK requirement and root vegetables such as radish, swede and turnip the lowest (Table 3). Exact requirements depend on soil type, soil nutrient reserves and expected crop yield. The application of nitrogen is usually based on crop recommendations whereas the demand for other nutrients, such as P and K, is generally calculated on the basis of soil analysis[1]. Leaf tissue analyses are also used to determine nutrient imbalances in brassica – and are effective at confirming both the visible signs of deficiency and

Table 4: **Nutrient sufficiency ranges for cabbage and cauliflower based on leaf analysis***

| Major nutrients | N | S | P | K | Mg | Ca | Na |
|---|---|---|---|---|---|---|---|
| (%) | 2.50-4.50 | 0.30-1.50 | 0.40-1.00 | 3.50-1.50 | 0.30-0.50 | 1.50-2.50 | 0.01-0.10 |
| **Micronutrients** | **B** | **Zn** | **Mn** | **Fe** | **Cu** | **Al** | **Mo** |
| (ppm) | 25-50 | 25-45 | 50-100 | 50-200 | 5-10 | 20-200 | - |

**Leaf from centre of whorl before head starts to form*

*Source: Haifa*

revealing any hidden deficiencies (Table 4).

Nitrogen is fundamental to achieving high yields and can be applied to brassica as a split dressing, with half applied at planting and half applied some weeks later. Phosphorus and potassium, in contrast, can be added to soils in the weeks prior to planting. Thorough incorporation of fertilizers into the soil is essential. Excess N and K, in particular, hamper germination and damage the root systems of seedlings, particularly on dry, sandy soils[1].

Top dressing with nitrogen after transplanting reduces the risk of damage to cabbage seedlings. Top dressing is also an option for cabbages grown in shallow or sandy soils in regions where rainfall is much greater than transpiration[1]. Full-size spring cabbages can use up to 400 kg/ha of nitrogen, although early harvests of smaller spring cabbages may need less than half this amount. Nitrogen can be applied to spring cabbages as a number of split dressings of 100-200 kg/ha, according to growth, weather conditions and the marketing period[1].

Nitrogen applications of 300-465 kg/ha are advised for broccoli grown in Germany. The initial application on transplanting can be reduced to 80-118 kg/ha if supplemented by top dressing subsequently. A similar nitrogen application rate of 300 kg/ha (adjusted for soil nitrogen content) is also recommended for brassica in the Netherlands, split between 50-250 kg/ha broadcast at planting and a further 50 kg/ha six weeks later. The recommendation is reduced to 225 kg/ha for sandy clay soils. UK nitrogen recommendations for cauliflower are between 100-300 kg/ha and split in similar manner to those in the Netherlands[1]. Fertilizer recommendations for brassica grown in Ireland are shown in Table 5.

Nitrogen applications of 130-170 kg/ha are advised for successful cauliflower cultivation in South Africa. Around 65-85 kg/ha of nitrogen is firstly broadcast before planting and worked into the soil. The remainder is applied as two side dressings, the first 7-10 days after planting and the second 4-6 weeks later.

The University of California's small farm programme makes the following recommendations for brassica:

- A nitrogen application of 101-224 kg/ha (90-200 lbs/acre) is recommended for cabbage, with between one and three side dressings before heads start to form
- Around 224 kg/ha (200 lbs/acre) of nitrogen is advised for cauliflower with 45 kg (40 lbs) of this applied at planting and the rest divided between one and three side dressings before heads start to form
- An application of 224 kg/ha (200 lbs/acre) nitrogen is suggested for broccoli, a quarter broadcast during preparation for planting and the remainder applied as two or three side dressings
- Phosphate is applied to broccoli, cauliflower and cabbage by broadcasting before planting, as determined by soil testing
- About 224-280 kg/ha (200-250 lbs/acre) $P_2O_5$ is applied when soil P is below 15 ppm, and 168-224 kg/ha (150-200 lbs/acre) applied when soil P is between 15-30 ppm
- Lower $P_2O_5$ applications of up to 90 kg/ha (80 lbs/acre) may be necessary for soil P levels above 30 ppm
- For potassium, between 112 kg/ha (100 lbs/acre) and 224 kg/ha (200 lbs/acre) $K_2O$ is broadcast and ploughed down before planting, depending on soil testing

Table 5: **Example fertilizer recommendations for brassica in the EU**

| Brassica | N, base dressing (kg/ha) | N, top dressing (kg/ha | P (kg/ha) | K (kg/ha) |
|---|---|---|---|---|
| Broccoli | 70-100 | Up to 140 | 20-60 | 125-250 |
| Spring cabbage | 0-50 | 150-250 in two applications | 20-60 | 125-250 |
| Other cabbage | 100-150 | Up to 100 | 20-60 | 125-250 |
| Summer and Autumn Cauliflower | 0-120 | Up to 120 | 20-60 | 125-250 |
| Brussels Sprouts | 100-120 | Up to 180 | 20-60 | 125-250 |
| Swedes, drilled | 0-70 | Not usually required | 35-70 | 125-250 |
| Swedes, transplanted | 0-80 | Not usually required | 35-70 | 125-250 |

*Source: Irish Agriculture and Food Development Authority*

Table 6: **Fertigation recommendations for broccoli, cabbage and cauliflower**

| | Fertilizer application rates | | |
|---|---|---|---|
| **Days after planting** | **Urea (kg/ha/day)** | **$KNO_3$* (kg/ha/day)** | **MAP (kg/ha/day)** |
| **Broccoli** | | | |
| 20-40 | 1.7 | 0 | 2 |
| 40-60 | 3.7 | 0 | 2 |
| 60-80 | 4.2 | 2.7 | 1.2 |
| 80-100 | 4.0 | 14.0 | 0.8 |
| 100-harvest | 2.7 | 5.3 | 0 |
| | **$KNO_3$* (kg/ha/day)** | **AN (kg/ha/day)** | **Phosphoric acid (litre/ha/day)** |
| **Cabbage & cauliflower** | | | |
| 0-45 | 2.3 | 2.1 | 1.2 |
| 46-70 | 8.1 | 7.0 | 1.5 |
| 71-harvest | 1.8 | 1.5 | 0.3 |

**Haifa Multi-K* *Source: Haifa*

> **Timely fertilizer applications have a positive effect on marketable yield, produce, price and profitability.**

The University of Florida's Institute of Food and Agricultural Sciences recommends nitrogen applications of 196 kg/ha (175 lbs/acre) for broccoli, cauliflower, Brussels sprouts, cabbage, Chinese cabbage and collards. Phosphate ($P_2O_5$) applications of between 112-196 kg/ha (100-175 lbs/acre) are advised for soil P levels of up to 30 ppm. Potassium ($K_2O$) applications of 112-168 kg/ha (100-150 lbs/acre) are suggested for soil K levels of up to 60 ppm. Split fertilizer dressings are recommended to reduce leaching losses and lessen the risk of fertilizer burn. The broadcasting of all P and 25-30% of N and K is advised on planting. The remaining N and K is best applied as a side dressing during the early part of the growing season.

Typical fertigation advice for broccoli, cabbage and cauliflower are shown in Table 6.

## Micronutrients

Cauliflower is sensitive to boron deficiency (Table 2), as are broccoli and cabbage, albeit to a lesser extent. Deficiency, which in cauliflower results in brown or water-soaked hollow areas in the centre of the stem, can be prevented by mixing sodium borate with soil before planting. Boron is usually applied at 1.1-1.2 kg/ha (1-2 lbs/acre). Applying boron at 0.33 kg/ha (0.3 lbs/acre) via foliar sprays of sodium borate can also be used to address cole crop deficiency. Cauliflower and broccoli are also susceptible to molybdenum deficiency, known as 'whiptail' (Table 2). This can be prevented by early foliar spraying with sodium molybdate.

## Crop nutrition and fertilizer product advice

The timely application of fertilizers in the correct quantities helps ensure that harvested brassica have the attractive external appearance desired by famers and their customers, particularly commercially-valuable and sought-after qualities such as compactness, vegetable size, weight, and colour. Regulating dry matter content and moisture loss also helps improve storage quality and increases brassica shelf life.

The human health benefits of brassica vegetables are also important and depend on calcium, folic acid, fibre and vitamin A, C and K content. Glucosinolate levels – the sulphur compounds responsible for the characteristic pungent aroma and bitter/spicy taste of brassica – are also critical. Sugar content is also a key determinant of taste and another indicator of quality. All of these marketable characteristics are partly influenced by crop nutrition as well as by cultivar selection.

Yara International offers a highly detailed online crop nutrition guide for brassica[2]. Good nutrition is an essential pre-requisite for the harvesting of high-quality brassica crops, in its view. "By getting crop nutrition right, the grower brings forward harvest and consistently improves head, curd and leaf quality," comments Yara. "This can have a significant, positive effect on marketable yield, produce grade, price and profitability."

Yara offers the following products as part of its brassica nutrition programme:

- *YaraMila COMPLEX*: a prilled NPK (12-11-18 + 20% $SO_3$) fertilizer which also contains magnesium, sulphur and micronutrients
- *YaraLiva NITRABOR*: a granular calcium nitrate fertilizer with added boron (15.5% N + 18% Ca + 0.3% B) suitable for field application to brassica prone to calcium and boron deficiency
- *YaraVita BRASSITREL PRO*: a micronutrient liquid fertilizer containing manganese, magnesium, boron and molybdenum for foliar application to oilseed rape and brassica crops
- *CHAFER STARTER SOLUTION PLUS*: a liquid fertilizer for rapid crop establishment that improves phosphate availability and phosphate utilisation

Haifa Group's online 'knowledge centre' also offers detailed fertilizer recommendations for broccoli, cabbage, cauliflower and winter oilseed rape[3]. Its *Multi-K* potassium nitrate fertilizer is particularly well-suited to brassica fertigation. Haifa also offers *Turbo-K*, a granular complex NPK fertilizer (18-9-18+ Mg +S+ Fe, Zn), for field applications. Average NPK application rates for open-field cauliflower and cabbages of 120-160 kg/ha for N, 50-100 kg/ha for $P_2O_5$ and 180-200kg/ha for $K_2O$ are suggested by Haifa.

Agronomic trial results for cabbages and cauliflower published by Tessenderlo Group show how SOP (potassium sulphate, $K_2SO_4$) can benefit brassica nutrition, and how potassium and sulphur can improve quality and yield[4]. Tessenderlo markets a range of direct application, fertigation and foliar products suitable for brassica vegetables, including the SOP fertilizers *GranuPotasse*, *SoluPotasse* and *K-Leaf*.

*Polysulphate*, a new multi-nutrient polyhalite fertilizer introduced last year by ICL Fertilizers, has been successfully trialled on cabbages and cauliflowers (*Fertilizer International*, 468 p36). *Polysulphate* also appears to have advantages over gypsum as a basal fertilizer for oilseeds such as mustard and sesame[5].

