Fertilizer FOCUS

MAY/JUNE 2018

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Fertilizer FOCUS

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Fertilizer Focus
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Front cover image: YaraMila is used in soy crops; courtesy of Yara

Fertilizer innovations

in East Europe

by **Kees Langeveld**, Technical Expert Marketing and Sales, ICL Fertilizers, Netherlands

Historically the market for fertilizers in Eastern Europe is commodity based : AN, CAN, MAP/DAP, SSP and MOP. The products were mainly supplied from local production or imported from Russia.

The expansion of the EU to the East has opened up this market for eastern produce. Higher yields are more interesting since higher margins can be obtained when exporting to EU members. This in turn leads to a higher demand for fertilization and the need for more precise fertilization. Fertilizers Europe estimates the growth in consumption per nutrient over the next 10 years to be:

N: +14%
P_2O_5: +29%
K_2O: +17%

If we compare this with the last 10 years with figures of 63%; 63% and 6% respectively we can see that the growth is going to be lower in absolute terms but that the N, P and K supply is heading towards a more balanced direction with the NPK ratio shifting from 4.6-1.0-1.1 in 2005 to 3.4-1.0-1.0 expected by 2026.

> *There is an increased need for energy crops*

The main drivers for this are growth in population and the increased need for energy crops (also usable for bio-plastics) such as sugar.

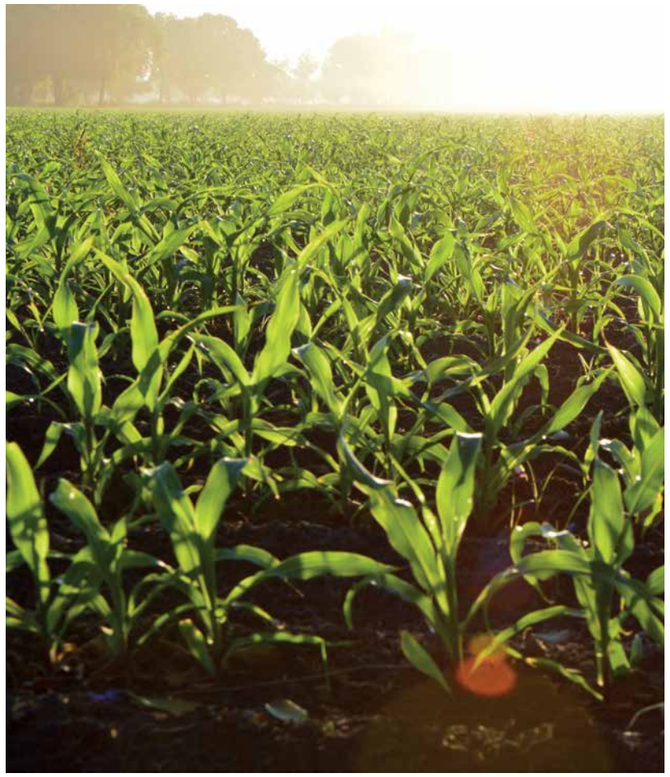
In addition, there will be an increased focus on a more effective use of nutrients from manure, which is expected to be a significant nutrient source in the future when applied in the proper time and at the proper way, minimizing emissions in the air and also in the surface/ground water.

The previously forecasted strong growth in oilseeds for biofuel will not materialize this way due to the continuous conflict between biofuel and food. Here society is waiting for second generation biofuels made from leaves and roots which do not conflict with food/feed.

Fields need to be provided with adequate nutrients in the correct ratio dependent on soil analyses and crop uptake. This creates the need for more tailor-made formulations than the typical 16-16-16, MAP used in the past.

Compatibility

Next to the option of making hundreds of different formulations in the local production units, which has a negative impact on production efficiency, there is increasing room for quality bulk blending and producing tailor-made products from high quality building blocks. This can be carried out in the production plants, but it is better to produce in a warehouse closer to the end-user.



(left) Polymer coated controlled release fertilizer, longevity 18 months

Fertilizer blend operation

High quality building blocks can be defined as:

- Physically high quality (hard, round, uniform)
- Chemically compatible (prevention of post reactions, caking, disintegration)
- Proper granule size to enable spreading up to 40 m wide by modern machinery
- Trace elements homogeneously distributed inside the granule, reducing chances of segregation and loss of trace elements as dust from the granules (some trace elements can be toxic in higher concentrations)

In addition, new products are needed in the market for the supply of macro-elements (S, Ca, Mg, Na) and micro-elements (Cu, Mn, Mo, Se, Co, Zn, Fe, etc.) since small deficiencies of these elements will limit the effect of N, P and K supply.

Inhibitors for nitrogen application will also be increasingly required in order to reduce the leakage of N to ground water. Several types are already on the market - each with their own peculiarity.

For the higher cash crop segment, slow release and controlled release fertilizers will become more popular due to the fact that they are more efficient in nutrient supply (with financial and environmental advantages) and they also reduce labour costs by reducing the frequency applications. Again, there are various types on the market - most of them polymer based.

Legislation

New fertilizer regulations will also apply in the eastern EU countries, meaning uniform limits on heavy metals will become more stringent.

The circular economy issue will become increasingly important in East Europe and a controlled method of re-using nutrients will have to be initiated. These include re-using struvite and sewage sludge ashes from water treatment and biogas for nitrogen production. These secondary products will not be free from contaminants, but the use of them will need to be validated on the basis of risk assessment. Remember that a circular economy will not be possible if legislation only allows virgin or very low impurity raw materials and as long as risk assessments do not show an unacceptable risk, there is nothing wrong with using those materials.

It is important to remember that conventional raw materials are not free from contaminants, yet these are acceptable.

Organic farming is a growing segment, although in absolute terms still the industry is still small. In principle, this type of agriculture is good, however one should be careful in applying some types of organic fertilizers since they could carry high amounts of contaminants.

In general, it is expected that advisory systems will increase in order to communicate the principles of good fertilizer practice to farmers who are not used to working 'on the edge' for the highest possible yield without a negative environmental footprint. Field tests to prove the statements made by sales people will need to be arranged in order to deliver input for the bottom line calculation to convince the farmer.

Technical instruments to support the farmer in his work such as nutrient detectors, drones and the use of big data will further improve the way accurate fertilization can be practiced.

Last but not least something about logistics: the number of navigable days on the main river Danube is dependent on several factors such as rain, frost and wind. Growing demand for fertilizer transport means there is the need for either buffer storages along the river that can be filled in times of 'normal' water levels or more transport by rail or truck. The latter two are clearly more expensive and have a higher CO_2 footprint than the former.

East Europe will be a major player in the supply of food and bio-based products for the total European market. In order to use the potential, more precise fertilization with an eye for macro and micro elements will be needed. Soil analyses, crop uptake, use of drones, nutrient detectors and big data will monitor the exact requirements of plants.

Both local production and imports will have to be used to meet this target sufficiently.

If suitably organized this can be the key for a more productive agriculture in the eastern part of Europe providing food to the increasing population and growing the raw materials needed for a future bio-based and circular economy in Europe. ■

How is ICL coping with these developments?

On top of the existing availability of commodity (P, PK and NPK fertilizers) and specialty fertilizers (controlled release, slow release, adjuvants, water-soluble fertilizers, bio stimulants and inhibited) ICL is developing new semi specialties on the basis of a newly mined raw material from the UK, called polyhalite. This multi-nutrient material, which is certified for organic farming, forms the backbone of several lines of new semi-specialty products based on the principle of not just adding the basic elements N, P and K but also the macro and micro nutrients in a sufficient amount to complete the whole 'barrel of Liebig' spectrum of essential feedstock for plants. Examples are the PKPlus line (PK's with reduced chloride content, MgO, CaO, boron and elevated sulphate based S-levels), PotashPlus (a K-fertilizer partly based on KCl, partly on Polyhalite).

Products based on the so called 'partly acidulated phosphate line (PAPR)', which contains a mixture of quickly available P_2O_5 and slowly available P_2O_5 has the capability to capture acidity in the soil to convert the P_2O_5 from insoluble to soluble.

In the specialty segment itself, ICL is trying to develop new coating products which are as functional as they are today, but with the coating even more biodegradable. This will contribute to a reduction of micro-plastics into surface water, which is a concern across the globe.

In the sustainability arena, ICL is a front runner on recycling P and K based materials like struvite (magnesium ammonium phosphate from municipal water treatment stations), ashes from chicken litter, sewage sludge, wood and meat and bone meal. Thousands of tonnes of these materials have already been piloted and processed on plant scale while investments are being made to expand in this field and products for organic farming are being developed from these recycled products.

The circular economy

and the EU Fertilizer Regulation

by **Antoine Hoxha**, Technical Director, Fertilizers Europe

A circular economy is defined as an industrial model designed to be regenerative and restorative, aiming to extract the maximum value from resources by keeping them in circulation as long as possible and by recovering them at the end of their service life within a system. It aims to eliminate the concept of waste by following the example of natural eco-systems where every by-product of a specific process becomes an input for other processes, feeding into a virtuous cycle. The concept of a circular economy has been developed on the basis of various principles such as biomimicry, industrial symbiosis, recourse efficiency and environmental economics.

This economic model has gained strong momentum, with the majority of stakeholders agreeing that this is the right approach moving forward if we want to ensure a sustainable future. The key point of a circular economic approach is that it finally addresses both environmental and business needs at the same time.

A core EU priority

The European Union has recognized that a circular economic model is a key driver for the European industry and thus presented on 2 December 2015 a 'New Circular Economy Package' that sets ambitious targets to be achieved by 2030 and outlines a series of actions to stimulate Europe's transition towards a circular economy. The measures cover a broad range of issues throughout the whole of the industrial value chain from production to consumption, remanufacturing, waste management and secondary raw materials. The aim of the European Union is to provide a proper regulatory framework that supports this transition.

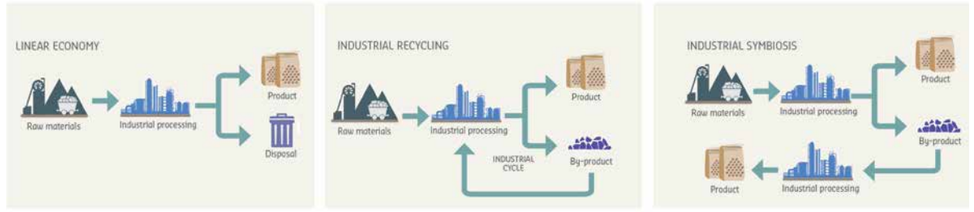
The fertilizer industry

Since its foundation, the fertilizer industry has been circular, adopting the principle of industrial symbiosis and making use of by-products derived from related processes. Industrial symbiosis consists in the reintegration of waste or by-products generated in production processes, where the waste of one process becomes the raw material for another – this is the building block of a circular economy. Symbiotic relationships can be achieved between processes, companies and industries by focusing on local, regional and European levels. While a linear economy is based on the logic of 'take, make, use and dispose', industrial symbiosis closes the loop of materials and energy flows, bringing with it numerous benefits. It makes the industry more efficient and less dependent on non-renewable resources, reduces land-fill waste, decreases emissions and creates new business opportunities (see figure 1).

The principles of recycling have always been in the DNA of the fertilizer industry, which over the past 100 years has continued to integrate a vast range of by-products from other industries. Modern chemical operations, as we know them today, began in the second half of the 19th century and were mainly fuelled by coal. During that time, coal was also used to produce gas for street lighting purposes. The tar residue, or by-product, of this process was found to contain a range of chemicals that could be extracted to provide aniline, the basis for artificial dyes, and ammonia, which is the basic raw material for modern fertilizers.

Since then, the industry has evolved and the demand for ammonia used as a component in fertilizers has substantially exceeded its availability, and thus the search began for an industrial route for ammonia production. This ultimately led to the Haber-Bosch process, which is still the most energy efficient production process in use today.

Figure 1. Linear economy, industrial recycling and industrial symbosis comparisons *Source: Fertilizers Europe*



Some more recent examples of the uses of by products in the industry are:

- The use of ammonium sulphate from nylon synthesis for making sulphate-containing mineral fertilizers
- The use of sulphur from oil and gas refining operations for making sulfuric acid
- The application of used acids in dissolving insoluble rock phosphates for making water-soluble and therefore plant available phosphate fertilizers

Chemical products are not the only resources recycled in the fertilizer industry. Fertilizer manufacturing needs, as well as produces, significant amounts of energy and heat at the same time - for example during ammonia and nitric acid production. These processes are currently optimized to achieve best energetic performance and reuse of energy and heat waste (see figure 2).

New Fertilizer Regulation

The 'Fertilizer Regulation' was the first piece of legislation to be proposed as part of the EU's 'Circular Economy Package'. The aim of the regulation is to harmonize the definitions and quality standards for all types of fertilizers that are traded in the EU. In addition to mineral fertilizers and blended products, the regulation covers organic and organo-mineral products, liming materials, soil improvers, growing media, agronomic additives and plant bio-stimulants. By defining common quality, safety and labelling requirements, the new regulation aims to create a single market for fertilizers, expand the circular economy and address the environmental impact of fertilizer use. However, the adoption of the New Fertilizer Regulation as it is proposed by the Commission, would imply that any product where 'by-products' have been used at any stage in production would effectively be excluded from the 'EU Fertilizer' label. This would cause serious consequences in the fertilizer industry, banning most fertilizers currently available on the market and affecting European producers' ability to produce and compete.