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# Nitrogen and energy costs

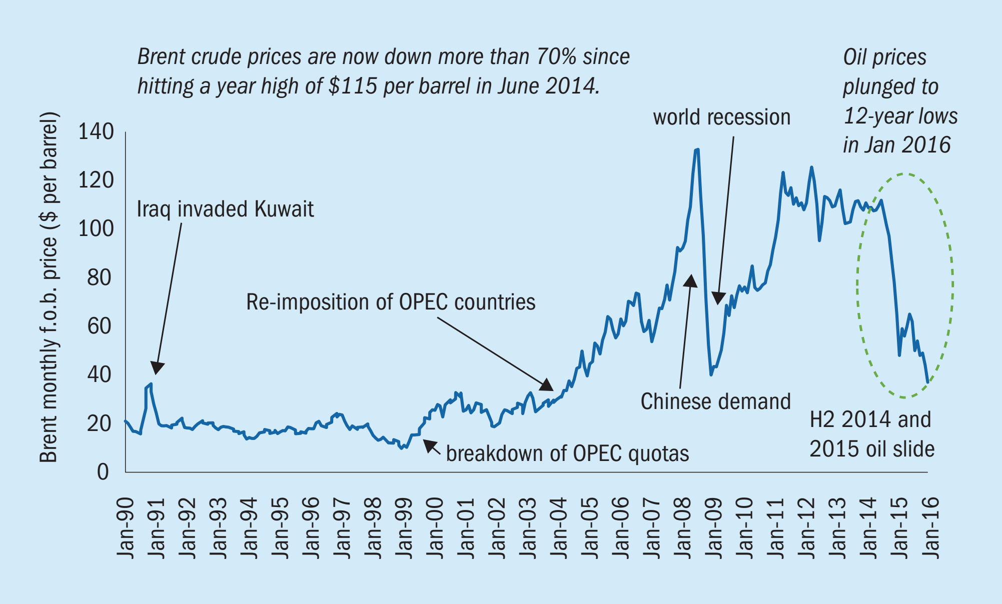
Lower energy prices have helped to cut nitrogen fertilizer production costs but also affected margins and the global floor price. Nexant's **Dr Dimitrios Dimitriou** and **Thomas Heinrich** explain the complex interplay between global oil pricing, nitrogen industry costs and other market drivers.

Fertilizer consumption is primarily driven by population growth. That makes large-scale fertilizer production essential if food availability is to be maintained and ensure food output continues to match global population growth. Secondary influences on fertilizer consumption include rising GDP, government tariff and subsidy policies, biofuels demand and environmental aspects of fertilizer use.

Different regions are expected to show wide variations in population growth in future. Sharp population rises are forecast in the Asia-Pacific region and Africa, whilst population numbers in Western Europe and North America's are expected to remain almost constant over the long term. Consequently, the demand outlook for food, and hence fertilizers, is expected to be significantly higher in Asia-Pacific and Africa – albeit from a low base – than in many western countries.

Historically, ammonia plants have been built in close proximity to the main centres of consumption, such as North America, Europe and Asia. In most nitrogen-producing regions, conventional ammonia technology is based on natural gas feedstock. Because of this, in recent times, ammonia and downstream fertilizer plants have largely been built in regions with abundant and cheap natural gas reserves, particularly the Middle East. (China has been an exception to this as its ammonia production is largely coal-based.) The main economic priority driving hydrocarbon development has been to add value and monetise oil and gas reserves.

Fig 1: **Historic average monthly brent crude oil price**




Inevitably, changes in natural gas availability over time have led to a growing mismatch between the locations where nitrogen fertilizers are produced and the main centres of consumption, the latter being linked to population size and arable land area. This mismatch between production and consumption also determines the prevailing trade flows for nitrogen fertilizers.

## Declining prices and oversupply

There have been profound price and supply changes in the fertilizer market over the past decade. After years of high commodity prices, a slowdown in the global economy has hit the consumption of basic commodities, including fertilizers. The state of oversupply currently facing the nitrogen market has resulted from a sustained period of investment in nitrogen fertilizer plants in feedstock-rich regions. Investments began at a time when both oil and fertilizer prices were at record highs, making such investments highly attractive. Sustained investment levels have, however, led to excess nitrogen fertilizer capacity around the world with supply outstripping demand growth. The current state of oversupply, when combined with the recent slide in crude oil prices to a 12-year low, has resulted in some nitrogen fertilizer prices falling to their lowest levels since 2006.

Furthermore, the demand situation has been further exacerbated by the weakening of many global currencies against the US dollar. This has led to lower farm purchasing power and falls in government agricultural funding in a number of key emerging economies. Currency changes have had benefits on the production side, though, with the strong US dollar helping fertilizer producers offset some of the profit falls caused by lower commodity prices.

## Opportunities and challenges

Falls in nitrogen prices have been most strongly felt by those producers with supply agreements which fix the price they pay for natural gas. This has closed the profitability gap between the lowest and highest cost nitrogen producers, resulting in a flatter overall cost curve for the industry.

Although there has been a slow-down in industry investment, due to oversupply and low product prices, a number of new nitrogen fertilizer projects are still under way and are

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76

expected to come onstream over the next few years. The financing of most of these projects was already committed before the downturn in the market and the fall in prices started. These projects are mainly located in:

- Asia where the main fertilizer demand growth is located
- The US where the shale gas boom has led to very low natural gas prices and feedstock advantages compared to other regions
- The CIS where a glut of gas has encouraged governments to think of alternative monetisation options
- China where old and small anthracite-based plants are gradually being replaced by larger scale, more efficient and cheaper sub-bituminous coal plants
- Sub-Saharan Africa where a number of countries with large gas reserves are showing interest in developing fertilizer projects, e.g. Mozambique, Angola, Nigeria and Gabon

US capacity developments, in particular, are expected to have a big impact on international trade flows. New US nitrogen fertilizer plants are set to displace import volumes and help reduce the country's current urea supply deficit.

Another country that has been attracting headlines lately is Iran. The country has the largest proven gas reserves globally and is geographically well-placed to serve the growing Asian fertilizer market. Iran has a number of projects under-development currently, and the recent lifting of economic sanctions has revived international interest in investing in Iran's fertilizer and petrochemical sector.

Oversupply is expected to put more strain on the international market, particularly at a time when China and India, two of the largest fertilizer consumers in the world, are increasingly worried about the environmental impacts of fertilizer over-application. Nexant predicts that global operating rates for urea will drop further over the next few years as continued capacity investment adds to oversupply.

## Pricing, costs and market drivers

In general, regional nitrogen fertilizer prices tend to be closely linked and follow one another. This is partly a reflection of the ability to ship ammonia and urea around the world. The presence of large-scale, export-orientated production facilities also helps ensure that regional prices do not diverge for any sustained period of time.

Global ammonia and urea prices are essentially driven by two key factors, the cost of raw materials and the market supply and demand balance. Product pricing is largely set by these two drivers and fundamentally reflects cost plus margin.

Global nitrogen fertilizer prices are also strongly influenced by the costs of producers at the top end of the cost curve – the so-called 'global laggard' producers.

It is production costs in the 'global laggard' region that typically sets the floor for global ammonia and urea prices. Prices are typically unable to fall below this floor for long periods of time, as plants in this region would shut down, thereby limiting supply and increasing prices.

The highest cost region for ammonia and urea production has varied over the past decade, switching between the US, Europe and more recently China. Highest cost regions will exert a strong influence on global nitrogen fertilizer prices due to their 'global laggard' status, market size and, in the case of US and Europe, high levels of ammonia and urea imports.

In recent years, however, US natural gas prices have decoupled from the oil price due to the on-going shale gas boom, and consequently no longer influence global nitrogen prices. Instead, in the current low oil price environment, Western Europe and China have become the highest cost producers of nitrogen fertilizers. These two regions are positioned at the very top end of the global cash cost curve and, for the foreseeable future, will be the main price-influencing regions setting the floor for ammonia and urea prices.

The decline in global energy prices which began in mid-2014 has triggered a concomitant decline in natural gas – and coal prices to a more limited extent – causing the nitrogen floor price to decline and pressuring prices. This has been especially true in Western Europe where gas prices are more strongly linked to oil prices. China's emergence as world's largest urea exporter, combined with a significant drop in coal prices, has also lead to significant pressure on prices.

As mentioned previously, nitrogen fertilizer pricing is not only determined by the cost of production but also by global and regional supply/demand balances. Typically, when demand exceeds supply, producers can increase prices and potentially achieve higher margins. Prices face downward pressures, in contrast, at times of low demand relative to supply, as is the case currently.

Large-scale investment in greenfield and brownfield nitrogen fertilizer projects in recent years has been partly fuelled by strong investor interest in low-cost feedstock regions such as the Middle East, Africa, parts of Asia and South America, and efforts to monetise their natural gas reserves. The output of many of these nitrogen fertilizer plants is destined solely for export, dramatically increasing the volumes available for international trade.

The expansion of the shale oil and gas industry – a major factor behind the current low oil price environment – has also spurred the development of nitrogen fertilizer projects in the US, although some of these have been cancelled or postponed recently. China, the largest fertilizer producer and consumer in the world, has also dramatically ramped-up its domestic nitrogen fertilizer capacity, with yet more plants currently under-development.

As a result, net additions to nitrogen capacity globally have outpaced demand putting further downward pressure on nitrogen fertilizer prices. Nexant expects that approximately 50-55 million t/a of nitrogen fertilizer capacity will be commissioned between now and 2019.

Fig 2: **Indicative urea cost curve in a low oil price environment**

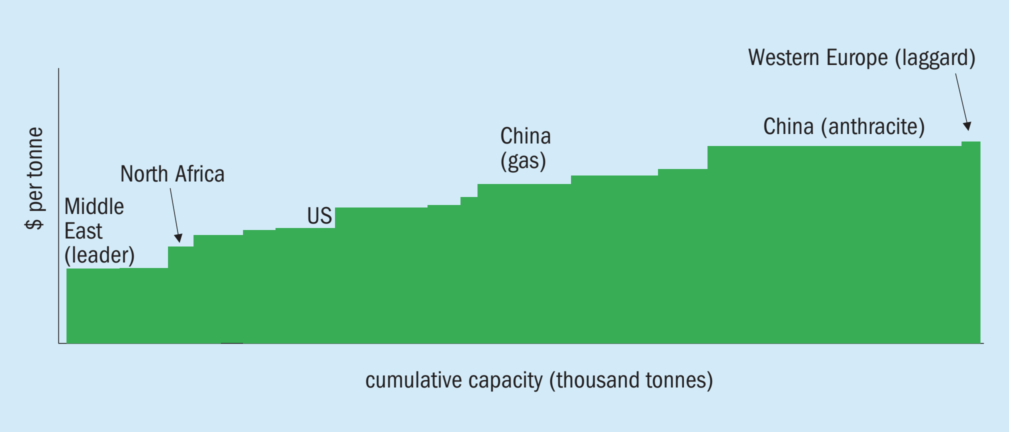


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Fig 3: **European natural gas to ammonia price linkage**

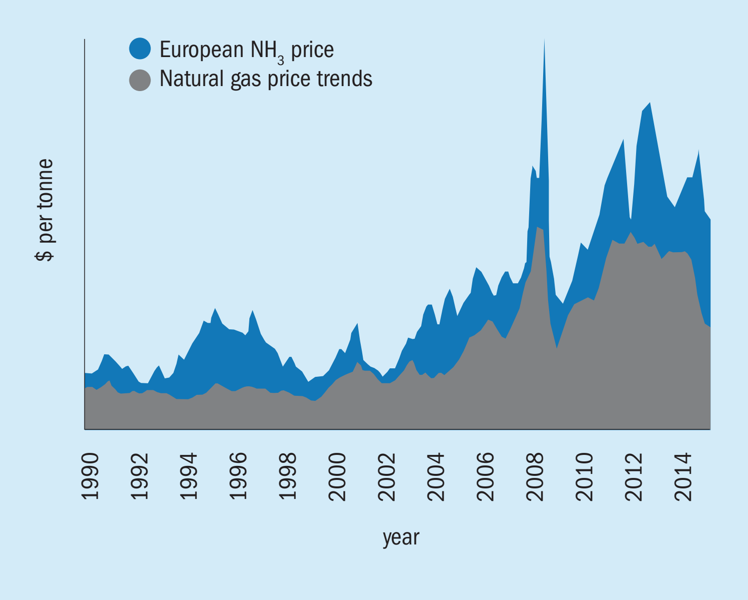
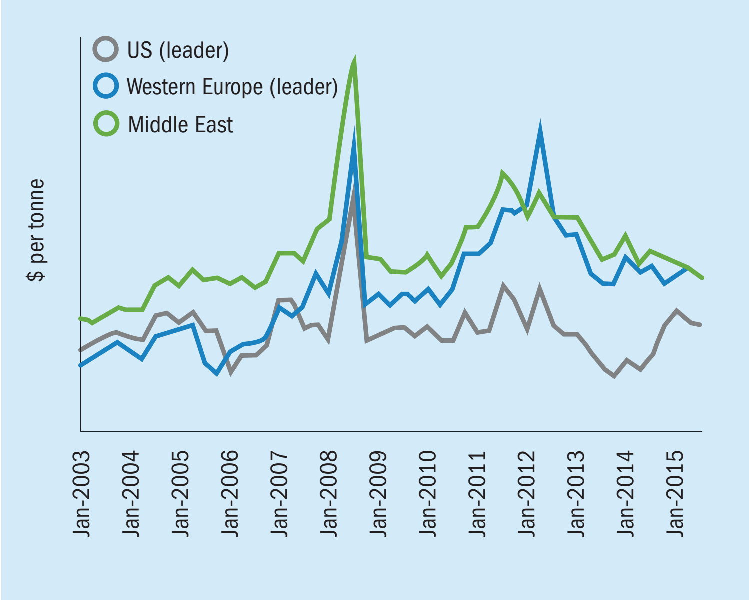



Fig 4: **Global urea cash cost margins**




As fertilizer prices are currently on the slide, the timing of investment in many of these projects appears to be unfortunate. Yet it is largely a function of the time delay between the period of peak prices and the outcome of industry investment. This means that new plants often come onstream at a time when supply is starting to overshoot demand. Investment decisions are usually made during times of high fertilizer prices, when demand exceeds supply, and high industry margins spur new investments, especially in low-cost feedstock regions.

A classic commodity cycle promotes investment during good times and under-investment in poor times. Since the realisation of greenfield projects can typically take 3-5 years or more, economic and investment cycles always tend to be out of sync. Only when demand eventually catches up with oversupply, as will inevitably happen at some stage, can nitrogen fertilizer prices and margins be expected to once again move upwards.

In the current oversupply situation and low oil price environment, most nitrogen producers have seen their feedstock costs and margins reduced. Traditional high-margin producers, those with fixed- or low-cost feedstocks, have been hit by lower prices, although they may still enjoy better margins than other producers.

Regulatory developments in China have also been an important but less noticeable factor behind the recent slump in urea prices. Because of the size of its urea industry, any changes to trade restrictions in China are likely to have a strong impact on global trade flows. Growing Chinese urea export volumes, for example, a consequence of lower export taxes, has put significant pressure on international fertilizer prices in recent years. Chinese import and export policy is therefore not just a domestic issue, as it affects the future of the whole of the global nitrogen fertilizer industry.

## Conclusions

The world currently finds itself in a low energy price environment. This has been caused in part by the increased availability of hydrocarbons combined with the relatively weak outlook for global economic growth. Low oil prices have helped cut the cost of ammonia production, particularly in 'global laggard' regions. Due to integrated production, the cost of downstream nitrogen fertilizer production has also fallen. This in turn has lowered the floor price of nitrogen fertilizers. At the same time, the availability of nitrogen fertilizers has risen sharply due to global capacity additions – itself a result of higher margins in previous years, investment in low-cost natural gas regions and the availability of shale gas in the US.

> **"The feedstock advantage that low-cost natural gas regions provide will continue to lead to new investments.**

The current low price/low margin environment is expected to continue, given the large additions to capacity expected in the near future. In many regions, lower raw material cost advantages are expected to be offset by a lower price environment. Those countries in which raw material prices are fixed have seen proportionally larger declines in their margins.

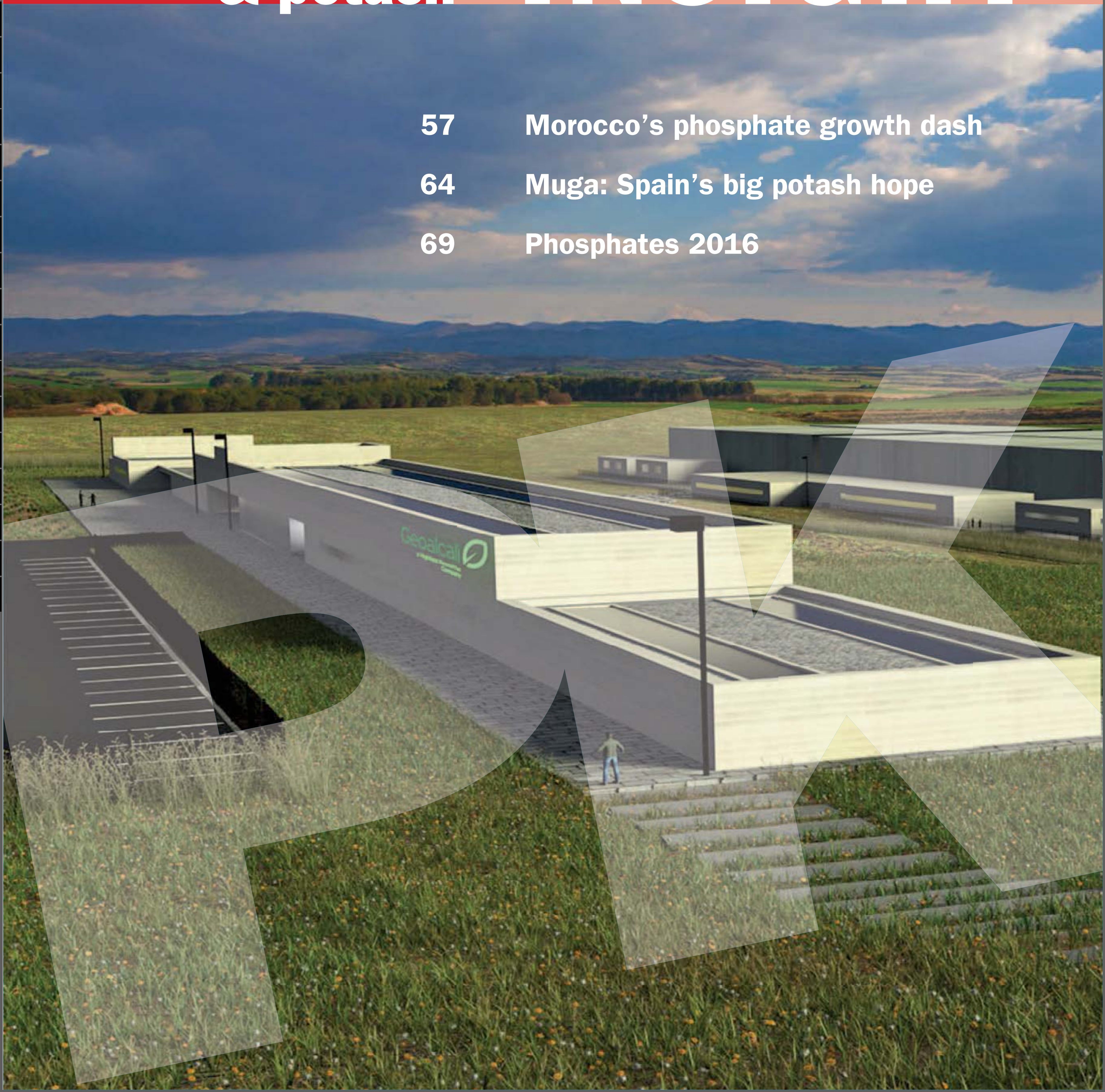
Increases in US nitrogen fertilizer capacity are expected to alter trade flows as North America becomes less dependent on urea imports in the future. China and India's fertilizer policies – the setting of export/import tariffs by the former and subsidy levels by the latter – will also strongly influence global fertilizer trade and ultimately prices. Additionally, Iran's re-emergence and Africa's production potential are expected to become focal points for the nitrogen fertilizer industry in years to come.

In the current low-margin environment, producers will be on the look-out for project investment opportunities elsewhere. Producers will undoubtedly focus on production growth, optimising their downstream value chain, operational efficiency and cost improvements. International consolidations and rationalisations during 2015 show that mergers and acquisition activity is also on the rise.

Nexant believes that, despite the current weak market conditions, opportunities in low-value feedstock regions still exist, particularly in the US, Africa, parts of the Middle East and the CIS. In the long run, the feedstock cost advantage that low-cost natural gas regions provide will continue to lead to new investments, albeit not at the levels witnessed in the recent past.

May-June 2016

# phosphates & potash INSIGHT



# Morocco's phosphate growth dash

OCP Group is investing on an unprecedented scale as it attempts to double phosphate mining output and triple fertilizer production capacity by 2025. This year marks the mid-point of what is the phosphate sector's most bold and ambitious expansion programme. We review OCP's recent landmark achievements and look at the company's future plans.

Morocco's OCP Group got off to a flying start in 2016. The state-owned company's new, one million t/a Jorf Lasfar phosphate fertilizer unit was officially opened by Morocco's King Mohammed VI in February. Named the 'Africa Fertilizer Complex', the large-scale plant provides a dedicated supply of phosphate and NPK fertilizers for the African market. The integrated unit also comprises a 1.4 million t/a sulphuric acid plant, a 450,000 t/a capacity phosphoric acid plant, a 62-megawatt solar power plant, as well as 200,000 tonnes of fertilizer storage capacity.

OCP has invested $545 million developing the unit, part of the Jorf Lasfar Phosphate Hub (JPH) that is currently under construction on Morocco's Atlantic coast in the northwest of the country. OCP is building three other identical phosphate fertilizer units as part of the same hub. The first stage of Jorf Lasfar's seawater desalination plant has also been completed. The plant will eventually produce 75 million cubic meters of water each year when all three stages are completed.