> *Since its foundation, the fertilizer industry has been circular*

The current provisions of the New Fertilizer Regulation proposal contradict its objective to position resource efficiency as a guiding principle for a circular economy. It seems that the European Commission's proposal forgot just how integrated, and circular, modern mineral fertilizer production already is. It is fundamental that the legislator finds a solution to this matter that ensures the continuation of good circular practices, while maintaining the competitiveness of the industry, in

Figure 2. Modern chemical fertilizer operations started from tar *Source: Fertilizers Europe*

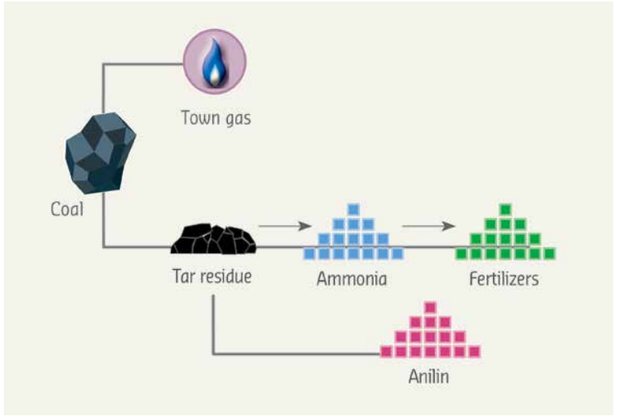


Figure 3. High quality fertilization *Source: Fertilizers Europe*

President of Fertilizers Europe Javier Goñi del Cacho meets European Parliament Rapporteur, MEP Mihai Turcanu, during By-products Seminar in Brussels, 7 March 2018

order to secure a sustainable future for agriculture in Europe.

Fertilizers play a key role in delivering resource efficiency in the food industry. This is even more important in the light of a predicted growing population that will put additional pressure on natural resources. In 1960, one hectare of land was needed to feed two people, the same amount of land will be required to feed five people by 2025 (see figure 3).

Therefore, resource efficiency will play a crucial role in the agriculture sector and fertilizers are the enabler of ensuring this. Thanks to the use of fertilizers, it is possible to increase yield productivity and thus ensure food security in the future.

The industry hopes that the trialogue discussion between the European Commission, the European Council and the European Parliament will result in a compromise that will allow the use of by products in the fertilizer industry without creating unnecessary bureaucratic burden for business and public authorities.

In March 2018, Fertilizers Europe, the association that represents the majority of fertilizer producers in Europe, hosted a seminar on 'Symbiosis and Circular Economy in Fertilizers.' The seminar brought together industry experts, EU legislators and national authorities to exchange perspectives on how to improve the New Fertilizers Regulation. More than 100 participants, as well as all the key policy players in the trialogues, were present during the seminar.

> *"The principles of recycling have always been in the DNA of the fertilizer industry*

Throughout the event it was highlighted how the fertilizer industry has always been a frontrunner in circular economy approaches, saving nutrients, energy, costs and precious resources. Javier Goñi del Cacho (CEO Fertiberia and President of Fertilizers Europe) and Jacob Hansen (Director of Fertilizers Europe) stated that the New Fertilizers Regulation must enable this to continue, be open to innovation on resource use and ensure quality and safety of products delivered to the farmers. By-products are not used for the sake of it, but because they contribute to the quality and agronomic efficiency of the final fertilizer products. The legislator can build upon existing pieces of legislation such as REACH, without creating unnecessary bureaucracy and burden for the industry.

This is in fact the solution that has been proposed by The European Parliament in its report drafted by Romanian MEP Mihai Turcanu, a solution which is in itself circular in terms of use of European procedures. The parliament suggests allowing the use of by-products on the condition that those by-products are compliant with REACH chemical obligations because these products have already been assessed as safe. This would ensure that fertilizer manufacturers have an effective and non-bureaucratic path to obtain a CE-mark for their products.

Bearing in mind the file's importance for the circular economy, the Bulgarian EU Presidency remains optimistic in finalising the negotiations by June. The legislation will come into force in 2021 or 2022, replacing the existing Regulation EC 2003/2003. ■

Specialty fertilizers

Techniques for optimising profit

by **Rejane Souza**, Senior Agronomy, R&D and Marketing Manager, Yara, Brazil

We no longer see the same machinery in the plantations today as we did 20 years ago. The hybrids and varieties are different and so are the chemical molecules used to protect the crop. However, if we take a look at the crop nutrition market, while there are some new options are available to the farmers, it still is largely backed by the conventional model of raw material use.

Going a little deeper into the theme of soil management and fertilization strategies, we now have special fertilizers, the so-called 'premium products', as an alternative to conventional sources. They offer an enhanced physical performance, which helps to increase the machinery's operating performance for fault-free applications.

These premium products rely on chemical forms with higher efficiency, ensuring an easier absorption. They also create a synergy with other nutrients and minimize losses, which can have a highly positive impact on the crop's performance.

There are also products used as nutritional supplement strategies that are applied directly on the leaves. These deliver micronutrients that are specifically developed to meet the crops' needs and act as an important ally to growers. Therefore, a simple suggested definition of specialty fertilizers could be that 'they are products that efficiently supply crops with nutrients in the required amounts', in other words - an assertive and safe management strategy.

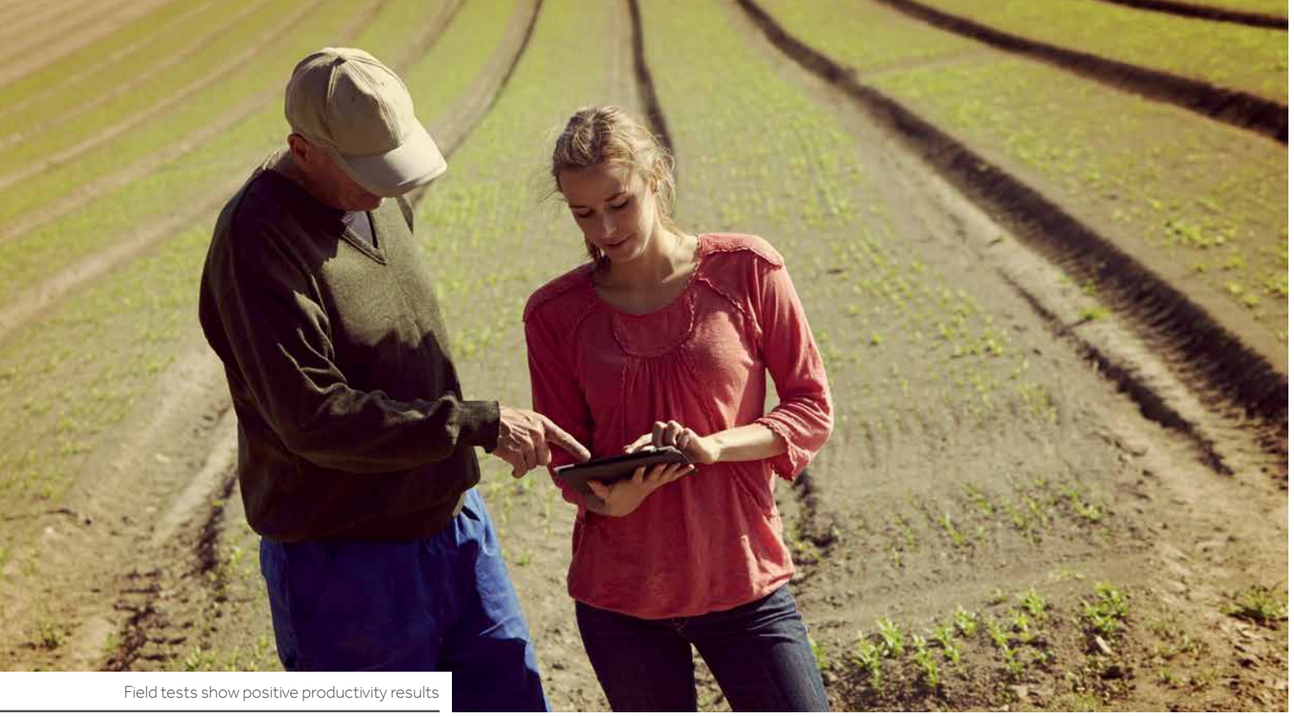
> *"Premium products offer an enhanced physical performance*

It is important to analyse the recommendations, taking into consideration factors such as the area's history, the crop's needs, productivity expectations and lastly, but not less important, the return on investment.

Segmentation

One factor that is fundamental from the viewpoint of premium product development is segmentation. The requirements for a crop may vary due to the region, planting season and crop type, but it is equally important to understand that the farmers' needs also vary depending on the maturation stage of their business, invested knowledge per area, openness to

YaraMila is used in soy crops



Field tests show positive productivity results

innovation and the availability of resources to invest. It would be fair to say that for an optimized agronomic recommendation, 'empathy' should be practiced as a starting point. This can be achieved by studying the needs of the consumer (in this case, the crop) as well as the 'user' (farmer centricity) in depth.

For this reason, it can be concluded that one product or technology may provide different performances,

> *It is important to understand what is happening in the plantation*

depending on management use and the intended objective. Consequently, it is very important to understand what is happening in the plantation and to adapt the recommendation to the farmer's circumstances in order to increase the performance of the premium product. Recommendation systems and software that use data for each separate situation on each farm are in high demand in order to provide a tailor-made strategy. The systems use the most advanced agronomic research results and also take into account the expected productivity. This concept that has been successfully introduced and deployed in Yara's Megalab placing technology at the farmer's disposal.

Yaramila granules

YaraMila in production

Access to food

The challenge to produce food for a growing population, while dealing with the shortage of natural resources and limited available arable farm land for expansion, technology is an ally in our fight against hunger. Knowledge and technology are ready to be used for this noble purpose and the plight of increasing food availability is becoming ever more possible.

Increasing both the productivity and quality of food, while growing the profitability of each area without the need for large expansions, is good for the farmer's business, good for the agribusiness companies and, without any doubt, good for developing access to food globally.

Technology plays an important role

When production is obtained by using raw materials such as specialty fertilizers, that have a cleaner production process (e.g. nitrogen sources such as nitrates), lower GHG emissions, lower losses (especially through volatilization) and a higher absorption efficiency, it also becomes a strategy to protect our planet. ■

News in brief

EUROPEAN UNION

Ina in talks to buy stake in Petrokemija

Croatian oil and gas firm Ina is in talks about possibly buying a stake in the country's state-owned fertilizer producer Petrokemija, Sandor Fasimon, Ina's nominated future chairman, said. "It is not a secret, there are negotiations about that," Fasimon told local broadcaster RTL in an interview. He said Petrokemija could be of interest and provide a new business line to Ina if it "can be run on a market-oriented basis, tak-ing out all the past problems," he said. The Zagreb government currently controls 80% of Petrokemija, but wants to sell most of this stake. The troubled company has faced continuing problems with gas deliveries because of outstanding debt to its two suppliers, Ina and domestic gas firm PPD.

Stamicarbon signs licensing and equipment supply contracts with Hubei Sanning for a new ultra-low energy urea plant

Sittard, The Netherlands, Stamicarbon, the innovation and license company of Maire Tecnimont Group, and Hubei Sanning Chemical Industrial Co., Ltd have signed contracts for the licensing of technology and the delivery of proprietary equipment for a grass root urea plant with a capacity of 2334 mtpd, to be built in Zhijiang, Hubei, China.

This project already represents the second plant contracted in China within one year. This plant is also going to use the novel Ultra-Low Energy Design of Stamicarbon and confirms the interest and trust of Chinese producers in this technology. It is truly a radical innovation in energy efficiency, which will lead to about 40% reduction in steam consumption in urea plants. This is a significant reduction in energy costs and therefore in OPEX, whilst also reducing the carbon footprint substantially in comparison with other types of urea plants.

The scope of the contract includes License, Process Design Package (PDP), and delivery of High Pressure Equipment and associated services for the urea plant. The scope of the HP Equipment includes the new design of the Safurex Pool Reactor which was adapted and perfected for the Ultra-Low Energy Design. The finishing will be prilling. Start-up of the plant is expected at the end of 2019.

Topcon Agriculture and Geo-Konzept collaboration

Topcon Agriculture and Geo-Konzept announce a collaboration to distribute the Topcon product portfolio and integrate it with Geo-Konzept hardware and software precision agriculture solutions — in an effort to respond to the rapid developments in the agriculture market and improve the offering in accordance with farmers' demands in Germany, Austria and Switzerland.

The collaboration expands the Geo-Konzept product portfolio beyond retrofit guidance systems, and is designed to benefit farmers with Topcon Agriculture's advanced automation solutions including sensor applications and IoT integration. The focus includes distribution of precision farming solutions for standard applications as well as for organic farming, special crops and vegetable growing.