King Mohammed VI also visited Laâyoune in early February, laying a foundation

Table 1: **Summary of OCP's assets and production capacity**

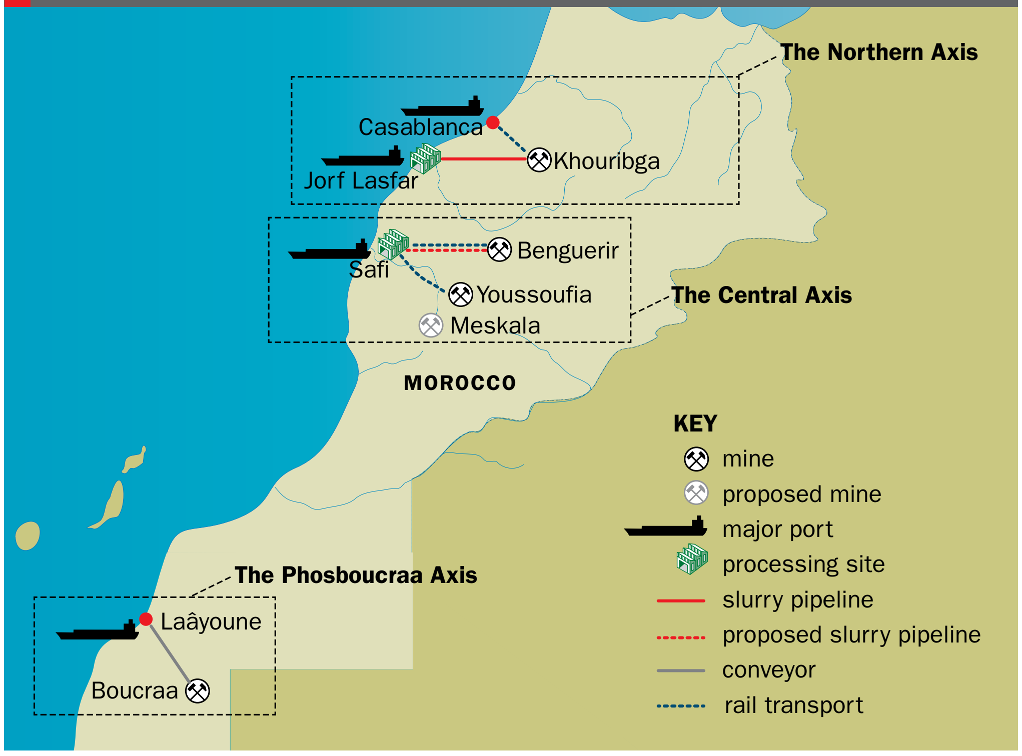
| Assets | Production capacity |
|---|---|
| **MINING ASSETS** | |
| **Northern Axis** | |
| Khouribga (1921) | |
| ● 3 phosphate mines with 53% of ore reserves | 26 million tonnes |
| ● Located 120 km from Casablanca, 200 km from Jorf Lasfar | |
| **Central Axis** | |
| Gantour (1931) | |
| ● 6 phosphate mines (Benguerir & Youssoufia) with 45% of ore reserves | 8 million tonnes |
| ● 90 km from Safi | |
| **Phosboucraa Axis** | |
| ● One phosphate mine with 2% of ore reserves | 2.6 million tonnes |
| ● 100 km from Laayoune | |
| **Total OCP mining capacity** | **36.6 million tonnes** |
| **CHEMICAL ASSETS** | |
| **Northern Axis – Jorf Lasfar** | |
| Maroc Phosphore III & IV (1986) | |
| ● Phosphoric acid | 1.9 million tonnes $P_2O_5$ |
| ● DAP/MAP | 5.6 million tonnes |
| Euro Maroc Phosphore (EMAPHOS) Joint Venture (1998) | |
| ● Purified acid | 150,000 tonnes $P_2O_5$ |
| Indo Maroc Phosphore (IMACID) Joint Venture (1999) | |
| ● Phosphoric acid | 430,000 tonnes $P_2O_5$ |
| Pakistan Maroc Phosphore (PMP) Joint Venture (2008) | |
| ● Phosphoric acid | 375,000 tonnes $P_2O_5$ |
| Jorf Fertilizer Co V (JFC V) (formerly Bunge Maroc Phosphore) (2008) | |
| ● Phosphoric acid | 375,000 tonnes $P_2O_5$ |
| ● DAP/MAP & TSP | 610,000 tonnes |
| Jorf Fertilizer Co I (JFC I) (2016) | |
| ● Phosphoric acid | 450,000 tonnes $P_2O_5$ |
| ● DAP | 1,000,000 tonnes |
| **Central Axis – Safi** | |
| Maroc Chimie (1965) | |
| ● Phosphoric acid | 430,000 tonnes $P_2O_5$ |
| ● TSP | 900,000 tonnes |
| ● MDCP | 160,000 tonnes |
| Maroc Phosphore I (1976) | |
| ● Phosphoric acid | 590,000 tonnes $P_2O_5$ |
| ● DCP | 140,000 tonnes |
| Maroc Phosphore II (1981) | |
| ● Phosphoric acid | 470,000 tonnes $P_2O_5$ |
| **Total fertilizer capacity** | **8.41 million tonnes** |
| **Total phosphoric acid capacity** | **5.17 million tonnes $P_2O_5$** |

*Source: OCP*

stone to mark the start of construction of a fertilizer complex being built by OCP subsidiary Phosboucraa. The $2 billion project will have the capacity to produce one million t/a of fertilizers and 500,000 t/a of phosphoric acid, once completed. The complex also includes a washing and flotation plant, a phosphate drying plant and a 500,000 tonne capacity storage area. Around $430 million has also been earmarked for the construction of a major new port facility on the coast.

This year has also seen OCP strengthen its commitment to African agriculture through the formation of a dedicated subsidiary company, OCP Africa. Announcing its formation, CEO Tarik Choho said in February: "We can't just wait passively for African fertilizer use to grow. We have to do something proactive to make it grow significantly – and that's what OCP is ready to do."

Fig 1: **Morocco's phosphate industry**




## Three main cash-generating units

OCPs main mining and chemical assets are summarised in Table 1. The company mines phosphate rock at three main sites: Khouribga in the north of Morocco, the more central Gantour region (Benguerir and Youssoufia) and Boucraa in Western Sahara (Figure 1). OCP also divides its business geographically. The company's three main cash-generating units, known as the Northern Axis (Khouribga–Jorf Lasfar), the Central Axis (Benguerir and Youssoufia–Safi) and the Phosboucraa Axis (Boucraa–Laâyoune), reflect the separate centres of mining and processing in Morocco and their associated downstream chemical assets. (Figure 1).

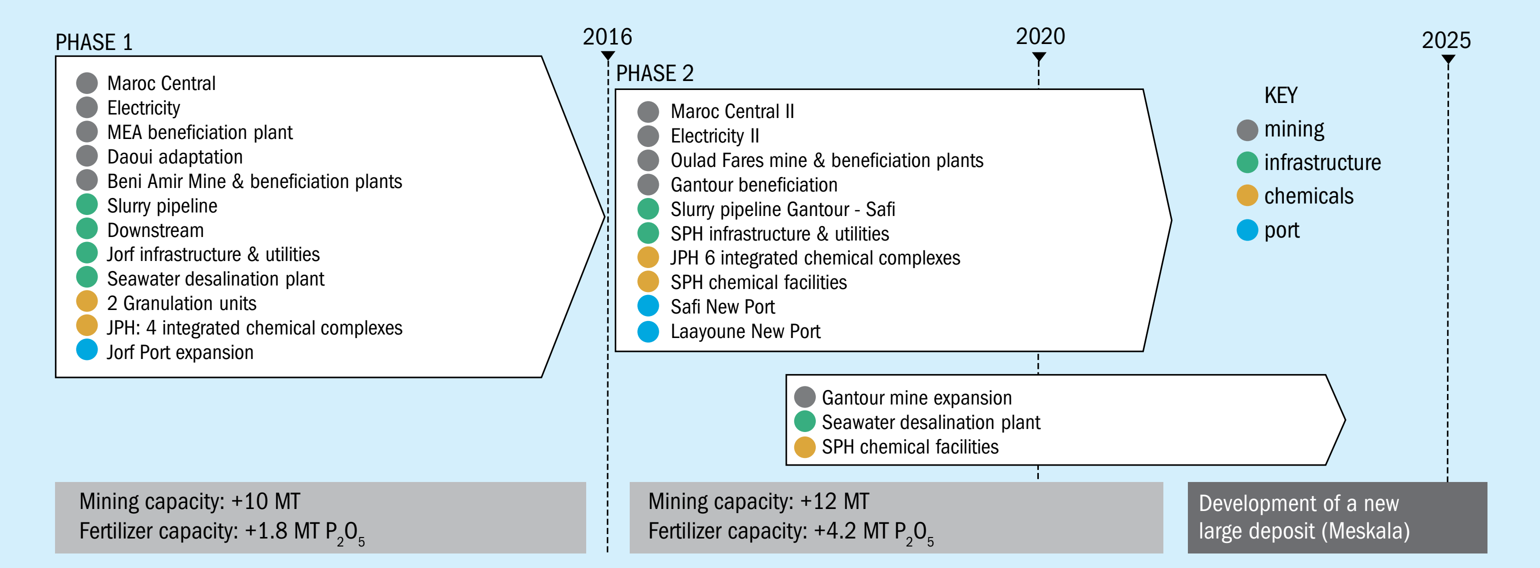
In the Northern Axis, phosphate ore from three mines at Khouribga is transported by slurry pipeline to the Jorf Lasfar complex where it is processed into phosphoric acid and DAP/MAP fertilizers. Finished products are then exported via OCP's Jorf Lasfar port. The complex is also the site of OCP's flagship Jorf Lasfar Phosphate Hub (JPH) project. In the Central Axis, phosphate ore from six mines at Youssoufia and Benguérir is transported by rail to Safi where, again, it is processed into phosphoric acid and TSP and DCP/MCP fertilizers. The finished products obtained are exported from OCP's Safi port. Finally, in the Phosboucraa Axis, phosphate rock from Boucraa is transported by conveyer for processing at Laâyoune for export by sea.

## Expansion at the mid-way point

OCP is midway through a $20.5 billion investment cycle that is aiming to double mining capacity and a triple fertilizer production between 2008 and 2025. The company is planning a 22 million tonnes expansion in mining capacity and 6 million tonne expansion in fertilizer capacity ($P_2O_5$ basis) over this period as part of a two-phase development programme.

Initially, OCP is adding 10 million tonnes of mining capacity and 1.8 million

Fig 2: **OCP's two-stage industrial development programme at March 2015**




*Source: CRU Phosphates 2015, March 2015*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tonnes of fertilizer capacity ($P_2O_5$ basis) during the first phase of this programme between 2008 and 2016. A second phase will then develop a further 12 million tonnes of mining capacity and add 4.2 million tonnes of fertilizer capacity ($P_2O_5$ basis) between 2016 and 2025, if all goes according to plan.

OCP's expansion plans are summarised in Figure 2 and Table 2. Mine capacity will be expanded at both Khouribga and Gantour. Additionally, there is a longer term plan to establish a new mine at Meskala to the south of Gantour within the next 10 years. OCP also plans to build five new rock beneficiation plants – three at Khouribga, one at Gantour, one at Meskala and another at Laayoune. Mining at Meskala, although not planned until after 2020, is highly significant as the deposit contains around 15% of known Moroccan reserves.

A cornerstone development is the construction of two slurry pipelines, the already operational 38 million t/a Khouribga-Jorf Lasfar pipeline and the planned 10 million t/a Gantour-Safi pipeline. The pipelines are replacing train freight as the means of transporting phosphate rock from mines and washing plants in Morocco's interior to facilities on the coast. Additionally, 10 new integrated fertilizer plants will eventually be built at the Jorf Lasfar Phosphate Hub by 2023, accompanied by a necessary expansion of port and storage infrastructure. A separate Safi Phosphate Hub (SPH), a new port at Safi and another new port at Laayoune are also planned after 2016.

## First wave of the Northern Axis

OCP's first wave of investment between 2008 and 2016 ($5.5 billion) has concentrated on a cluster of Northern Axis projects located between Khouribga and Jorf Lasfar (see box). Former industrial development director, Redouane El Omri, confirmed last year that many of the 12 mining, infrastructure and chemical projects that make up the first phase of OCP's development programme (Figure 2) are either well underway or complete. The impressive list of first phase projects that are now up-and-running include:

- The Khouribga-Jorf Lasfar slurry pipeline, its head and terminal stations, and the 450,000 tonne capacity 'Line E' phosphoric acid plant it supplies, all officially opened in October 2014
- Upstream, the new Merah El Ahrach (MEA) beneficiation plant and adapted Daoui washing plant have also entered production and are supplying the Khouribga-Jorf Lasfar pipeline with phosphate slurry
- The large-scale Beni Amir (previously El Halassa) mine and beneficiation plant have also been commissioned

## NORTHERN AXIS PROJECTS: MAJOR ACHIEVEMENTS

### Mining projects

**Maroc Central**, a project to supply and distribute 45 million m³ per year of water from the Aït Messaoud dam to mining and beneficiation sites at Khouribga, was completed in 2014. The dam project by capturing surface water offers OCP a more sustainable alternative to groundwater extraction. Another project has adapted the seven million t/a **Daoui washing/flotation plant** and the Merah El Ahrach (MEA) beneficiation plant to ensure their output can be handled by the head station of the slurry pipeline. The **MEA beneficiation plant** is expected to raise production capacity at Khouribga to nine million t/a.

The 6.5 million t/a **Beni Amir mine** was commissioned in 2015, adding to the 5.5 million t/a output of Sidi Chennane mine. The recently-commissioned 12 million t/a **Beni Amir beneficiation plant** is one of the world's largest phosphate washing units. Over 80% of the water consumed by the plant, which supplies slurry to the head station of the Khouribga-Jorf Lasfar pipeline, is recycled, helping minimise its environmental impact.

### Infrastructure & chemicals projects

The **Jorf Lasfar Phosphate Hub (JPH)** is the cornerstone of OCP Group's multi-billion dollar strategic expansion plans. The hub will eventually consist of 10 integrated fertilizer units each with a production capacity of one million t/a. Four of these production units are scheduled to enter production every six months over two years, adding four million t/a to Jorf Lasfar's existing 3.6 million t/a of DAP/MAP capacity. The first of these units, the Africa Fertilizer Complex, was commissioned in February and the commissioning of the second unit is expected to follow this July. At the same time, the port at Jorf Lasfar is also being expanded to handle up to 35 million tonnes of products annually.

The JBH units have been designed using a 'plug and play' concept. This opens up the possibility of OCP inviting international companies to produce fertilizers at the hub by granting access to the infrastructure, processes and expertise available at Jorf Lasfar. This is one way in which OCP could attract foreign direct investment (FDI) to finance its downstream production in future.

The **Khouribga-Jorf Lasfar slurry pipeline** was officially opened in October 2014. The pipeline – by replacing train freight with a gravity-fed transport system – was designed to cut transport costs by 90%, cut $CO_2$ emissions by 930,337 t/a and increase phosphate rock concentrate capacity to 38 million t/a. The 187-kilometre pipeline starts at a height of 650 metres above sea level and falls through a height of over half a kilometre ending at 90 metres above seal level. ■

Table 2: **Summary of main OCP expansion projects, 2008-2025**

| Northern Axis projects | Capacity |
|---|---|
| Maroc Central water dam/distribution | 45 million m³ |
| MEA beneficiation plant | 9 million t/a |
| Daoui washing plant adaptation | 7 million t/a |
| Ben Amir (El Halassa) mine | 6.5 million t/a |
| Ben Amir washing plant | 12 million t/a |
| Khouribga-Jorf Lasfar slurry pipeline | 38 million t/a |
| Jorf Lasfar Phosphate Hub | 4 million t/a |
| Jorf Lasfar desalination plant | 75 million m³ |
| Jorf Lasfar port expansion | 10.5 million t/a phosphate rock<br>10.8 million t/a fertilizer products<br>2.6 million t/a phosphoric acid |

*Source: OCP*

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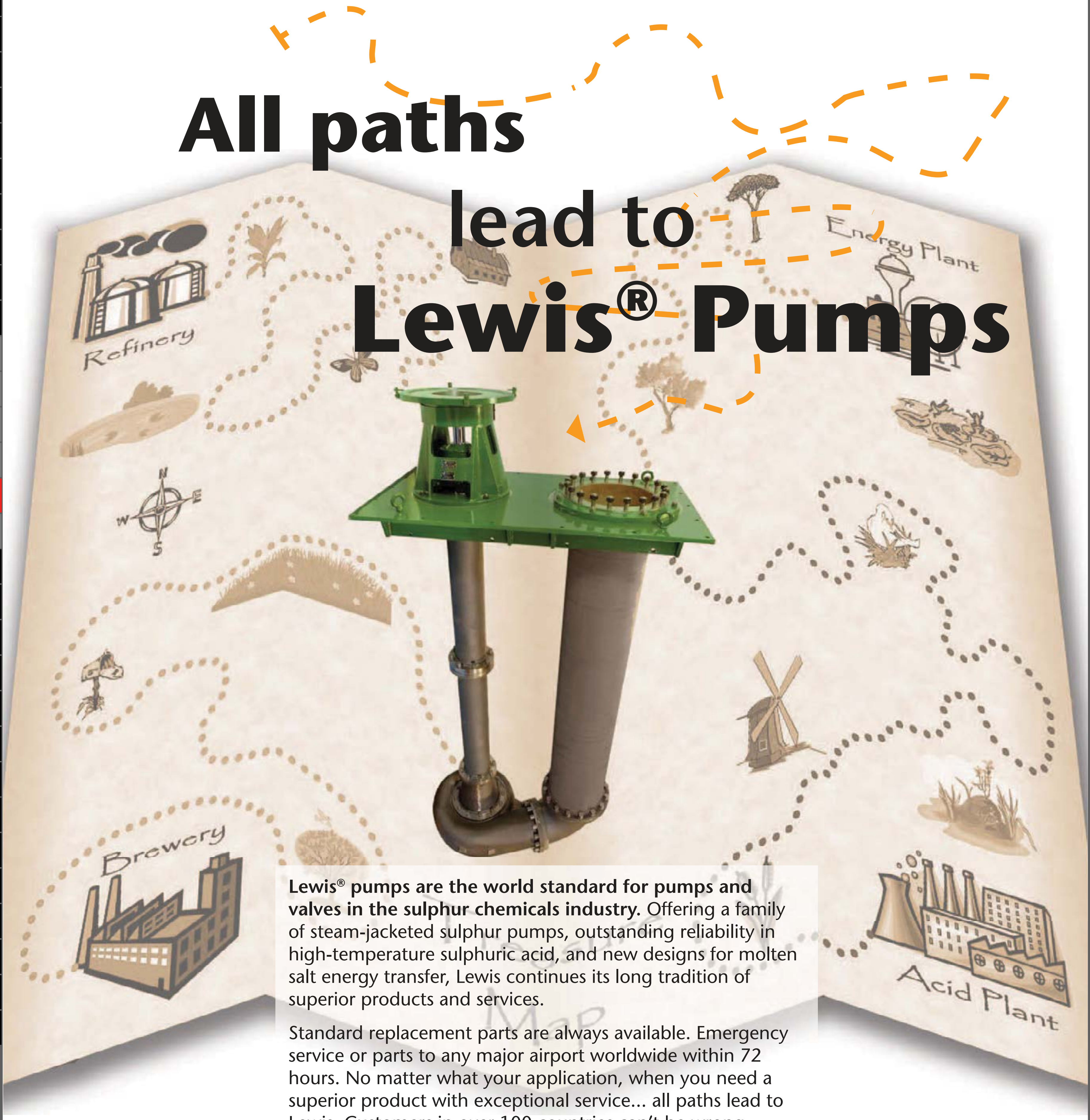

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Table 3: **Financing of OCP's development programme, 2014-15**

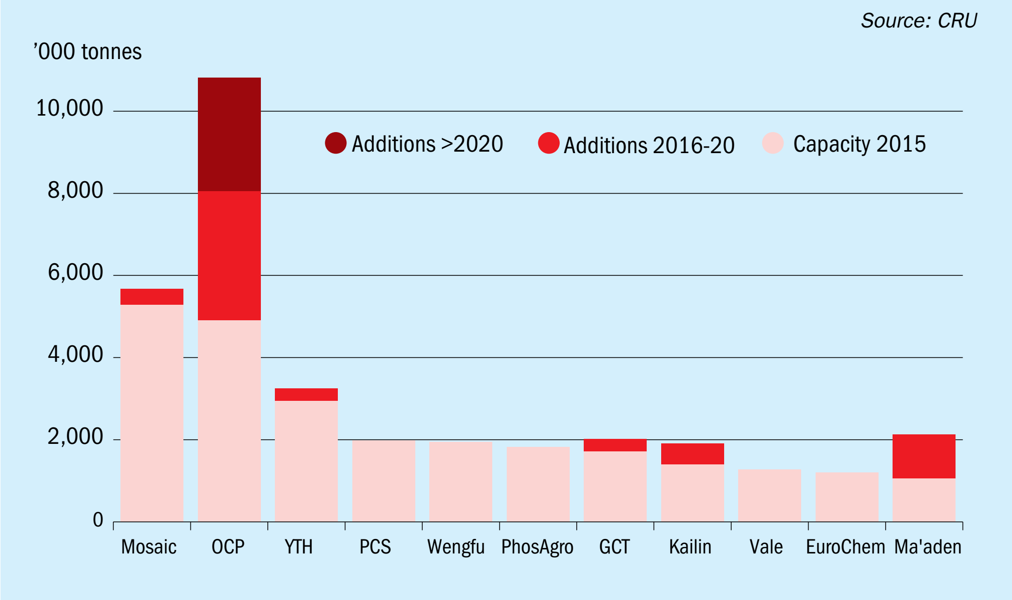
| Purpose | Amount drawn | Amount available | Agreement |
|---|---|---|---|
| Financing investment programme | $1.85 billion | 0 | Bond loan, 2014 |
| | $1 billion | 0 | Bond loan, 2015 |
| Financing revamp and extension of Jorf Lasfar port infrastructure | $91.3 million, Dec 2015 | $58.7 million | Islamic Development Bank (IDB) |
| Financing of the MEA and El Hallassa washing plants and Jorf Lasfar sulphur lines | $243.5 million, Dec 2015 | €130 million | European Investment Bank (EIB) |
| Financing of the MEA beneficiation plant and the Daoui washing plant adaptation | $271 million, Dec 2015 | 0 | German state development bank (KFW) |

*Source: OCP 2014 and 2015 Financial Reports*

- The reverse osmosis seawater desalination plant at Jorf Lasfar, one of the largest in the world, is now supplying 25 million cubic metres of water annually, a third of its eventual output
- The twin DAP fertilizer plants (107 B&C) at Jorf Lasfar were completed in 2013

Four new integrated fertilizer units at Jorf Lasfar, each of one million tonne DAP capacity, are the centrepiece of the phase one investment programme. These were originally due to come on-stream at six monthly intervals from the second quarter of 2015 onwards. The first integrated unit was commissioned in February and consists of a DAP plant, a phosphoric acid plant, a sulphuric acid plant with a turbine generator, and two storage units. A third of the turbine generator's output is surplus to requirement and powers the desalination plant.

Fig 3: **Expected growth in phosphate sector capacity**




## Finance and the future

OCP's development programme comes with an overall investment price tag of $20.5 billion. OCP invested around $3.6 billion alone in 2013, for example, and a further $3.5 billion in 2014 (*Sulphur*, 363 p18). OCP has partly bankrolled its large-scale expansion through finance agreements (Table 3) with lenders such as the European Investment Bank, the German state development bank KFW and Saudi Arabia's Islamic Development Bank. Even more significantly, the company raised a further $2.85 billion for its investment programme during 2014 and 2015 via two separate bond loans. These Dublin stock exchange listed bonds were rated BBB- by both Fitch and Standard & Poor's.