Fabio Isaia, CEO of Topcon Agriculture, said, "We are very proud to announce our new joint effort. Topcon Agriculture and Geo-Konzept share the same vision for the future of agriculture, especially regarding the adoption of new IoT technologies. Together, we will be able to offer a stronger portfolio of products and solutions to meet our customers' needs and support them in the best possible way. This is a perfect match that will boost our business in the European market."

Thomas Muhr, CEO of Geo-Konzept, said, "Our professional customers expect us to be at the leading edge of technology. While automated guidance still is among the more popular technologies of the markets we serve, our clients expect us to further integrate hardware solutions with the increasing amount of data they have to handle on their farms. Our staff of specialists with more than two decades of experience always works close to our customers. This is seen as a prerequisite for success in a demanding market, which strongly depends on the availability of systems and infrastructure. Our partnership with Topcon Agriculture will be very beneficial for all segments of our market in this respect."

STRABAG awarded tunnelling contract for Sirius Minerals' North Yorkshire polyhalite project

Sirius Minerals has entered into a design and build contract with STRABAG AG for the construction of the first drive of the mineral transport system (MTS) tunnel between Wilton and Lockwood Beck. The section to be built by STRABAG is part of a 37 km tunnel with a diameter of 4.7 m for a low environmental impact conveyor system to transport the mined polyhalite from Woodsmith Mine near Whitby to Wilton on Teesside for processing. Site mobilisation is to begin immediately.

The announcement came as the company announced its quarterly update, which stated that the project remains on track to deliver first polyhalite and commercial production on time and on budget.

Chris Fraser, Managing Director and CEO of Sirius, commented: "It is an exciting time for the Company as we continue to construct our game-changing Woodsmith Mine which represents the largest private sector investment in the North. The infrastructure we're building will allow us to create thousands of jobs, deliver economic benefits for the local and national economies for generations to come, whilst at the same time both delivering value for our shareholders and playing our part in improving fertilizer practices around the world.

"STRABAG brings with it world-leading tunnelling experience, a can-do attitude and another significant, well-aligned partner committed to the success of our project. We are now looking forward to adding progress on our mineral transport system to the impressive progress we have already made on early works and mine shafts."

STRABAG is one of the world's leading civil engineering and tunnelling contractors. The company is part of a consortium that last year was awarded two lots for the HS2 high-speed rail line, and also recently worked on the 57km Gotthard Base Tunnel (the longest railway tunnel in the world).

"We undertook a competitive tender process in respect of drive 1 of the Mineral Transport System, from Wilton to Lockwood Beck, to ensure that the best tunnelling option was developed," said Simon Carter, Chief Development Officer at Sirius Minerals. "STRABAG provided a compelling offer in terms of price, schedule, safety management and risk allocation."

Sirius continues to work closely with a number of parties in relation to the second and third drives of the MTS (Lockwood Beck towards Woodsmith and Woodsmith towards Lockwood Beck respectively) with a view to having these scopes of work awarded in conjunction with the completion of the stage 2 financing later this year. The Company is aiming to achieve first product from the mine by the end of 2021, ramping up to an initial production capacity of 10 mn t per annum (Mtpa) by 2024.

EU talks on cadmium begin

Final talks have taken place at the European Commission in Brussels on proposals to cap the amount of the toxin cadmium in fertilizers.

As part of the EU Circular Economy Package, the European Commission presented in March 2016 new rules on organic and waste-based fertilizers in the EU with an objective to boost the use of recycled materials in fertilizer production.

The EU executive also aims to introduce harmonised rules on fertilizer production, including limits on contaminants such as cadmium. However, the final limit of cadmium has sparked an intense debate in trilogue meetings between the Commission, Parliament and member states.

The Commission proposed a limit of 60mg/kg for three years after the rules take effect, then down to 40mg/kg after nine years and 20mg/kg after 12 years.

The European Parliament has suggested a final limit of 20mg/kg after 12 years while the EU Council's initial position is a limit of 60mg/kg after 8 years.

OTHER EUROPE

Yara sales volumes hit by application delays in Europe

Fertilizer application delays in Europe contributed to a reduction in Norwegian fertilizer producer Yara's sales volumes in Europe, the company said. Colder than normal weather in Europe increased energy costs, but margins for all of Yara's main product groups were up on the year, more than offsetting the higher gas prices. "The operating environment for our business remains tough, and we expect fertilizer markets to stay supply-driven for some time yet," chief executive and president Svein Tore Holsether said today. Total fertilizer deliveries by Yara, its joint ventures and third-party sources fell by 7% on the year to 5.93mn t in the first quarter of this year. Only urea deliveries rose on the year, while nitrate, NPK compounds, NPK blends, UAN and others — comprising MOP, SOP, DAP, SSP and CN — all fell.

EuroChem produces first test product at Usolskiy potash project

EuroChem Group AG has announced the successful test production of potassium chloride at EuroChem-Usolskiy Potash in the Perm region, Russia. This initial production is an integral part of the commissioning process currently underway at Usolskiy. Production of first marketable product is expected during the second quarter of 2018, as previously guided.

Potassium chloride, also known as Muriate of Potash or MOP, is the most commonly used potash fertilizer in agriculture.

Once fully operational, Usolskiy's Phase 1 will have a total annual production capacity of 2.3 mn t of MOP. Eight continuous mining machines are working underground at Usolskiy, which is expected to employ about 2,000 people once production is fully underway.

Dmitry Strezhnev, EuroChem CEO, commented: "The test production of MOP means we have come closer to the start of regular production at Usolskiy, which has been a substantial and complex greenfield project. We are now focused on completing commissioning and ramping up to commercial production, targeting about 450,000 t of finished product before the end of the year."

EuroChem is mining sections of the Verkhnekamskoe potash deposit in the Perm region, one of the largest in the world. As well as the Usolskiy Potash project, EuroChem holds a licence to develop the Gremyachinskoe deposit in the Volgograd region of Russia, known as the VolgaKaliy potash project. Development at VolgaKaliy continues and first production of marketable product is expected later this year. To date, EuroChem has invested about USD4.13 bn in the two projects, of which Usolskiy has accounted for USD1.81 bn.

Acron's urea output at Veliky Novgorod hits an all-time high

Based on March results, Acron's urea unit in Veliky Novgorod reached a monthly record high of 95,910 t, exceeding the target figure by 5,210 t or 5.7%. Daily output has been consistently over 3,000 t. This success can be attributed to measures to stabilise the operation of urea units 1-4 and 5, as well as equipment upgrades and shorter maintenance periods.

Acron has been implementing a programme to upgrade its urea units to increase output and meet the growing demand for AdBlue urea, which is used to produce Aus-32, an environmentally friendly and increasingly popular fuel additive.

Acron is building a 600-tpd urea unit six at its Veliky Novgorod site. Once the modernisation of the existing units is completed

news in brief

and the new unit is commissioned, total capacity will reach 3,650 tpd, and annual output will be considerably in excess of 1 mn t.

NORTH AMERICA

Yara reports improved margins but lower deliveries

Yara International ASA delivered lower first-quarter results compared with a year earlier. Net income after non-controlling interests was USD116 mn (USD0.42 per share), compared with USD201 mn (USD0.73 per share) a year earlier. Excluding currency translation gains and special items, the result was USD0.42 per share compared with USD0.59 per share in the first quarter 2017.

First-quarter EBITDA excluding special items was USD377 mn, down 5% compared with a year earlier as lower deliveries, higher energy costs and a weaker US dollar more than offset the impact of higher prices.

"Yara reports lower results, as both our volumes and energy costs were impacted by the cold weather in Europe which has delayed planting and fertilizer application. On the positive side, our improvement program is on track," said Svein Tore Holsether, President and Chief Executive Officer of Yara.

"The operating environment for our business remains tough, and we expect fertilizer markets to stay supply-driven for some time yet. We therefore continue to focus on improving our operations and delivering our committed growth projects," said Holsether.

Total fertilizer deliveries were down 7% compared to first quarter 2017 driven by lower deliveries in Europe and Brazil. Industrial deliveries were in line with last year. Yara's ammonia production was 13% higher than first quarter last year, while finished fertilizer production increased by 2%. Margins improved compared with a year earlier, with higher realized prices for all main product groups, more than offsetting the effect of higher gas prices in Europe.

The global farm margin outlook and incentives for fertilizer application are showing signs of improvement, with the FAO cereals, meat and dairy price indices all at higher levels than a year ago. However, European first-quarter nitrogen industry deliveries were down by an estimated 22% compared with a year earlier and Yara expects full-season nitrogen industry deliveries to be down by 3-5%. Based on current forward markets for oil products and natural gas, Yara's spot-priced gas costs for second and third quarter 2018 are expected to be USD90 mn and USD70 mn higher than a year earlier.

The Yara Improvement Program is on track to reach at least USD500 mn of annual EBITDA improvement by 2020, of which USD275 mn has been realized as of first quarter 2018.

Nutrien announces rebrand to Nutrien Ag Solutions

Nutrien Ltd. has announced the launch of its newly branded retail business, Nutrien Ag Solutions. The name Nutrien Ag Solutions will align the retail businesses across the globe and strengthen the long-term mission of helping growers to increase food production in a sustainable manner.

"Our goal is to create a consistent global Agriculture Brand that represents value and productivity for our customers," said Chuck Magro, President and CEO of Nutrien. "As the leading provider of crop inputs, services and solutions, Nutrien Ag Solutions will continue to work side by side with our grower customers to maximize crop production and their returns."

The name change will apply to all offices and operating facilities in North and South America that hold the names: Crop Production Services, Agroservicios Pampeanos and Utilfertil. The official change to Nutrien Ag Solutions will begin on July 1, 2018.

"We're extremely proud of the retail organization we've built," said Mike Frank, President of Nutrien Retail. "To ensure we meet our grower customers' evolving needs, we will continue to partner with key suppliers and to invest in best-in class technology, platforms and tools. We will have more news on our enhanced digital platform and other investments in the coming months."

Yara and BASF open world-scale ammonia plant in Texas

Yara International ASA and BASF today celebrated the opening of a new world-scale ammonia plant in Freeport, Texas, US. The USD600-million, state-of-the-art facility uses a cost-efficient and sustainable production process, based on by-product hydrogen instead of natural gas.

Yara Freeport LLC is owned 68% by Yara and 32% by BASF. The plant, located at BASF's site in Freeport, has a capacity of 750,000t of ammonia per year. Each party will off-take ammonia according to their ownership share.

"Together with our partners at BASF, we built a world-scale ammonia plant that not only raises the bar in terms of safety, efficiency and quality but also applies the principles of industrial symbiosis by using a by-product as feedstock for ammonia production," says Yara President and CEO, Svein Tore Holsether. "Yara Freeport strengthens our leading position in the global ammonia market and expands our production footprint in North America."

"This joint venture with Yara not only strengthens our production Verbund at the Freeport site, it demonstrates BASF's commitment to investing in North America," said Wayne T. Smith, member of the Board of Executive Directors of BASF SE and Chairman and CEO, BASF Corporation. "The new plant allows us to take advantage of world-scale production economics and attractive raw material costs to strengthen the competitiveness of our customer value chain in the region."

Conventional ammonia plants use natural gas to produce the hydrogen needed during ammonia production. Yara Freeport's hydrogen-based technology allows the plant to forego this initial production step, leading to lower capital expenditure and maintenance costs. By using hydrogen, which originates from the production processes of various petrochemical plants nearby, Yara Freeport safeguards resources and mitigates environmental impact.

A long-term supply agreement for hydrogen and nitrogen with industrial gases company Praxair Inc. links feedstock cost to the advantageous natural gas prices on the US Gulf coast.

BASF will use its share of ammonia off-take to produce polyamide 6, which is commonly used in the production of carpet fibers, packaging and casings for the wire and cable markets. Polyamide 6 for injection molding is used in high-performance engineering plastics for automotive applications. Yara will market its share of ammonia to industrial customers and the agricultural sector in North America. To support the new plant, Yara built an ammonia storage facility at Port Freeport. BASF upgraded its existing terminal and pipeline assets.

SOUTH AMERICA

Canpotex opens Sao Paulo office as Vale exits fertilizer industry

As Brazil's largest mining company exits the fertilizer industry, Canada's leading potash exporter is ramping up its operations in South America's largest agricultural market.

Canpotex Ltd., the Saskatoon-based company that sells potash from 10 Saskatchewan mines to farmers around the world, is expected to announce the opening of its first office in Brazil on Monday. In an interview, Canpotex chief executive Ken Steitz said expanding its sales effort in Brazil is part of a USD1-billion investment to better position the Canadian company as a dominant fertilizer supplier to a country that's expected to lead the world in food production over the next three decades.

The new Sao Paulo-based sales team is led by Talita Arcaro, hired in October as Canpotex's managing director in Brazil. Ms. Arcaro previously worked for a major domestic fertilizer distributor and the Brazilian arm of a Morocco-based fertilizer producer. She was born and educated in Brazil.

Brazil is the world's largest importer of potash and Canpotex is beefing up its presence after Rio de Janeiro-based Vale, one of the world's largest mining companies, disappeared as a competitor.

Vale sold its fertilizer division to Minneapolis-based Mosaic Co. for USD1.4 bn in a deal that closed in January, more than a year after it was announced, as part of a restructuring aimed at paying down debt. The unit included the largest potash mine in Brazil.

ASIA

Korea Zinc's 2017 refined zinc production decreases

Korea Zinc announced in its financial results that sulphuric acid production at its Onsan plant totalled 1.24 mn t in 2017, down by 10% on 2016 levels.

Volumes from Sun Metals' smelter in Townsville, Australia were at 443,600t, down by 2% on 2016. Output from Young Poong's acid unit was 715,900t in 2017.

Both Korea Zinc and LS-Nikko Copper completed respective unplanned and planned works in the past week.

Korea Zinc will undergo a government mandated 20-day shutdown in June, resulting in a loss of around 20,000t of acid production.

Fauji Fertilizer gets approval to invest USD121 mn in Thar Energy Limited

Fauji Fertilizer Company (FFC) Limited board has given go-ahead for an investment of USD121 mn in Thar Energy Limited (TEL).

The decision has been taken by FFC further to its decision to invest equity in TEL amounting to USD10 mn, taken on January 30, 2018, as a result of which TEL will become an associated company of FFC.

FFC, incorporated in 1978 manufactures, purchases, and markets fertilizers and chemicals in Pakistan and Morocco.

Thar Energy Limited develops, owns, operates, and maintains a mine mouth coal power plant for generation of electricity. The company was incorporated in 2016 and is based in Karachi, Pakistan.

AUSTRALASIA

Sackett-Waconia commissions new precision fertilizer blending facility in New Zealand

Sackett-Waconia has announced the launch of the second Precision Fertilizer Blending facility by Ravensdown in New Plymouth, NZ. The new facility has gone into production this month and will soon be offering its customers custom blends of fertilizers tailored from their soil test results. Using these precise blends in conjunction with precision spreading technology and digital mapping system is all about enabling smarter farming, according to Ravensdown.

The site has enclosed operations for mixing, handling, and bagging fertilizers to reduce dust and prevent trucks tracking product out. In addition, the company says, all storm water on site is collected using a site water capture and bioremediation system to strip nutrients from the water.

Greg Campbell, CEO of Ravensdown, said "We import over 100,000t of mineral fertilizers through the local port each year, supplying 150,000t to approximately 4300 farms. We also have strong control of our supply chain, from the port through our 17 stores across the Western and Central North Island to the farm gate thus ensuring quality, consistency and competitive pricing." The new blending plant is only the second Precision blending facility in Australasia after Ravensdown opened the first at its Christchurch, South Island, site in 2016.

Ravensdown is making great strides in Nutrient Use Efficiency, and Sackett-Waconia looks forward to supporting their endeavours.

Mitsubishi group agrees to take half of Salt Lake Potash's sulphate of potash

Salt Lake Potash has added another partner to its armour after multinational Mitsubishi Corporation agreed to take up to half of the sulphate of potash the West Australian junior plans to produce at a demonstration plant in the Goldfields, for sale into Asian and Oceanic markets.

Perth-based Salt Lake is planning to produce 50,000 t a year of high-quality SOP at its Goldfields Salt Lakes project at the yet-to-be-constructed plant to demonstrate the viability of its resource which covers 3312 sq km of playa surface.

The company says the surface, found in 290sq km of tenements near Wiluna, is amenable to low-cost on-lake construction.

Salt Lake has set a conceptual resource target of 290-458 mn t of contained SOP grading between 4.4 kg per cubic metre and 7.1kg/m3.

So far only one of its nine lakes has a JORC-compliant-resource – Lake Wells – which sits at between 80t and 85t of contained SOP.

Salt Lake's deal with parent company Mitsubishi Corporation and its wholly owned Australian arm Mitsubishi Australia is a non-binding memorandum of understanding which sets out key terms.

Among them are a commitment from Mitsubishi to continue to hold discussions regarding the future funding requirements for the project and market pricing, commission, specifications and delivery mechanisms.

The multi-industry Japanese group will also provide strategic advice on marketing in the region and potentially distribute Salt Lakes SOP in other geographic regions.

Salt Lake Potash chief executive Matt Syme said the offtake deal was an important step for the effort he described as an export project.

"We are very pleased to have taken this important first step in establishing offtake and distribution channels for the Goldfields Salt Lakes project," he said.

"Our model of distribution partnerships is vital for what is essentially an export project.

"Mitsubishi's global pre-eminence in commodities trading and finance, and longstanding involvement in Australian industry, give us great confidence that we can build a very cohesive and beneficial partnership over time. Their interest is a strong endorsement of the market outlook for SOP and also of our plans to supply these markets."

Salt Lake's chief Mr Syme also tipped more offtake agreements for the West Australian company.

"We anticipate one or two more potential distribution agreements and we believe our patience in aiming for the very best channels and markets is the right approach," he said.

The company's market capitalisation hit USD110.6 mn on the news. The Salt Lake's December half-year accounts, released on 16 March 2018, revealed the company had USD10.5 mn cash on 31 December after making a USD5.35 mn loss during the half-year.

'HydroPotash'

A new chloride-free potassium fertilizer

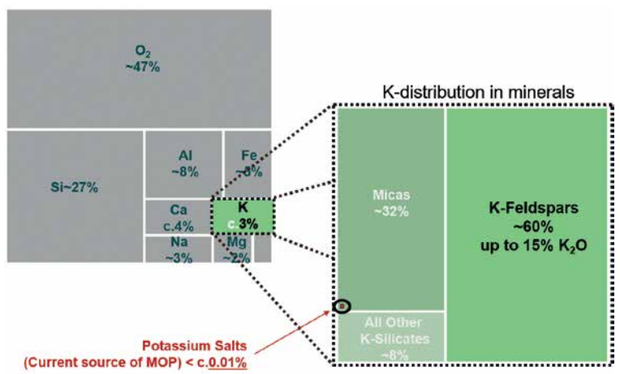
by **Brian Spatocco**, Chief Technology Officer and **Philip Wender**, Managing Director, Advanced Potash Technologies, United States/Brazil

The early days of modern agriculture, with a focus on measured and intentional fertilization of crop-producing land, reads much like a war-time novel. It is a whirlwind tale of get-rich-quick speculation and development, imbalanced international trade and national security imperatives. In his book, 'The alchemy of air: a Jewish genius, a doomed tycoon and the scientific discovery that fed the world but fuelled the rise of Hitler', author Thomas Hager details the empires built and levelled and the resulting societal inflection point brought about by the invention and scaling of the Haber-Bosch process. This process, used to fix nitrogen from air into ammonia, is often regarded as having been a primary ingredient in the global population explosion from 1.6 billion humans in 1900 towards over 7.5 billion today.

Although the scale of the impact might not have been fully anticipated by Haber and Bosch then, the ability to produce fixed nitrogen economically at-scale all over the globe has not only been a great levelling force in global agriculture, it has also proverbially been the rising tide that has helped elevate the health and welfare of our entire species. What was once a great luxury and tool of only rich global superpowers (principally the US and Europe) has now become a fundamental commodity input of economies with GDP per capital spanning two orders of magnitude. The story of modern agriculture is therefore very much a story of globalizing crop inputs so that they can be produced, sold and consumed in every corner of the planet.

It is this lesson that inspired the work at Advanced Potash Technologies (APT) seven years ago when, while touring potassium-rich feldspar deposits in Brazil, the founding team realized that the potassium market still looked very much the same as nitrogen had over 100 years ago. Whereas nitrogen and phosphorus are made from inputs, air and apatite respectively, which are the most abundant globally, potassium is still principally derived from geographically scarce and globally rare sylvinite resources.

Figure 1. K-Feldspars (Kfs) contain 60% of all K resources on earth's crust



Source: K-Feldspar Deposits: Location of Kfs rich rock deposits based on general public information and geological data obtained using proprietary methodology.

Potash development

The predominant product, muriate of potash (MOP), although being a vast improvement from early 'pot ash' fertilizers derived from combusted biomass, is highly geographically constrained. This, in turn, drives burdensome logistical costs resulting from the fact that all significant production sites are located in the northern hemisphere while many of the planet's largest and fastest growing agricultural economies are located close to, or south of, the equator. These costs are often passed on to the farmer.

The current state of the industry, being predominated by MOP and therefore geographically constrained, led to a natural question at APT: What if we could make a potassium fertilizer from the world's most abundant source of potassium - feldspar?

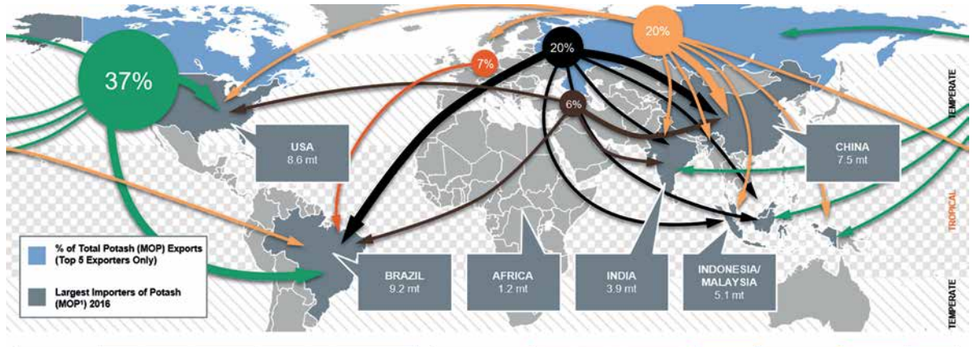
In addition, given that high-grade potassium feldspar (KAlSi3O8) deposits tend to be very pure and homogenous, the opportunity to create a premium chloride-free fertilizer also appeared within reach. The key, then, was to find a new processing pathway for making this potassium available.

> *"MOP is highly geographically constrained*

Inventing a path forward

Unsurprisingly, in addition to potassium fertilizer taking a prominent place in the academic and patent literature, the pursuit for alternative potassium fertilizers is not without

Figure 2. The top 5 groups, all located in the northern hemisphere, supply 90% of the traded market

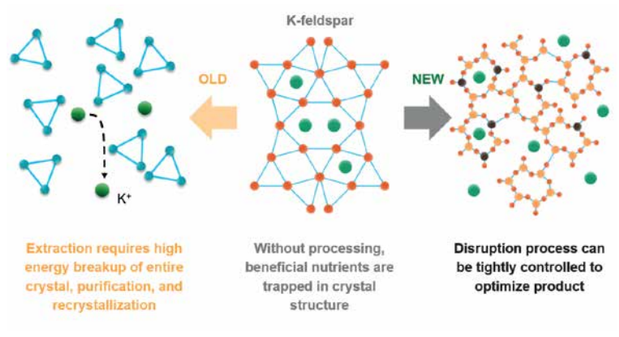


	Producing Countries	Major Producers
Potash	9	5 groups control ~90%
Phosphate	~40	10 groups control 45%
Nitrogen	~60	10 groups control 19%

Producer Country Pct World Prod.	Nutrien/Mosaic Canada 37%	Uralkali Russia 20%	Belaruskali Belarus 20%	K+S Germany 7%	ICL Israel 6%

Source: Map: Export Routes: ICIS Fertilizer Trade Map (https://www.fertilizer.org/GlobalFertilizerTradeMap); Export / Import Tonnages:Fertecon as of 2017
¹ Muriate of Potash (MOP) which represents ~91% of the global K-fertilizer market per K_2O.

Figure 3. APT's breakthrough focuses on disrupting the crystal structure just enough to allow plants' roots to do the rest of the work.



significant precedent. In fact, in the last century, over 100 papers and patents have focused on the extraction of the potassium element or simple salts from high-grade potassium feldspar ores. What characterizes most of these attempts, ranging from work by Thomas Edison in 1922 all the way to modern research is a preoccupation with the full extraction of the potassium element from the alumino-silicate structure. Due to the high bond strengths exhibited by alumino-silicate crystalline structures, such an extractive goal often translates into high temperatures, pressures, and/or times. The result is a process which incurs significant cost in terms of plant CAPEX as well operational inputs such as heat or electricity.

What makes the approach recently taken by APT different from all previous attempts is that the research question posed by the founders and investigated by the team at the Massachusetts Institute of Technology (MIT) was rather 'how does one disrupt the crystal structure just enough in order to make the potassium available to plants.'

The answer to the availability question, when compared with the extraction question, is the fundamental difference that allows recently discovered approaches to yield the first truly economically scalable method of producing a chloride-free potassium fertilizer.

Figure 4. The HydroPotash production process is a simple hydrothermal reaction run according to specific parameters. The process produces no byproducts or waste.

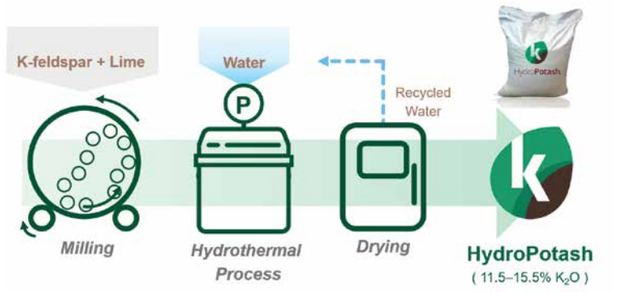


Figure 5. HydroPotash's diverse composition drives the many unique properties of the fertilizer. This composition can be tuned via processing variables and so the properties can likewise be adjusted.