OCP's total medium- and long-term debt was 40,007 million dirhams (around $4.2 billion) at end of 2014. This rose to 51,590 million dirhams (around $5.4 billion) by the end of 2015. Under a covenant with its four main lenders, OCP has guaranteed that its debt-to-earnings ratio (net debt/EBITDA) will not exceed three.

London-based merchant bank Hannam & Partners expects OCP's investment programme to be equivalent to around half of the phosphate sector's total capital expenditure (around $12 billion) between now and 2020.

Analysts CRU also expect OCP to continue to expand aggressively over the next ten years. According to CRU, the completion of Jorf Lasfar Phosphate Hub units 2-7, together with an extra 450,000 tonnes of $P_2O_5$ from Phosboucraa in the Western Sahara, will boost OCP's capacity from around five million tonnes $P_2O_5$ currently to over eight million tonnes by 2020. After 2020, refits at Safi and the completion of Jorf Lasfar Phosphate Hub units 8-10 could ultimately take OCP's total phosphate capacity to above 10 million tonnes $P_2O_5$ (Figure 3).

OCP's product mix is also changing, according to CRU. Merchant grade acid (MGA) and NPK/NP+S production increased in 2015 at the expense of TSP, DAP and MAP output. "OCP makes good margins on MGA exports so they have tried to increase those. Interestingly, less MAP, DAP and TSP was produced year-on-year in 2015 as more NP+S and NPKs were produced," says Juan von Gernet, CRU's phosphate team leader "In our view, these shifts in the product mix will continue as we go forward."

In what will be a truly landmark achievement, CRU expects OCP's first four Jorf Lasfar Phosphate Hub units to be commissioned by spring 2017. "The second plant is fairly close to commissioning – the expectation is for the second quarter of 2016. Projects three and four still need a little bit of work but the expectation is that they'll all be pretty much commissioned by this time next year. That's important as each one of them can produce a million tonnes of phosphate fertilizer," concludes von Gernet.

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# Muga: Spain's big potash hope

*An artist's impression of Muga potash mine.*

PHOTO: HIGHFIELD RESOURCES

Highfield Resources is awaiting a mining concession permit prior to green-lighting its one million tonne capacity Muga potash project in northern Spain. We weigh-up the prospects and look at the next steps for this highly-promising European potash project.

Highfield Resources, the Australian stock exchange listed developer, is pursuing five separate potash projects across a 500 $km^2$ area of the Ebro basin in northern Spain. These five Iberian ventures – the Muga, Vipasca, Izaga, Pintanos and Sierra del Perdón projects – are being developed by Geoalcali, Highfield's Spanish subsidiary.

Northern Spain benefits from a highly-skilled labour force, good access to grid electricity, gas and water, plus a well-developed motorway, rail freight and sea port transport network.

Highfield's flagship Muga potash project, located 50 kilometres south-east of Pamplona, made great strides last year. Landmark achievements include:

- An electricity supply deal with utility company Iberdrola Distribucion
- Export capacity at Bilbao and Pasajes Port for its planned one million t/a potash production
- Publication of a definitive feasibility study (DFS).
- The raising of AUD 101 million ($78 million, €69 million) through a share offer
- Cornerstone investor EMR Capital taking-up around half of that share offer and purchasing a further 10 million shares
- A €222 million project finance mandate from four major European banks
- Doubling Muga's mine life from 24 to 47 years as part of a project 'optimisation' review

## Conventional mine and processing plant

Muga covers an 80 $km^2$ area of the Ebro basin straddling Spain's Aragón and Navarra provinces. The project is targeting a folded sylvinite ore zone that mostly occurs at a depth of less than 200 metres. The ore, which is inter-bedded with halite, will be extracted by conventional underground 'room and pillar' mining using continuous miners, road headers and conveyors. A processing plant, to be constructed at Sangüesa, will then upgrade mined ore by a two-stage crushing process, attrition scrubbing, hydrocyclone desliming and froth flotation.

Additional proposals include a 1.3 million tonne capacity crystallisation plant capable of producing 135,000 tonnes of granular potash and 260,000 tonnes of industrial salt (NaCl) as by-products from the treatment of tailings.

Highfield plans to export potash, primarily to Brazil and North-West Europe, via the nearby ports of Pasajes and Bilbao. It will also transport potash to domestic customers using 20 tonne trucks.

## Preparing for construction and operation

Last summer's definitive feasibility study (DFS) for Muga revealed information about potash reserves and the output and costs of the planned mine, including:

- A mine life of 24 years based on reserves of 146.0 million tonne at 12.73% $K_2O$ average grade
- Total capex of $354 million, including a 12.5% contingency, with a pre-production capital cost of $256 million (€227 million)
- Production of 1.123 million t/a of granular K60 potash at an opex of $135/t
- Net present value (NPV) of $1.42 billion
- Internal rate of return (IRR) of 51.9%
- Projected first full year earnings (EBITDA) of £296 million

However, just months after its publication, Highfield Resources substantially revised the DFS to optimise the project. The following changes were introduced to improve operational efficiency and prepare Muga for the construction phase:

- Upward revision of proven and probable reserves to 253 million tonnes at 11.5% $K_2O$ average grade, a 73% increase on the DFS estimate
- An increase in the mine's life from 24 years to 47 years, based on annual MOP production of 1.08 million tonnes
- Three parallel infrastructure drifts to be built during the initial construction phase, making increases in production easier and enabling future expansion of the mine
- Phase 1 capex increased by 7% from €267 million from €249 million
- Total capex of $434.5 million (€412.7 million)
- Project NPV increased from US$1.42bn to US$1.46bn (10% discount rate)
- Move to construction in the second quarter of 2016, subject to permitting
- Re-scheduling the start of production to October 2017

Anthony Hall, managing director, Highfield Resources.

## Ready to start spending money

Summing up the project's progress during 2015, Anthony Hall, Highfield Resources' managing director, said: "We have had a very productive six-month period, taking our Muga mine from a definitive feasibility study to a mine ready to be built and operated." He also emphasised the company's "steadfast commitment to constructing and operating a low-capex, high-margin potash mine as the first step in our target of becoming a significant global potash producer".

The Muga project was originally due to enter construction last December. This has now been re-scheduled for the second half of this year, although hurdles do remain. A final investment decision and the start of construction are currently waiting on two key approvals from the Spanish government – the issuing of an environmental declaration and a mining concession permit.

Managing director Antony Hall updated *Fertilizer International* on the progress of Muga project and Highfield Resources' current priorities in an exclusive interview. "It's a really exciting period because we are about to become the first potash mine built outside the hands of a major in 50 years," says Hall. "Our board's already committed over €30 million to the mine."

The fact that Spain is currently under the administration of a caretaker government has been a challenge, admits Hall. "We are in a position waiting to commence construction. We're obviously waiting for our environmental approval. We still think we are going to get that during the caretaker period – it's just been delayed as there's less incentive for people in government to sign those."

Hall remains confident about the eventual go-ahead for the Muga project. "We've got very positive support from the local community, the provinces and from central government in Madrid. We're ready to start spending some money. We've got €75 million in the bank, we're close to securing our project finance facility – and that means we will pull the trigger."

## Potash is about capex, margin and risk

Hall is very clear about the merits of the Muga potash project compared to rival ventures "We articulate our competitive advantages quite simply: fantastic geology – because we don't have an overlying aquifer – fantastic location, fantastic margin and minimal technical risk. That manifests itself as a low capex, high margin potash project."

These three key factors – capex, margin and technical risk – are what defines a potash project in Hall's view: "We summarise and try and simplify it [our goals] by saying potash is about three things: capex, margin and technical risk."

Capital expenditure is largely a function of geology and location, explains Hall. "We've an enormous competitive advantage at a capex level. Better geology equals lower capex, better location equals lower capex."

Muga benefits from one particularly critical geological advantage, as Hall points out. "It's really simple: we don't have an aquifer over the top. That means we can



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Contents

build a mine for half of the price that it costs in Canada or Russia. That's just an enormous advantage. Also we'll be mining relatively-thick ore seams – that's obviously a positive too."

Hill reels off Muga's numerous location advantages, which include port access, cheap energy and strong local markets. "We're in a first world country which means we can raise commercial bank project finance. We've got memoranda of understanding with two ports, so we don't need to go and build those. Plus we've secured 60-megawatts of electricity at a cost of €5.5 million – and we've got roads and we've got labour."

He continues: "We also have enormous margin advantages because of our location. We've got significant domestic [EU] customers, in Spain, France and the emerging UK market. We've got no royalties, we've got cheap energy."

## Margin, not production cost

Margin is a critical, if poorly understood, project metric, in Hall's view. "We've been trying to articulate that margin is the most important thing, not the cost of production. What people miss is that margin is not just how much it costs you to take potash out of the ground and process it. Margin is about how much it costs you to actually get potash to your customer and what your customer pays you for it."

When it comes to margin, Hall argues that the Muga project will not be subject to the same costs which burden Canadian potash producers. "PotashCorp this year is going to spend $600-800 million on sustaining capex. It's amazing that people don't factor sustaining capex into margin. The standing capex on a PotashCorp mine is $40-50/t – and they've got brine inflow issues and royalties that we don't have. In addition, you've got 1,800 km of railway before getting to the Port of Vancouver."

Minimising technical risk has been another priority. "We are not proposing to do something that has never been done before," Hall emphasises. Indeed, Muga will be a standard underground 'room and pillar' type potash mine accessed via a decline and will use a conventional froth flotation circuit to process ore. "What we're talking about doing is an identical mine to what they did 40 kilometres away for 35 years," sums up Hall. "It's an identical mine to what Iberpotash are currently doing in Catalunya."

## Enhancing Muga and the final obstacles

Highfield Resources overhauled its plans for the Muga project last November, taking the opportunity to enhance the proposed mine. "What we did with the optimisation study was seriously improve the flexibility and efficiency in the way the mine is going to operate," says Hall. "We did a lot of things that will ultimately make it a much better mine – one able to operate with a much lower risk and significantly greater efficiencies."

He elaborates: "Optimisation partly] focussed on throughput for the processing plant. It also gave us another two extra infrastructure galleries underground, seriously reducing the risk of bottlenecking and making the operation significantly more efficient. Plus we've also shifted from road headers to continuous miners. Moving the expansion option into the first round of design also means the mine will now take significantly more production."

> **"The fact that the board has approved three commitments for over €30 million probably suggests that the final investment decision is as good as made.**
> **Anthony Hall**

Confidence is high and a final investment decision on the Muga project now looks almost inevitable, in Hall's opinion. "The fact that the board has approved three commitments for over €30 million probably suggests that the final investment decision is as good as made, that's the reality," observes Hall. "The board of a company like ours is not going to go out and commit €30 million if it's not confident of making a positive final investment decision."

A formal process will be adhered to, though, confirms Hall: "We need our environmental approval and we need our mining concession permit to be able to commence construction. So the board will not formalise the final investment decision until we receive those."

Muga's construction could begin over this summer if, as Highfield Resources expects, the issuing of the environmental declaration is imminent. Halls sets out the timetable: "As soon as we get the environmental declaration, there's generally a two month period in which the mining concession application gets gazetted. So we will probably commence construction two and a half months after we receive the environmental declaration."

## Funds in place

Hall also remains confident that the project's €222 million finance mandate will be finalised by the summer, as Muga has met the exacting standards set by the lenders. "We've successfully gone through a stringent independent technical expert review and due diligence. We're still [at least] two and half months away from the mining concession so we don't need the finance facility before the end of June."