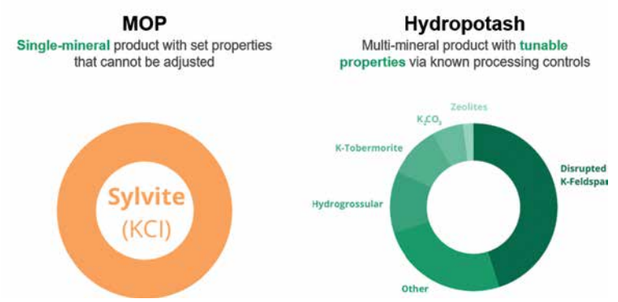


Figure 6. One of APT's K-Feldspar deposits (Brazil). These deposits occur on the surface of the earth and are easily mined via open pit operations as compared to deep drilling with sylvanite evaporites.

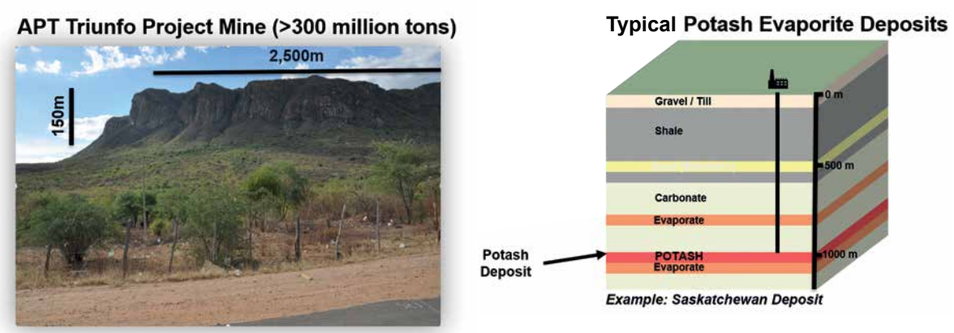


Figure 7. APT has several concurrent field-scale trials of its products occurring with various farms and cooperatives in Brazil.

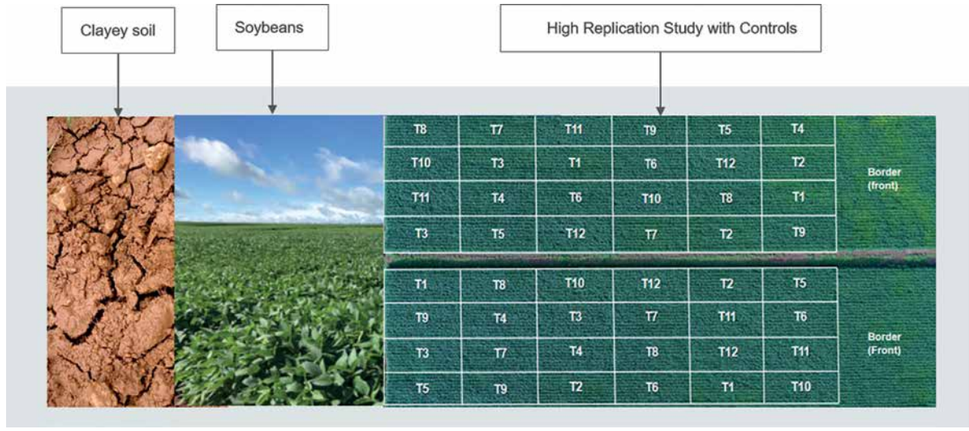
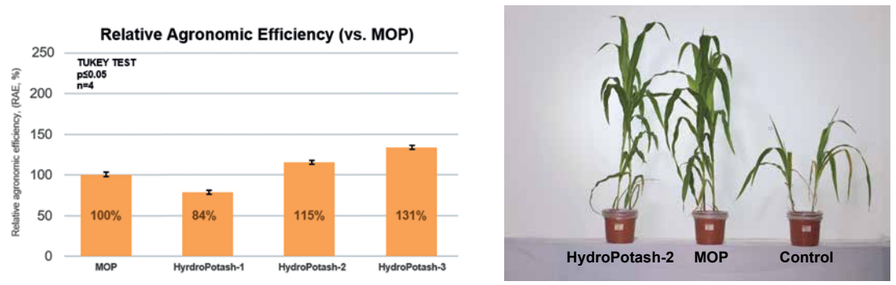


Figure 8. Representative results of three subsequent generations of HydroPotash tested against MOP as well as control.



The product, known as HydroPotash, is chloride- and salinity-free, provides multi-stage potassium release, does not suffer from leaching losses and creates no by-product as a result of the production process other than water vapour. In addition, HydroPotash is an excellent source of silicon and calcium, has an extremely high CEC, and is microbiota friendly. This wide variety of beneficial properties is the direct result of the fact that HydroPotash is not a single-mineral product as is the case with incumbent MOP and SOP. Rather, HydroPotash is composed of a diversity of mineralogical phases and microstructures that each contribute in unique ways to the product's performance. What this means is that, rather than being beholden to the fundamental properties of a single component as with MOP or SOP, a producer of HydroPotash is instead able to tune properties by changing the relative proportions of the phases or the presentation of the material structure. The control of processing parameters to control product properties is an area that has been exhaustively studied by APT and is captured in recent patent publications which APT has worldwide exclusive

> *"HydroPotash is free of both chloride and saline*

license to. This production process is now being scaled up in partnership with a Tier-1 EPCM firm. Studies are ongoing this summer with a pilot plant target of 2019.

Parallel to process development, APT has worked over the last seven years to identify and acquire top grade ultra-potassic feldspar resources globally. These resources tend to have between 11.5-15.5% K2O. Although the grade is lower than that presented by MOP (60%), the ability to locate these resources close to agricultural centres and simultaneously exploit a simpler processing route results in prices that are competitive with MOP on a K2O basis. In addition, although the farmer will have to apply more HydroPotash, the ability of the product to withstand leaching and the long-term impact of the multi-phase material mean that a farmer will see more impact per point of potassium than with highly soluble salts. The end result is a product with a competitive price point to MOP but the premium benefits of SOP.

The proof is in the plant

The final and most critical metric is how plants perform when utilizing such feldspar-derived fertilizers. Over the last two years APT has undertaken significant greenhouse and field testing of various product formulations, with a variety of crop and soil types, and against a diversity of incumbent products.

By summer 2018, nearly 6,000 pots will have been tested in controlled greenhouse experiments and nearly 100 hectares planted. Results have consistently shown equivalent or better agronomic performance against MOP when dosed with identical amounts of K2O. Unlike many other rock-powder based fertilizers with low grade or very slow leaching, HydroPotash outperforms many types of incumbent products, likely owing to the additional properties and nutrients offered by the complex mineralogy.

Many of these interactions between the product and the soils, roots and microbes instrumental in plant growth are still being mapped out. In addition to supporting higher crop yields, it is believed that HydroPotash may also permanently improve soil quality via the augmentation of organic matter, improved water retention during dry periods, a stronger pH buffering capacity, reducing nitrogen run-off as well as the ability to absorb and trap heavy metal contaminants that may prohibit the use of certain lands.

The opportunities to utilize this new form of chloride-free potassium fertilizer are numerous, however the key property which makes HydroPotash a potential game-changing product is not one that can be measured by a laboratory tool or harvested at the end of a crop cycle. Most importantly, the ability to produce a premium potassium fertilizer close to farmers and which satisfies the needs of that regional agricultural economy is an advancement which mirrors that of nitrogen. Creating a cheaper product that is physically closer to those farmers, who previously used little or none because they could not afford potassium nutrients, will fundamentally change the way the world feeds itself. ■

Figure 9. HydroPotash held up to 80% of the Cd previously adsorbed, while mica desorbed almost 75% of adsorbed Cd.

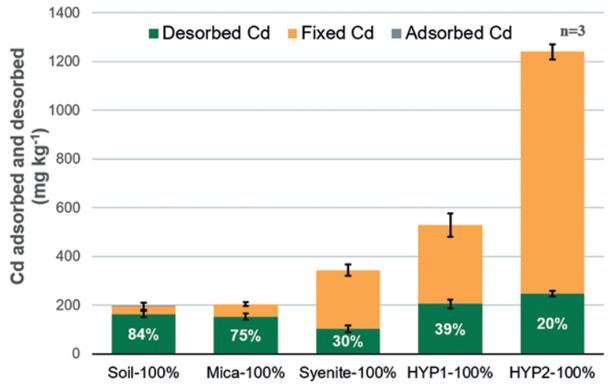
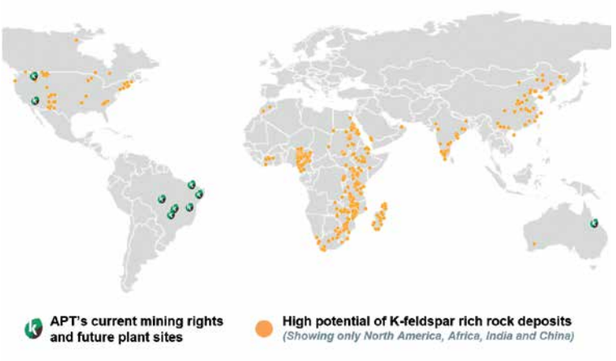


Figure 10. APT's global footprint. In addition to current mines, APT has identified key resources globally that occur close to large areas of agricultural activity.



Price watch

NITROGEN

Indian buying supports the market

Urea prices declined through March and first half April, but received an unexpected boost from an Indian tender that closed on 10 April, which surprised both in quantity and in price terms.

Indian agency IPL purchased 1.1mn t of urea under the tender, some 300,000-400,000t more than expected and, at USD260-265/t cfr, about USD5/t higher than expected.

While the Middle East producers benefited most from the Indian demand, the large tonnage bought meant that traders also bought extensively from Algeria and the Baltic, removing inventory pressure in those areas. Egyptian and AG producers are also covering around 300,000t of sales in Ethiopia for April-May shipment.

But prices are firmer east of Suez than west. The US market has disappointed for a second year running and Brazil is in low season.

Cold and wet weather has had a large impact on fertilizer prices over the past month, delaying the start of spring application in North America and Europe. European and Turkish demand is re-emerging for May and will absorb most of the Egyptian urea available. Prices are in the USD240s/t fob Egypt for May and should at least hold.

Traders have largely given up hope of a rebound in US prices for 2018.

The US market appeared short of urea going into March, but lack of demand on account of the weather has meant the shortage has never been felt in the market and prices declined through March and first half April. Corn plantings are forecast lower in 2018 and overall nitrogen demand may fall. US producers are already seeking urea export business.

It is also notable how successful Asian buyers have been in rejecting higher prices proposed in the absence of Chinese urea. Cfr prices for granular urea have fallen from in southeast Asia from the mid-USD280s/t at the start of March to around USD270/t cfr.

Chinese exports are not expected to resume in any significant quantity before July.

Domestic prices are equivalent to around USD300/t ex-works, some USD20-30/t above cfr values in Asia. Production rates have risen to 64-65% of capacity, but are not expected to rise much more. The local market is, therefore, much more attractively priced and can absorb all the urea being produced for another 2-3 months.

Overall urea usage declined in China in 2017, falling by an estimated 3mn t according to industry sources. Production was 53.4mn t and exports 4.7mn t, giving an apparent consumption of 48-49mn t before stock adjustments. Production is forecast to fall to around 52mn t in 2018.

The period in which China exercised a major influence on the international urea market appears to be over, unless it becomes a big importer. At present, imports are not workable.

PHOSPHATES

DAP firms on tight Chinese supply, MAP softening

Phosphate prices largely firmed over the past few months as DAP supply was constrained by the Chinese domestic season, and the MAP market west of Suez was tight.

The Indian budget announced in late January was viewed as pro-farmer and the decision to implement a minimum support price for kharif crops was thought to lead to a boost in fertilizer consumption. But Indian DAP importers were reluctant to step into the market with Chinese supply tight and offers high. The nutrient-based subsidy (NBS) for the 2017-18 fertilizer year had rendered imports over USD405/t cfr India unworkable. Prices were accordingly flat at USD400/t fob, but quickly increased to USD420/t cfr a month later following a Saudi sale in the face of low DAP stocks in India. Importers' unwillingness to buy in the face of high prices had left stocks at just over 200,000t at the end of March, according to provisional data, the lowest level this fertilizer year.

But there was clarity on the NBS for the 2018-19 season at the end of March with the DAP subsidy increased by around USD22/t. This resulted in a flurry of purchases in the first half of April in the low/mid-USD420s/t cfr India totalling around 335,000t. Importers largely sourced DAP from Saudi Arabia, Jordan and Russia as Chinese producers maintained high offers.

The Chinese DAP price was largely notional over the period as suppliers focused on the domestic market through to the end of March, where DAP traded at a premium to the export market. Offers were held by producers at USD415/t fob, and the price climbed as export offers increased to USD420-425/t fob following regional sales in the mid/high-USD410s/t fob. By April, the DAP price had slipped from USD410-415/t fob to USD405-410/t fob as around 500,000t headed to the ports for export.

Elsewhere on the Indian subcontinent, the Pakistan DAP market was subdued as stocks were healthy at 215,000t by the end of February – compared with 59,000t at the

end of the month last year. DAP price levels were flat at around USD425/t cfr, before rising to the high-USD420s/t cfr following a Chinese sale to Engro and OCP's sale to Pakarab. The central bank's decision to devalue the rupee from Prs110/USD to Prs116/t at the end of March weakened import demand further.

On the supply-side, Saudi Arabian producers were best placed to take advantage of the Chinese producers' high offers. Saudi DAP firmed from around USD410/t fob to the USD413-423/t fob range following Sabic's sales into India and Ma'aden's sales into Kenya at the low- and high-end, respectively. The range tightened to USD417-423/t fob after Ma'aden sold 65,000t to Indian buyers in the mid/high-USD410s/t fob. There was around 150,000t of Saudi DAP booked for India in April.

In Morocco, OCP continued to target sales into Europe with DAP priced in a wide range of USD400-435/t fob. This range was held through the period as it sold DAP into the US, West Africa, Europe, Vietnam and Pakistan. The low-end of the range was underscored by Sudan's tender award at the equivalent of USD400/t fob in April, and the high-end was marked by DAP sales to north-west Europe at USD435/t fob. Shipments from Jorf were hampered in March and April with multiple port closures because of bad weather.

In Europe, Eurochem continued to move product from its Lithuanian Lifosa facility to meet spring application demand. The DAP price increased steadily from USD400-410/t fob Lithuania Baltic through to USD420-425/t fob at the end of March as demand in the UK, Germany, Benelux and France increased. Demand began to slow by mid-April, but the producer had allocated its output for the month to northern Europe before the two-week turnaround scheduled in May.

West of Suez, Mosaic's Tampa DAP/MAP price firmed in line with the international market from USD400/t fob to USD413-415/t fob with sales into Latin America. But weakened demand from Brazil and Argentina resulted in the price slipping to USD409-411/t fob Tampa for April shipment after 16,000t of DAP/MAP was sold. This was the first reverse in the Tampa price since October 2017.

In Brazil, the MAP 11-52 price largely tracked offers upwards to USD430-440/t cfr from USD420/t in February. But demand weakened despite the tight supply with first quarter 11-52 imports down by over 50% on the year. The range fell to USD420-425/t at the end of March as Russian and South African product was offloaded and the increased supply of Chinese 11-44 weighed on the market. Weak demand saw the range fall to USD418-423/t cfr by mid-April.

The Russian MAP price reflected the Brazilian MAP market, rising from the low-USD400s/t fob Baltic to USD403-410/t fob. The price slipped through March and April to USD395-400/t fob, reflecting Eurochem's target of USD420/t cfr Brazil.

AMMONIA

Spot market activity picks up after slow start to year

The east and west of Suez markets have diverged at the beginning of the second quarter, with a large amount of ammonia on offer in the west but maintenance and contractual shipments have dried up spot availability in the Middle East and southeast Asia.

After a standoff in spot buying for the majority of the first quarter, the end of March saw a raft of spot activity and fresh inquiries are now steadily emerging for April and May.

The fresh round of buying was instigated by the announcement of the April Tampa price at USD275/t cfr, down by USD30/t on the previous month. The settlement between consumer Mosaic and international ammonia supplier Yara marks the third month of lower prices after peaking at USD355/t cfr in January, and its lowest level since October 2017. The April contract settled USD65/t lower than the prior year period.

This brought several large buyers into the market in the Black Sea, Caribbean and north Africa, with deals reported at USD230-235/t fob for April shipments, pushing the Yuzhny price down by USD40/t on the month. The resumption of several plants in the fourth quarter of 2017 has built up healthy supply levels in all key production hubs this year, and now many of these units face coming offline in an attempt to stabilise the market.

Several outages are scheduled for April in the Middle East and Trinidad, which could maintain current global prices, but sentiment is forecast to remain bearish until significant demand returns.

In Trinidad, the CNC unit has come back online after the producer reached an agreement to resume gas supply from Trinidad's national gas board NCGTT. This will add another 50,000t of availability to the market and reduce the pressure on Koch to fulfil its contractual commitment to OCP from other sources.

The supply and demand balance suggests that western markets are 200,000t long in April, while the east could be over 100,000t short. This trend is supported by fresh inquiries emerging from buyers in the east for western cargoes in early April. The outlook for May and June west of Suez remains heavily oversupplied while eastern markets appear finely balanced.

The official launch date for Indonesia's 2,000 t/d Panca Amara Utama plant remains at the end of April while the BASF-Yara Freeport facility in the US is working towards an April launch. If both come online when projected, at least two more spot cargoes will be available in the market by the end of the second quarter.

But with prices plummeting to around USD220/t in key benchmark markets, several producers are getting close to cost of production and the speed at which production units choose to come offline will dictate any price fluctuations in the three months ahead.

POTASH

Price levels climb in tight market

The first quarter of 2018 was characterised by rising prices for MOP across all the major markets due to limited availability.

The supply-demand balance continues to favour producers. Demand last year was stronger than anticipated in Brazil, the US and Europe for granular MOP, and suppliers have kept a tight order book, with many reporting being fully committed — generally meaning that sales volumes and expected orders have been allocated, and no MOP is available to buy without order cancellations or a reallocation of resources from elsewhere — for months at a time. SQM is fully committed until the end of 2018, and Canpotex until the end of June. Other suppliers report pockets of tight supply, particularly for granular MOP.

Sellers struggled to raise southeast Asia prices in January. But a surprisingly high Indonesian tender result in February caused a rapid rise in prices for standard MOP. The standard MOP midpoint for southeast Asia was USD260/t as of 1 February, but rose to USD275/t by the end of March, comfortably the highest increase in at least five years.

The recent Indonesian Petrokimia Gresik tender that settled at a headline price of USD280-300/t cfr prompted a hike in offer levels in surrounding countries, and higher sales prices where buyers were in the market. Malaysia was not active in February or March, but buyers there expect to be paying significantly more than the previous tender season levels at around USD250/t cfr.

Granular MOP prices in Thailand and Vietnam started February at USD290-300/t cfr, but rose to USD290-305/t on 8 March and have stayed there since. Suppliers have struggled to increase prices for granular MOP recently, as competition between distributors has been strong, compounded by Laotian product undercutting more traditional suppliers' prices.

In Brazil, prices started in December at USD280-285/t cfr, after enjoying a steady period that began in October. But the country has had to endure regular price hikes since, and by the end of March, granular MOP was selling for USD300-

305/t cfr. Demand was strong in February and March, although imports have dipped so far this year, compared with a year earlier.

MOP imports to Brazil have dropped by more than a quarter in January-February compared with a year earlier. Demand may finally be slowing, after a year of significantly higher imports in 2017 compared with 2016. But the market reports strong demand so far this year, and imports could pick up again in the coming months.

In the US, at New Orleans, the fob price for granular MOP started December at USD224-233/st before rising to USD235-240/st by 1 February. The range has widened since, and ended March at USD235-245/st. The market overall remains stable and illiquid, with most market participants awaiting spring planting activity.

The abundantly wet spring in the southeast US postponed spring farmer demand in the region in March. The lack of an early application season in the south pressured retailers in the area to make room for incoming winter fill tonnage ahead of the 31 March offtake deadline. As a result, retail markups in the southeast fell from a typical USD60-80/st to USD20-30/st. Railroad reliability was a major issue, with some Canadian producers seeing constraints in shipping out of mines because of a lack of locomotives or rail cars. The situation impacted both rail shipments for offshore export as well as to the US and continued into April and is limiting order fulfilment.

The northwest European market — which started 2017 at EUR230-245/t cfr for granular MOP — has accommodated several price increases since. Prices were EUR260-265 at the beginning of February. And prices in northwest Europe remain at EUR270-275/t after suppliers failed to raise prices by the target of EUR5/t by the end of March. Expectations are for prices to continue rising during the second quarter, but perhaps not as much as suppliers had initially hoped.

SOP prices in Europe were steady in February-March. Increased MOP prices, used as a feedstock to create SOP using the Mannheim process, could have sent SOP prices up. But supply was ample, which limited suppliers' in raising prices. Prices may rise modestly in the second quarter though.

SULPHUR

Prices soften on limited interest

Sulphur prices trended towards soft between February and March, driven by a seasonal pause in buying activity, maintenance works at key phosphates facilities and continued downward pressure from end-users.

In China, cfr granular prices held steady across February at USD140/t. Business was limited, with end-users citing healthy inventory levels, and most buying interest coming from traders looking to secure cargoes for sale in early March, after the Chinese New Year holiday period. March saw prices initially firm to USD152/t cfr on post-holiday sales, but softened week-on-week later in the month, settling at USD137/t cfr by the close of March with buyers remaining confident of achieving lower prices, and key phosphates producers Kailin, YUC and Hubei Sanning scheduling plant maintenance works as India's Rabi application season concluded.

In India, prices tumbled by USD20/t in early February – to USD130-135/t cfr – against sales to MMTC and IFFCO within this range, but then promptly recovered to the low-USD150s/t cfr the following week, after the award of Paradeep Phosphates (PPL) tender. The end of the sugar season contributed to keeping demand low for domestic tonnes. Rashtriya Chemicals and Fertilizers (RCF) made a few inquiries seeking a 10,000t, but failed to secure an order amid limited offers. Falling sentiment in the global market saw cfr India prices soften to USD145-149/t by the start of April, and further softening is expected on next done business.

In the Middle East, February Official Selling Prices (OSPs) were announced in the range USD119-140/t fob by Mideast Gulf producers, down by USD15-25/t on the month before. Qatari state-owned marketer Muntajat set USD119/t fob Ras Laffan/Mesaieed for March, Saudi Arabia's Aramco Trading set USD120/t fob Jubail, and Abu Dhabi's state owned Adnoc put its March OSP at USD140/t fob Ruwais. In the spot market, Muntajat's February tender was awarded at USD130/t fob Ras Laffan/Mesaieed to a trader, keeping spot prices flat at USD120-130/t fob for the remainder of the month, with limited interest and limited spot availability curbing fob Middle East action.

March OSPs where set in the range USD134-140/t, with producers confident of firmer post-Chinese New Year prices. But buyers resisted, and Muntajat's March tender was awarded at USD125/t fob Ras Laffan/Mesaieed, around USD5/t below the company's previous tender. Spot prices settled at USD115-120/t fob Middle East by the end of March, softening to this level against sales to Brazil's Vale/Mosaic, as well as the announcement of April OSPs at the end of March.

Second quarter contract negotiations have also been keeping spot activity limited, as attention is directed toward settlements. In the Middle East, the UAE's Adnoc is heading towards settling contracts with reports of traders settling agreements so far near the mid-USD120s/t fob, around USD25/t below the company's 1Q settlement prices. Price negotiations with end-users and for other Middle East producers continue.

In Brazil, Vale/Mosaic had secured the majority of its second quarter requirements, with prices indicated in the range USD131-140/t cfr Brazil, for cargoes from the Middle East, US Gulf and FSU regions. Spot prices in Brazil settled at USD132-135/t cfr by the start of April, roughly flat on levels during early February.

For North Africa, spot prices remained relatively static, inching upwards by USD3/t at the start of March following the purchase of ex-Saudi tonnes in the range USD120-132/t cfr. But confirmed business remained muted for the remainder of the month, keeping spot prices flat at this level into April as attention is focused exclusively on quarterly contract negotiations

Contract negotiations remained largely ongoing into April but settlements are widely expected to settle soft on 1Q prices for most markets. ■

Ammonia production is now smarter, safer and more profitable

by **Yawar Abbas Naqvi**, Technology Licensing Manager and Chemicals Technology Licensing, Haldor Topsøe, Denmark

The ammonia and fertilizer industries are changing as the drive for smart industrial solutions that exploit feedstocks in an optimal way continues to intensify. Natural resources must be utilized in the best possible way to secure profitability and reduce environmental impact, but advances have been scarce in the very mature ammonia production technology. Nonetheless, a new solution based on SynCOR synthesis gas technology widely used in the gas-to-liquids industry offers the ammonia industry an opportunity to produce ammonia in a smarter, safer and more profitable way – with significantly reduced environmental impact.

> *"The technology is well-proven in other industrial applications*

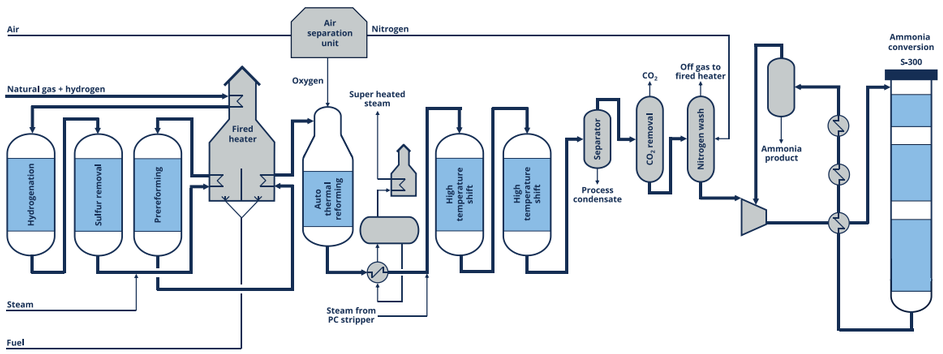
The new solution is based on auto-thermal reforming for the production of syngas in ammonia plants and thereby challenges conventional tubular reforming. The technology brings significant benefits in large-scale applications, most notably an extremely low steam-to-carbon ratio of 0.6 and capacities above 6,000 MTPD in single-train plants. This enables ammonia and urea producers to gain significant economies of scale that cannot be achieved with conventional technology.