The availability of cash in the bank and the finance mandate means that the Muga project's first phase is close to being fully-funded, although minor additional equity will be needed. "We've obviously got the option of raising money on the market – which we don't want to do but is one option – and we're in discussion with potential partners about a minority interest," comments Hall. "We are also working with some mezzanine financiers at present who have shown a lot of interest."

Highfield Resources would prefer to develop the Muga project by itself but has not ruled out a minority partnership with a major producer. "At this stage, our base case is that we will do it alone because we think that's the best way to maximise value for shareholders," comments Hall. "But we're not adverse to considering a minority partnership in the company."

The Muga project has many potential partners, believes Hall, simply because of its Spanish location. "Because of where we are situated, we have the major European fertilizer companies, but in addition to that we have some of the African and Middle East companies, OCP, ICL, APC. We've also got the Former Soviet Union players, Uralkali, Belaruskali... Acron, EuroChem, Uralchem, PhosAgro."

Hall points out examples of where minority investments have been mutually beneficial and added value to potash companies. "PotashCorp made investments into SQM and APC and both of those companies, as a result of those investments, have actually outperformed their potash-producing peers," concludes Hall. "Those PotashCorp investments did add value to the underlying entities." ■





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# Phosphates 2016

More than 400 delegates from 36 countries gathered at the Marriott Rive Gauche, Paris, France, 13-15 March for CRU's Phosphates 2016 conference.

We report on the key market outlook presentations at CRU's 9th Phosphates International Conference and Exhibition held in Paris in March. **Mike Gallagher**, CRU's general manager for fertilizers, opened proceedings: "Welcome to Paris in the spring and the 2016 CRU Phosphates conference. Over the next two days we're going to examine a number of challenges but also opportunities for our industry."

Gallagher went on to outline four of the conference's main themes. "First of all, as we've seen a squeeze on profit margins in 2015, what is the outlook for demand and supply in 2016 and how is that going to impact fertilizer prices? Secondly, what are the regional opportunities for key markets, China, India, Brazil, and the US, and what is the developing opportunity for Africa?"

He continued: "The third theme relates to the opportunities for capacity growth. Are there opportunities outside existing large, world-scale projects, and what will be the issues surrounding these, both in term of finance and geopolitics? And the final strand relates to the outlook for speciality fertilizers, industrial, food and feed phosphates."

## The good, the bad and the ugly

When faced by a mixed outlook and opposing trends, a wise analyst will opt for a nuanced if open interpretation of market conditions. CRU's **Juan von Gernet**, an admirer of Clint Eastwood films, offered up the good, the bad and the ugly in his keynote conference address. He predicted good demand prospects for the phosphates sector – albeit offset by bad fundamentals – tempered by a warning that the export market could turn ugly this year. "There's certainly some good news to share, there's some bad news coming, and in future the markets might turn ugly."

> **"There's some good news, some bad news coming and in future markets might turn ugly.**

## Brazil

In Brazil, the market started off badly in 2015 as credit concerns emerged and macroeconomic woes deepened. This reduced annual consumption by about 700,000 tonnes on a $P_2O_5$ basis. "Government credit got squeezed because of the macroeconomic problems," explained von Gernet.

He continued: "In 2016, I expect a new form of financing to appear in the form of distributor credit. Fertilizer producers have spent a lot of money on buying distributor assets in Brazil in the past few years, and we do expect them to be supplying more credit to farmers in the future."

Looking ahead, the bartering ratio – the number of 60 kilogram bags of soybeans per tonne of MAP – is likely to drive credit availability in Brazil. Farm margins in the country should also hold up because of currency depreciation. "The outlook for Brazilian consumption is actually pretty good – that's the start of the good news for 2016," suggested von Gernet. "There are margins to be made for farmers and as a consequence, if credit is made available, we are expecting to see a bit of an improvement in fertilizer consumption out there."

## United States and India

Continuing the good news, von Gernet also expected "a slightly better year" for US ammonium phosphate consumption – due to the combined effects of a shift to corn planting, an ability to get fertilizer product to market more easily and an earlier spring. Indian demand, in contrast, although "phenomenal" last year, looks set to be on "the bad" side in 2016, according to von Gernet. Current high fertilizer stock levels appear to be the main issue.

"India bought a lot of product last year, the problem is it wasn't all consumed," said von Gernet. "By the end of last year there was around a million tonnes of DAP stock at Indian ports. Stocks do need to be drawn down before we see additional purchasing taking place." Actual Indian DAP stock levels could be much higher than this estimate, possibly in the region of 2-3 million tonnes.

Von Gernet pointed out that Indian government subsidy support is also on the wane: "There is a squeeze happening with fewer subsidies available for phosphate and potash. The latest news is the DAP subsidy will be further reduced this year from 12,350 rupees to below 9,000 rupees per tonne." He added: "The trend is very clear: compared to 2015, we expect a worse year in India in terms of consumption. But we are expecting a decent draw down of stocks during the year which could free up space for imports for the Rabi season at the end of 2016."

## China

For the Chinese phosphate market, the main story is about declining crop subsidies, in von Gernet's view: "Affordability is under pressure at a farm level and as a consequence should lead to lower consumptions rates." China also ramped up its production last year in response to strong prices and now commands a half share of global DAP and MAP production.

With production levels rising and domestic consumption falling, Chinese finished phosphate products are entering international markets in ever larger volumes. "We've now seen for the second straight year record exports out of China last year," comments von Gernet. "A lot of those additional exports were pushed into Indian markets. When it comes to 2016 it's going to be difficult to sustain these levels of exports."

With DAP trading at just above $350/t currently, prices have fallen markedly since last spring 2015. CRU attributes this to weaker demand, a ramp-up in capacity and lower raw materials costs. "This time last year, prices were looking pretty good. DAP and MAP prices were around $480/t. In forecasting prices I always look at input costs, then corn and soya for affordability, and finally market fundamentals. Market fundamentals have been weaker, although on a positive note for producers so have input costs." Lower raw material costs in 2015, combined with falls in the dollar exchange rate, resulted in a flattening of the industry's cost curve compared to previous years. "Prices are down but there is also some protection on margins," noted von Gernet.

He added: "The outlook for the next year isn't particularly bullish. We've got a lot of capacity that's going to enter the market over the next 24 months and, in my view, that will keep the ceiling on the price outlook. The second thing is we don't expect raw material prices to be much higher as we look over the next two year or so." This has longer term implications. "Positive margins are being squeezed quite sharply, given our price outlook. That means a lot of producers will be making negative margins. The question is how long can this last for? At some point there will have to be changes in the industry."

Summing up the market outlook for 2016, von Gernet said: "There are some good demand prospects, at least in the US and Brazil. Bad fundamentals have driven down prices but at the same time input costs are also much lower year-on-year which has protected margins. As we look over the next five years or so, the market could turn ugly if exporters chose to fight for market share."

## Geopolitics is back

**Charles Hecker** of Control Risks surveyed the geopolitical risks for the Middle East and Sub-Saharan Africa. In a wide-ranging presentation, Hecker outlined the risks associated with Islamic State and the Syrian conflict, and the security, operational and reputational risks of doing business in Africa. Now, more than ever, was the time to pay attention to such risks, suggested Hecker: "Geopolitics is back, bigger than ever, and has a strong impact on business and the way we work."

The Middle East emerges as "one of the darker regions of the world in terms of risk" in Hecker's view: "You can't really talk about what's happening in the Middle East without touching on IS [Islamic State]. The main driver behind IS in 2016 is ideology and its desire to create a caliphate in Syria and North West Iraq – everything it does focuses on that ideological and strategic goal."

He also noted the group's recent ability to stage violent terrorist "spectaculars" internationally. "IS has developed the ability to carry out attacks far from its zone of comfort, as goes without saying in Paris." However, Hecker suggested that the direct impact of terrorism on businesses was limited: "Transnational terrorism is quite good at provoking a very high level of fear. But we haven't yet seen a true targeting of business and commercial activity by groups like IS and al-Qaida."

On Syria, Hecker offered the following observation: "What began as a ripple effect in Syria from what's happening in North Africa has really turned into the world's most serious geopolitical conflict." Syria's civil war is notable for the many different players who have been drawn into the conflict in Hecker's view. "It's not just the US against Assad, think about Turkey and the Kurds, think about Russia and Turkey, think about Saudi Arabia and Iran."

Ethiopia was singled out as an African "bright spot" by Hecker, especially for its progress on literacy, poverty reduction and investments in infrastructure, logistics and transport. "This is a country that has seen a double digit growth in GDP for the past 10 years. In that time its economy has tripled in size."

Hecker also had an interesting take on the commodities 'supercycle' and whether it is truly over. "We don't feel as if the slump in the commodities supercycle is permanent – we think it's more like a pause. The two of us [Control Risks and Oxford Economics] believe there will be an upswing in commodity prices – not necessarily right away but in the next 12 to 24 months."

## Investment still has steam

**Ingo Hofmaier** of Hannam & Partners explained current investment sentiment towards the phosphate sector, from an equity and debt market perspective. "The overall view in the short term and the long term, is that the outlook, especially for phosphate fertilizers is stable and continuing to rise," said Hofmaier, although he cautioned: "The market thinks the sector looks good, but there are a few indications that things might go relatively ugly in the next few years."

Fertilizer company share prices have generally performed better than FTSE 350 mining stocks over the last five years. Although fertilizer majors have seen their market capitalisation fall by 38% since 2011, this is significantly lower than the 60% experienced by large, diversified mining companies. Over this period, net debt levels of major fertilizer producers have increased to 25% of their enterprise value (EV), with total net debt in the sector standing at around $21 billion currently.

The investment cycle for fertilizers "still has steam" according to Hofmaier. Major fertilizer company investment peaked last year at $9,975 million but will still stand at $6,047 million in 2018. Capital expenditure of $12.0 billion is expected in the phosphate sector between now and 2020, adding around 4.2 million tonnes of $P_2O_5$ capacity, according to Hofmaier. OCP's investment programme alone is expected to contribute to at least 50% of this total. Ma'aden and Mosaic's Wa'ad al-Shamal $3 billion joint venture is likely to be responsible for another 25% of 2016-2020 phosphate sector investment.

## OCP gets proactive on Africa

**Tarik Choho** of OCP explored the outlook for the African fertilizer market. Growth in fertilizer consumption in Africa, explained Choho, was constrained by a general lack of availability, high prices, underinvestment in distribution, poor application practices and a lack of knowledge about products. Concerted action was needed if Africa is to avoid becoming locked into a "downward fertilizer spiral" in his view.

Fertilizer availability is a major issue for Africa's farmers. "We need to make sure there is fertilizer capacity dedicated to Africa," said Choho. "That will incentivise downstream distribution and storage. We also need to make fertilizers available as close as possible to the farmer at the time it is needed. We also need to invest in agronomy."

OCP Group has set up a new subsidiary company, OCP Africa, to provide products and services to African farmers and help transform the continent's agricultural prospects. Currently operating out of Addis Ababa and Abidjan, OCP Africa plans to expand to a network of 14 regional offices across the continent. "We can't just wait passively for African fertilizer use to grow," explained Choho. "We have to do something proactive to make it grow significantly – and that's what OCP is ready to do."

Making African farmers richer so they were able to invest more was a major goal of OCP's new endeavour. "We need to focus on everything that is needed to stimulate demand and also to improve supply – production, storage, transport, retail – to make fertilizers available to the farmer at the best price," said Choho.