Technology shift

Conventional ammonia plants use a high temperature shift followed by a low temperature shift. A standard high temperature shift uses an iron/chromium based catalyst, which demands a minimum operating steam-to-carbon ratio of 2.6. That changed with Topsoe's introduction of the first commercial iron-free high temperature shift catalyst (SK-501 Flex). This catalyst is based on promoted zinc aluminium spinel, which can operate at very low steam-to-carbon ratios at typical high temperature shift conditions, but without the risk of mechanical integrity or by-products associated with iron/chromium catalysts. The zinc aluminium catalyst opens up new possibilities for ammonia producers, as they can reduce their plants' steam-to-carbon ratio significantly with Topsoe's SynCOR Ammonia process.

This solution may be a new opportunity in ammonia production, but the technology is well-proven in other industrial applications, especially within gas-to-liquids. SynCOR Ammonia is based on stand-alone auto-thermal reforming by oxygen and uses well-known and industrially proven process steps and equipment. Today, the combined industrial operation of SynCOR units exceeds 70 years and the technology has demonstrated availability factors

Figure 1. Simplified process sheet of Topsoe's SynCOR Ammonia plant



greater than 99% as an average over operating periods longer than five years.

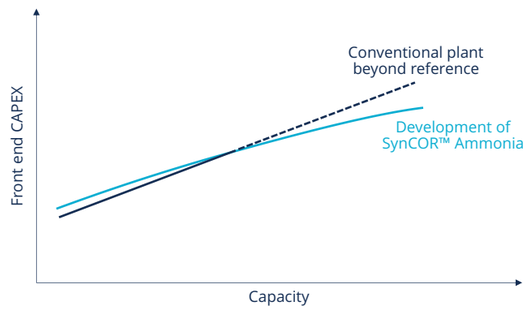
Due to the introduction of the new shift catalyst, the operating conditions are quite different from the conditions in conventional ammonia plants. With only 0.6 steam-to-carbon ratio, the shift section is limited by the low water content to perform the shift reaction, to achieve an acceptable CO slip, and at the same time minimize the formation of by-products.

However, an efficient solution to deal with this low water content, is the introduction of a second shift operated at medium to high temperature in combination with recirculation of steam from the process condensate stripper. Depending on the specific requirement, the second shift catalyst can be SK-501 Flex or a copper-based catalyst.

After the shift section, by-products are condensed out together with process condensate. The solution reduces the well-known problem of especially methanol entering the CO_2 removal section in conventional process layouts. The process condensate and washing water, which contains the shift by-products, flows to a process condensate stripper that strips off practically all shift by-products.

The stripper steam containing the shift by-products is recycled to the inlet of the high temperature shift section.

Figure 2. Comparison between steam methane reformer (SMR) vs. SynCOR Ammonia



Less equipment reduces cost

From a cost perspective, it is critically important to stay within commercially available standard sizes for equipment and piping, no matter the size of the plant. Exceeding standards limits the number of possible vendors and increases cost.

SynCOR Ammonia operates at a steamto-carbon ratio of 0.6, which reduces steam throughput by 80% compared to conventional plants. In combination with an inert-free ammonia synthesis, this makes it possible to significantly reduce the size of piping and equipment throughout the plant. It also enables the use of a single ammonia converter operating at single pressure.

The process uses a standard commercial CO_2 removal unit. However, the CO_2 absorber is relatively smaller than for conventional design because nitrogen is added further downstream.

After the CO_2 removal section, remaining CO_2 and H_2O is removed in a synthesis gas drier unit. Then CH_4, Ar and CO is removed in a nitrogen wash, in which N2 is admitted to the synthesis gas to adjust the hydrogen-to-nitrogen ratio to the level required by the ammonia synthesis. The result is an inert-free synthesis gas, which makes methanation, purge gas ammonia wash, and hydrogen recovery units obsolete and significantly reduces sizes of high-pressure equipment and piping. Furthermore, less power for recycling compressors is needed. The simplified process scheme translates directly into CAPEX and OPEX savings.

The inert-free synthesis loop uses a single S-300 ammonia converter in a standard, well-proven Topsoe ammonia synthesis loop with single pressure level. The required converter size is already referenced.

Figure 1 shows the main process steps, and table 1 provides a comparison of the main differences between a conventional plant and SynCOR Ammonia.

Table 1. The main differences between a conventional SMR based plant and SynCOR Ammonia.

Technology	Conventional ammonia plant	SynCOR Ammonia™
Desulphurization section	Standard	Standard
S/C ratio	3.0	0.6
Reforming section	Tubular steam reformer and air blown secondary reformer	Prereformer and oxygen blown SynCOR™
Shift section	High temperature shift followed by low temperature shift	Two high temperature shifts in series with recirculation of by-products
CO_2 removal section	Standard	Standard
Synthesis gas cleaning	Methanation	Nitrogen wash with purge and nitrogen addition
Ammonia synthesis	Ammonia synthesis loop with purge	Inert free synthesis loop with no purge
Purge gas treatment	Ammonia wash followed by hydrogen recovery	No treatment required
Relative energy consumption	100	97
Relative make-up water consumption	100	40-50
Maximum referenced capacity (Single train ammonia / other industries)	3,500 MTPD / -	4,000 MTPD/>6,000 MTPD

**An equivalent production of 4,000 MTPD*

> *Energy consumption is up to 3% lower*

Economies of scale

The scaling exponent relating to the CAPEX cost of a plant has huge impact on economies of scale and Total Cost of Ownership in the plant's lifetime. SynCOR has a very advantageous scaling exponent in comparison with conventional tubular steam reforming and is referenced within the full capacity range to above 6,000 MTPD ammonia. Tubular steam reforming is beyond reference above 3,500 MTPD (see figure 2 for a comparison).

The SynCOR technology is competitive from well inside the conventional tubular steam reforming capacities and becomes the preferred choice at large capacities because of its referenced single line capacity above 3,500 MTPD and significant economies of scale.

Production cost in large-scale single train plants is reduced by a combination of attractive scaling exponent, reduced steam throughput, inert-free ammonia synthesis, and reduced sizes of piping and equipment. Due to the differences in scaling exponents and CAPEX cost, SynCOR Ammonia becomes increasingly competitive the higher the capacity and the result can be two-digit savings per ton in production cost.

Environment and safety

SynCOR Ammonia significantly improves environmental impact, personal safety and process reliability and has the potential to bring down the number of lost production days.

The overall energy consumption figure for SynCOR Ammonia is up to 3% lower than for conventional designs. In addition, electric power for the air separation unit can be obtained from sustainable energy sources, which will reduce CO_2 emissions per ton of product considerably. The total reduction of CO_2 emissions from natural gas firing and sustainable power sources amount to 30%, when assuming 100% conversion into urea.

NOx emissions are more than 50% lower compared to conventional tubular steam reforming plants.

Another safety benefit is gained from the SK-501 Flex catalyst because it is completely free from chromium, most notably the highly toxic hexavalent chromium found in all iron-based high temperature shift catalysts in the market. This helps plants to avoid the potential risk that hexavalent chromium poses to personnel safety and to the environment during product handling, operation and disposal.

Ammonia producers can also achieve cost reductions as well as safety benefits from the high degree of automation in the SynCOR Ammonia process. The difference in fieldwork from large scale tubular reforming can be as much as two to three persons in favour of SynCOR.

Automation enables remote operation that can lead to fewer human errors and higher efficiency.

The auto-thermal reactor itself requires no fieldwork during operation, and, typically, a simple plant walk-through per work shift is all that is needed to perform surface monitoring. Alternatively, camera surveillance can replace this.

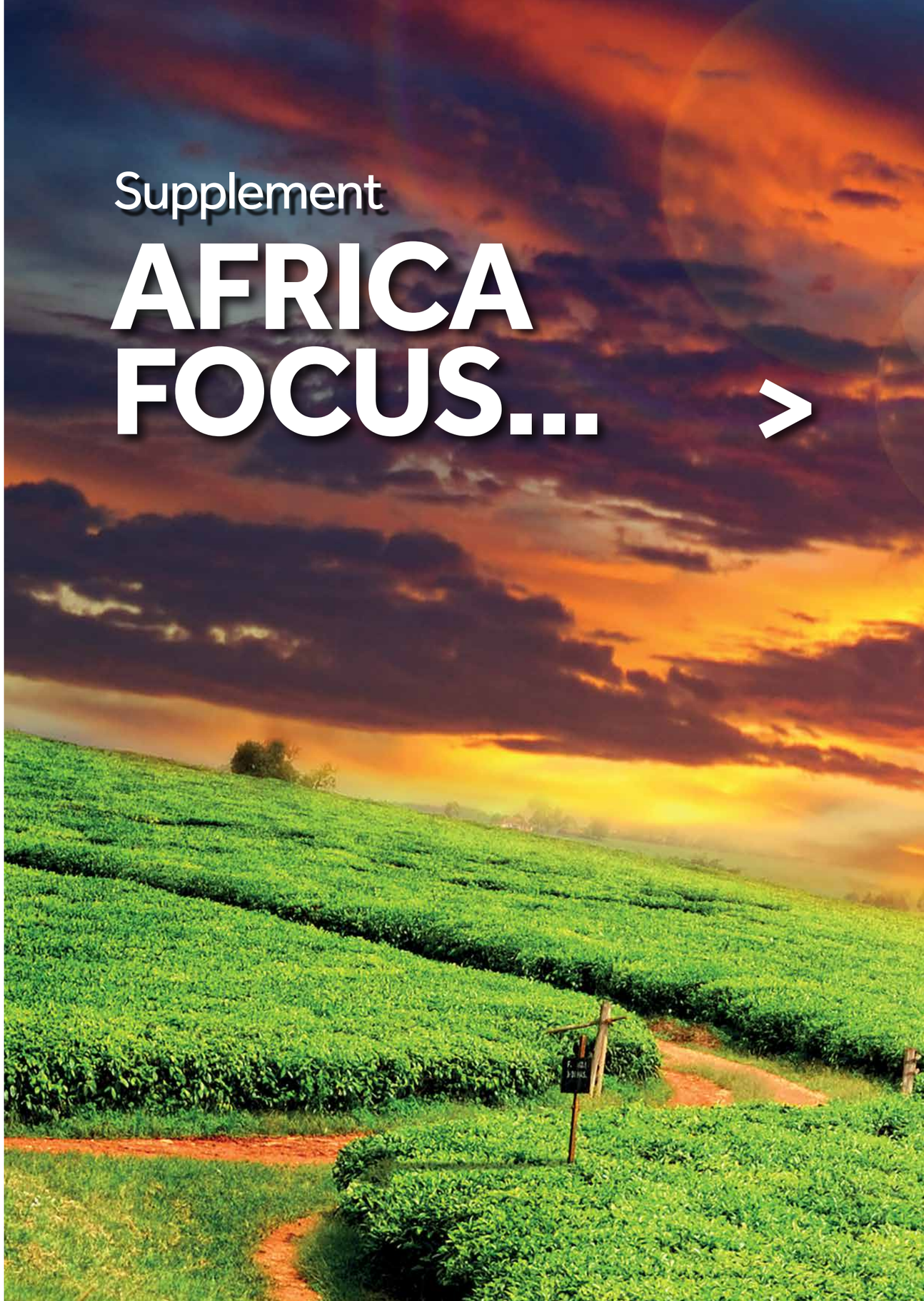
> *Automation can lead to fewer human errors and higher efficiency*

SynCOR Ammonia incorporates a complete integrated Safety Integrated System (SIS), which guides plant operators and ensures safe operation at all times. The number of Lost Time Incidents is reduced, simply because less people are prone to accidents. Fieldwork is turned into control room work with more time spent proactively optimizing performance. The result is a higher general safety level and a better bottom line. ■

Key benefits of SynCOR in ammonia production

- Significant economies of scale – single trains at large capacities
- More than 3% lower operational expenses – 3% lower energy consumption
- Reduced environmental impact – up to 30% lower CO_2 emissions, more than 50% lower NOx emissions, and up to 50% reduction of make-up water consumption
- Increased safety – high degree of automation reduces manual fieldwork significantly

Note: SynCOR™, SynCOR Ammonia™ and SK-501 Flex™ are all registered trademarks of Haldor Topsøe



Balanced fertilizers

The changing face of sub-Saharan Africa's quest for increased productivity

by **Paul Makepeace**, Senior Fertilizer Specialist, African Fertilizer and Agribusiness Partnership (AFAP), Kenya

Over the last five to seven years, there has been a growing awareness and acceptance of the need for a more holistic approach to crop nutrition in Sub-Saharan Africa. Decades of cropping, that has witnessed wholesale removal and minimum replacement of plant nutrients has taken its toll, but it is fair to say the tide is turning.