As well as directing output from its new one million t/a capacity African Fertilizer Complex at Jorf Lasfar in Morocco to African farms, OCP wants to invest in additional capacity elsewhere in Africa. "We are discussing the building of fertilizer plants with other countries In Africa," confirmed Choho. "We are looking at countries that have natural gas – so we can produce ammonia to mix with phosphoric acid coming from Morocco – for dedicated fertilizer production for that country and its neighbours."

## US producers extracting maximum value

**Wayne Welter** of JR Simplot Co discussed how agricultural drivers are shaping phosphate demand in the US. He also touched on key market factors such as environmental regulation and North America's declining phosphate production. US phosphate demand has been relatively flat for the past thirty years, averaging around 4.2 million t/a on a nutrient basis. "That's in spite of the fact that we've seen dramatic yield growth," noted Welter. "So it's just a function of farmers getting more efficient. Improved seed technology, precision farming and environmental awareness have all driven more efficient use of phosphate."

Corn, soybean and wheat, account for about 70% of planted acres in the US. Of these, 'King Corn' is the "major driver of fertilizer farm use in the US" and the country's most significant crop, according to Welter. Around 65% of US phosphate consumption is concentrated in a cluster of seven Midwest and Upper Midwest states. "It's amazing how significant that area is in terms of demand drivers," commented Welter. "King Corn really drives it."

The last three years have seen the biggest corn harvests in US history. The resulting high stock-to-use ratio has driven corn prices down, and USDA is currently forecasting a corn price of $3.60/bushel for 2016. Factors such as the strong dollar, low commodity prices and "intense pressure" from Brazilian and Argentinian growers are "limiting opportunities for US farmers trying to sell their corn and soybeans" in Welter's view.

Looking ahead at long-term demand for phosphate in the US, Welter said: "I can't really overstate the significance of corn and its impact. If, at the stroke of a pen, we see ethanol policy change dramatically in the United States that could really influence the market."

Welter was stoical about the complexity of environmental regulation faced by US producers: "It's not impossible to navigate, it just means we have to be more measured and have more of a strategic outlook. It takes an awful long time to get a mine permitted – but we'll get it done."

North American phosphate producers will concentrate on "extracting maximum value" in future, becoming more differentiated and concentrating on high-value market segments, predicted Welter. "That's why we've seen the rise of NP+S products and see PotashCorp shifting more into industrial and feed products," he concluded.

## Fertilizers power Brazilian agriculture

**Carlos Heredia** of Yara described how the 84% rise in fertilizer consumption over the last 15 years has helped drive major improvements in Brazilian grain and oilseed production. Brazil is currently the fourth largest global consumer of fertilizers, with a 6% slice of world demand.

Fertilizer use in Brazil grew from 16 million t/a to 30 million t/a between 2000 and 2015, accompanied by an increase in average yield from 2.5 kg/ha to 3.6 kg/ha and a massive rise in grain production from 100 million t/a to 210 million t/a. Fertilizer use on soybean crops in major growing regions of MAPITO, Mato Grosso and Parana is particularly high, at around 300-600 kg/ha.

Fertilizer demand has outpaced domestic supply leading to increased import dependency. Brazil has around 11.3 million tonnes of phosphate fertilizer capacity, although reliance on phosphate imports has increased from 46% to 57% of consumption since 2008. Brazil's farmers have a long-standing preference for SSP, which accounts for over half of phosphate consumption, although its use is in decline due to the greater use of MAP, NP and NP+S products instead.

## India benefits from China's largesse

**Chris Lawson** presented CRU's market outlook for Asia, a major phosphate-consuming region. Asia holds a 58 % share of the fertilizer phosphate market as well as a 35% share of the feed phosphate market and a 45% share of the industrial market.

Lawson pointed out that China now produces over half of global phosphates, but questioned how sustainable this was over the longer term. "Costs are becoming comparatively high, compared to low-cost producers, and [production] cuts will be made. But we think the government is going to prop up the industry, and that, in a way, is subsidising farmers around the world with a cheap source of fertilizer." Cost differences in the region are very stark. Saudi Arabia can export phosphate to Asia at $171/t f.o.b., for example, undercutting Chinese phosphate costs ($231/t plus $30/t for freight) by around $90/t.

The main beneficiaries of Chinese phosphate exports have been India's farmers. India, although it was the phosphate market's "saving grace" in 2015, could well turn into "a thorn in the side" of the market in 2016, suggested Lawson. He was highly cautious about Indian buying prospects this year advising "don't expect too much strength in that market in 2016". India's DAP import are likely to fall to around 2-4 million tonnes this year, predicts CRU, compared to the 5.5 million tonnes imported in 2015.

Any moves by India's government to dismantle the country's urea subsidy, although unlikely to be imminent, would inflict "immediate harm" on the phosphates market, warned Lawson: "Don't expect this to be good for phosphate fertilizer consumption because it's going to completely shake up the farm fertilizer budget."

Encouragingly, Lawson predicted strong market prospects outside of India in countries such as Indonesia, Vietnam and Pakistan: "Growth in that market is still relatively strong and they're going to be consuming a lot of the phosphate that's coming online over the next five years."

**Anders Isberg** presented CRU's outlook for ammonia and sulphur, two key raw materials for phosphate fertilizer production. Raw material costs have fallen dramatically over the past 12 months, confirms Isberg. "We've seen ammonia prices fall by close to 40% since this time last year and sulphur prices similarly by close to 30-40%."

The hangover from the end of the nitrogen investment boom is expected to last for another 3-4 years, according to Isberg. Oversupply is expected to persist and will push down prices. The arrival of new merchant ammonia capacity, in particular, is likely to mute prices this year, prior to an expected ammonia price recovery in 2017 on the back of rising oil and gas prices. CRU also expects sulphur supply growth "to overwhelm the market in 2016" as the market moves into a significant surplus. The advent of new low-cost supply from the Middle East is also expected to force Canada and CIS suppliers to stockpile sulphur.

## Potash is special

**Sean Mulholland** gave CRU's take on the demand, supply and trade outlook for potassium sulphate (SOP). The fact that SOP products currently enjoy a 120% price advantage over standard potassium chloride (MOP) has sparked interest in a number of greenfield SOP projects. "The sharp increase in the SOP price premium has generated significant interest from the investment community in the last year or so," commented Mulholland.

China, with consumption of 3.9 million t/a, is the world's largest consumer of SOP and has driven growth in the global SOP market. Chinese SOP demand has grown by 2.2 million tonnes since 2007 and the country's consumption currently accounts for around 55% of world demand. Looking ahead, Chinese consumption is forecast to grow by a further 1.1 million tones by 2020. "China continues to transform the global SOP market, although it remains isolated from the international market," Mulholland explained. In contrast, there has been zero growth in the global SOP market outside of China over the last eight years.

Much of the demand for SOP comes from chloride-sensitive crops, such as almonds, potatoes, tobacco, mangoes, peas and beans, and is concentrated in countries where these are grown, particularly China, India, the US, Russia and Brazil. CRU has developed a sophisticated country-by-country model for the global SOP market. This estimates SOP consumption in individual countries based on the land areas dedicated to the cultivation of different chloride-sensitive crops. "The model identifies India and Brazil as really large potential SOP markets of the future," said Mulholland, adding: "We expect SOP prices to remain pretty resilient towards 2020 in the face of weak MOP prices."

## Speciality and non-fertilizer markets

PhosAgro's **Irina Evstigneeva** examined the outlook for speciality fertilizers. She lamented the lack of market information available, and instead focussed on the benefits and value of applying micronutrients. Evstigneeva highlighted the issue of severe sulphur deficiency, suggesting it was especially prevalent in the US, Brazil, India and China.

Importantly, in Evstigneeva's view, micronutrient deficiencies can have major impacts on human health, being especially associated with childhood malnutrition. Zinc and iron deficiency, for example, are said to be the fifth and sixth most important health risk factors in low-income countries. Adding micronutrients to fertilizers, Evstigneeva pointed out, is effective at helping eradicate such human health risks. "About two billion people are missing certain micronutrients and that is something that causes early deaths and other diseases as well," commented Evstigneeva. "So what the industry can do is provide more food and more micronutrients that can save children's lives."

Zinc deficiency alone is thought to contribute to 450,000 deaths of children under five annually, according to the International Zinc Association. It affects large swathes of Sub-Saharan Africa, South America, the Middle East and Asia, and was a particular crop nutrition problem in Evstigneeva's view.

Two conference presentations dealt with non-fertilizer markets for phosphates. **Julia Presnova** of Prayon examined the outlook for food and industrial phosphates. She stressed the importance of markets with high growth potential, particularly Asia-Pacific and Latin America. A shift in the market away from detergents is also taking place currently. This has led to "more interest in high-end industrial markets, the food industry and speciality fertilizers", Presnova suggested. "The food industry is a boom industry for phosphates. There are many different applications, there is innovation going on," concluded Presnova, adding: "We shouldn't underestimate the potential risk from non-phosphate alternatives, although I wouldn't be pessimistic."

**Yohann Becker** of TIMAB Phosphates revealed some positive trends in the feed phosphates market. Phosphate use in this market is linked to underlying animal feed production. Over the last four years this has grown by more than 10% to 982 million tonnes. The growth in feed production over this period has been particularly strong in Asia-Pacific, the Middle East and Africa, and in Central and Latin America.

World feed phosphate consumption has risen at 1.4% annually, in response to growing demand from developing countries, and currently stands at 8.2 million tonnes (41% $P_2O_5$). International trade volumes are not especially large as around 85% of feed phosphate demand is met within regions. Demand does, however, outstrip supply in Europe, Latin America and the Middle East.

PotashCorp, Mosaic, TIMAB and Vale are the four leading global feed phosphate producers at present. The market is oversupplied, however, and the opening of large, vertically-integrated and export-oriented plants by OCP, Ma'aden and Yunnan Phosphorus Chemicals will add to current global feed phosphate capacity. Looking ahead, the adoption of substitute products such as phytases and the declining use of animal protein in developed countries are two of the main threats to the feed phosphate market.

## Phosphate recovery

**Willem Schipper** of Willem Schipper Consulting gave an update on phosphorus recycling technologies and the legislation that is driving their adoption. Schipper pointed out that of the 20 million t/a of phosphate mined each year, 10 million t/a enters soils and surface waters, two million tonnes gets eaten by humans and 2-3 million t/a is consumed by animals. The remainder ends up in food waste, animal bones, crop residues, detergents and other chemicals. The main sources of P for recycling are sewage (wastewater), animal by-products, manure and industrial waste.

Struvite recovery at wastewater treatment plants has become increasingly widespread. But Schipper was sceptical about its efficacy as a recycling technology, partly because of its low recovery rate. Technologies such as sewage sludge incineration and ash treatment may offer more promise for P recycling over the longer term, suggested Schipper. He also concluded that policy drivers – such as Switzerland's mandatory P recycling legislation and changes to EU rules on waste-derived fertilizers – will be necessary for society to shift to commercial phosphorus recovery on a large-scale. ■

1 47
2 48
3 49
4 50
5 51
6 52
7 53
8 54
9 55
10 56
11 57
12 58
13 59
14 60
15 61
16 62
17 63
18 64
19 65
20 66
21 67
22 68
23 69
24 70
25 71
26 72
27 73
28 74
29 75
30 76
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

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- **Saudi phosphate industry expansion**
- **Urea technology trends**
- **Greenhouse crops**
- **Global demand analysis**
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