Failure to feed a growing population is not an option for the developing countries of Sub-Saharan Africa and productivity increases are essential to achieve this rather than the current *Modus Operandi* of cultivating more land. The issues are complex and not unilateral, but core to resolving these issues is addressing the nutrient balances that are required for optimum crop growth. On average, yield responses of 30% can be expected and this can have a significant impact on the ROI at the farm level and the food security of a nation. Balanced nutrition in this context refers to delivering the right quantities of all of the 17 essential plant nutrients to optimize growth. We can split these into issues related to correcting elemental plant needs and correcting soil acidity. While soil acidity is a major problem in Sub-Saharan Africa, with countries having as much as 40% of their agricultural soils regarded as highly acidic, this is on the radar, and has its own development/recification agenda.

Bagtech plant installed, Kenya

Market drivers

The fertilizer landscape has changed significantly in the past 10 years. Global manufacturers are now playing a bigger role in the African fertilizer value chain, being more flexible in their approach to market needs, developing products that better suit the markets, investing in research and development and actively participating in the value chain. Historically the market has been largely a traded market focused on commodity products. Limited investment and participation in the value chain has restricted the knowledge sharing and associated development that comes with participation and the need to define, develop and implement competitive products and services. This is changing and the specific drivers of change vary by country. In Nigeria, the development of export production capacity in urea has seen a rise in blending to maximize the use of domestically manufactured N, In Ethiopia, the government sought answers to the failure of crop responses to increasing rates of N and P and initiated a blending strategy to deliver the potash, sulphur, zinc and boron that was needed. These elements have been shown to be limiting across most of Sub-Saharan Africa. OCP developed compounds that addressed many of these needs as well as the challenges in operating blending plants in the country. In Kenya, Toyota Tsusho took a leading role in building capacity, understanding the market to deliver yield improvements and setting up programmes with local universities to build the understanding. ETG have just commissioned a large blender in the port of Mombasa to service the Mombasa corridor and lever off its skill and knowledge from its wholly owned subsidiary Kynoch Fertilizers in SA. OCP is undertaking projects to support soil mapping, supply of balanced fertilizers, farmer training and agrodealer development. Yara have engaged with development partners providing agronomic support in a more holistic way to ensure small holder farmers, as well as commercial farmers, are being reached.

Future challenges

Development partners understand the importance of building the private sector to ensure sustainability and to lever the skills associated with changes in the global fertilizer industry ensuring technologies that improve nutrient use efficiency, and crop production are on the shortest path to adoption on the continent.

So the challenges in supplying balanced fertilizers range from understanding source products that are available internationally, getting products to users in small quantities for a developing market and determining the best application methods. Other questions that producers are faced with include; whether to use compound building blocks like NPS, NPSZn, granular additions, what chemical forms to use, and whether to coat and granulate and what additives can be used to improve nutrient use efficiency. The options are many and often compromises may have to be made to ensure delivery of some improved products, with the medium term aim of developing productive agricultural systems.

There is a momentum across Sub-Saharan Africa to deliver balanced fertilizer. There is a strong interest by many governments to make this happen. These changes are not without their challenges. Private sector, particularly the international sector, is playing a key role in filling the knowledge gap that has resulted from operating in a trading environment. Policies and distribution systems, output market systems and finance down the value chain are all activities that that need adjustments to ensure the collective delivery of improved productivity. ■

EMT weighcont blender and bagging line, Malawi

AGI-Yargus blending plant, Uganda

EMT weighcont blender and bagging line, Ethiopia

The African Fertilizer Agro-business Partnership (AFAP) is an African Non-Profit organization whose mandate is to support the development of sustainable fertilizer value chains. It achieves this through private sector support, policy support and value chain development.

(left) A view of smallholder farmers land in the Kenyan countryside. ©IFDC

Increasing the use of fertilizers in Kenya

by **Dr. Joshua Ariga**, Senior Economist for Markets, Economics and Policy Unit, International Fertilizer Development Center (IFDC), USA

Kenya is one of the few countries in Sub-Saharan Africa where fertilizer consumption has gained a momentum of its own despite unpredictable government interventions in the market that sometimes sows uncertainty among stakeholders. Total national consumption has increased from 200,000 tonnes in 1990 to the current estimate of approximately 700,000 tonnes of product. Prospects point to even higher volumes in the future. In addition, the country is strategically located on the east coast of Africa making it a gateway to a number of landlocked countries that rely on its infrastructure to procure fertilizers from international sources. Fertilizer in transit to other East African countries come through the port of Mombasa, on Kenya's Indian ocean coast. Kenya, like its neighbours, depends on international markets for most of its fertilizers (imports account for over 90% of these countries' national requirements). Local production is confined to a few blending facilities, although the number is growing.

Therefore, it is not surprising that several domestic and international companies have set up business in Kenya to benefit from opportunities offered by the expanding fertilizer market. The increase in fertilizer use and expansion in business investments did not happen overnight.

The fertilizer market started its initial surge in the 1990s when the government began to relinquish its hold on markets and allowed private investors to import and distribute fertilizers. This transition came about for a number of reasons, including limited public funds to continue purchasing, subsidizing, storing and distributing large quantities of fertilizers across the country, pressure from groups that were affected by the status quo and evidence-based research that showed the harmful effects of government control of these markets. With the liberalization of the fertilizer market, private businesses entered the market at various points in the value chain. A decade later, driven by the private sector, the market was relatively competitive. Gradually, the government also stopped fixing the monetary exchange rates and prices for maize crops, which had distorted markets, dissuaded investors and constricted profits for farmers.

The above narrative shows why it is important to encourage private sector participation and investment in fertilizer markets. Creating an enabling environment that eases entry of new firms develops competitive markets, which has been a crucial aspect of Kenya's significant growth in fertilizer use. However, this has not gone smoothly, with the government implementing some agricultural strategies that have kept the markets on edge and threatened the sustainability of the system.

Kenya is a strategic gateway to a number of landlocked countries that rely on its infrastructure to procure fertilizers from international sources.

Food security

Over 80% of Kenyan farm households in major agriculturally productive regions use fertilizers, especially on chief food and cash crops, such as maize, coffee, tea and horticultural crops. However, not all of these farmers use the right application rates per hectare to satisfy the soil and crop conditions, because most of the farmers are constrained by finances or technical know-how. Most of the coffee and tea is grown for export and so the relatively high returns have encouraged and sustained high volumes of fertilizers for these crops despite other challenges facing the farmers. Kenya's horticultural crops (fruits, flowers and vegetables) have a lucrative market in Europe and other international destinations, which has helped support fertilizer demand for these crops, especially foliar feeds and other specialty fertilizers.

Kenya, South Africa, Ethiopia and Nigeria are the major fertilizer consumers in Africa south of the Sahara desert. It is estimated that approximately 1 million tonnes of fertilizer product is required to meet Kenya's agricultural growth targets as set out in the country's national development plan. Of the current national consumption of nearly 700,000 tonnes of fertilizers, approximately 74%, 13%, 5%, and 7% is applied on cereals (mostly maize), tea, coffee and horticultural crops respectively (this excludes foliar fertilizers mostly used in the horticultural industry and whose national consumption data is difficult to find). The larger proportion applied on cereals is a culmination of food security policies and government subsidies focused on fertilizers meant for growing maize – the main food staple in the country. Part of this focus on maize is related to the distribution of farmer types in the country. Landowners with less than five hectares of land constitute the majority of farmers (estimated at over 80%). Most small holder farmers lead a subsistence life dependent on maize as a food crop. For political reasons, and to ensure food security for the majority of citizens, national agricultural policies have always aimed to encourage maize production to satisfy domestic needs. Despite these efforts, the farmers are net consumers of maize, meaning that the volume they produce is not sufficient to satisfy their household needs, and so they must purchase food from the market during the year.

> *"Most small holder farmers lead a subsistence life*

Market prospects

So, where is the potential for increased fertilizer consumption in Kenya's agriculture sector? The tea industry has its own agency that imports and distributes a particular product for application on tea bushes: NPK 25:5:5:5S. Coffee, on the other hand, uses mostly NPK 17:17:17. Fertilizer

use on these two crops is dependent on expected international prices and distribution costs within the country, which affects retail prices. Like maize, these two crops are grown mostly by small holder farmers, although there is a significant number of larger growers and plantations, some with the ability to market their products to international buyers outside of the small holder value chains. These large farms and plantations also procure their fertilizers either directly or using bids with private sector importers. For maize production, the prevalent fertilizers are DAP, CAN, MAP and urea, which are used on other crops as well. These are purchased primarily from private sector businesses or importers and partially from government-procured subsidized products. The value chains cut across the country with the importers selling to distributors and wholesalers, who then sell to retailers in rural towns and villages where farmers make their purchases. Much of the specialty fertilizers in Kenya are used on the horticultural crops, especially those grown for export. The horticulture industry is one of the top foreign exchange earners for the country. It is made up of large plantations or farms as well as small-scale growers mostly in regions with access to irrigation water sources. Horticulture growers are some of the most informed farmers in the country, dealing with foliar fertilizers and herbicides and other complex products that require technical expertise.

> *“There is a lack of information on the benefits of fertilizer use*

Kenyan farmers are aware of the benefits of fertilizers, but some are hampered from adopting or using optimal quantities by a number of factors, including insufficient funds for purchasing, poor access to markets and long distances to input retail shops. A major constraint to fertilizer use in Sub-Saharan Africa is lack of information on the benefits of fertilizer use due to poor extension services or other unreliable sources of information. Kenya's relatively high literacy level, cellphone communication network, innovative money transfer system and decent road networks have contributed to better access to fertilizers.

A field of maize in rural Kenya. Maize is the main staple food in Kenya, and most smallholder farmers lead a subsistence life based on it. *©IFDC*

State policy

A discussion of Kenya's fertilizer industry is not complete without mentioning state policy regarding fertilizer subsidies and their impact. The fertilizer sector really expanded beginning in the early 1990s, when the government realized that its control of import and distribution of fertilizer was not sustainable due to budgetary constraints and that the government agencies did not have the business skills to deliver products to satisfy farmers' demands. The private sector took over this role as government gradually liberalized the fertilizer sector and stopped fixing maize producer prices at arbitrary levels unrelated to market fundamentals. Since maize is a major consumer of fertilizer, controlling the producer prices had an impact on demand for fertilizers. Although producer prices favoured farmers, since they were generally set higher than market levels, it took more than six months for the bureaucratic state agencies to pay farmers after the produce was delivered to these agencies. This late payment was a considerable disincentive to farmers, who needed the money to pay bills and plan for the next cropping season.

The state withdrawal from the market led to a spurt in private sector growth and greater consumption of fertilizers. But following the 2007/08 global spike in fertilizer prices, the state re-entered the market and intervened by subsidizing fertilizers, fearing that farmers would stop or reduce fertilizer use, leading to poor maize production and generating food insecurity. When the crisis abated, the state decided to provide a targeted subsidy aimed at vulnerable farmers. The subsidy programme was administered without clear guidelines and in an ad-hoc manner that did not provide advance warning or information to the private sector, thus disrupting business

A smallholder farmer stands with her harvested tea leaves. Tea and coffee both provide potential for increased fertilizer consumption in Kenya. *©IFDC*

decisions. Despite this uncertainty, the private sector has adapted to this arrangement, in part because it is clear that the government intervention is not sustainable and also because the programme is so poorly managed its impacts are confined to a small section of the market composed of mostly large farmers.

> *“Some government interventions pose a challenge to the private sector*

Future growth

To summarize, an enabling environment led to increased fertilizer consumption in Kenya, building up investments from the private sector and reaching more farmers than the previous state-run system. However, some continuing government interventions, implemented to ensure food security, pose a challenge to the private sector. Despite the challenge, there is optimism for the sector in terms of (i) a knowledgeable farmer base that understand the benefits of using fertilizer, (ii) good road and communication networks which facilitate access to fertilizers: the newly constructed railway line from the port to the capital city has the potential to reduce transport costs and hence farm-gate prices, (iii) a strong private sector that has thus far withstood government interventions in the market and (iv) farmers beginning to use fertilizers that are right for the crops and soils, with blending facilities that can supply the appropriate fertilizers. Fertilizer consumption in Kenya is poised to continue on an upward trend, but the steepness of the climb will depend on improved coherence of state interventions and avoidance of actions that will damage the progress that has taken decades to build. ■

Sub-Saharan Africa:
The challenge continues

Food security in sub-Saharan Africa remains an important issue, with slow progress seen over the last couple of years. The region continues to be affected by low productivity of agricultural resources, high population growth, political instability and civil unrest.

The region is home to more than 960 mn people, approximately 13% of the global population. The regional population is expected to grow by almost 120% to 2.1 bn people by 2050.

Furthermore, the sub-Saharan Africa region has been particularly prone to recurrent drought conditions, with precipitation shortages having a severe impact on agricultural output owing to the predominance of rainfed cropping and pasture-based livestock systems.

Global food demand is projected to rise by at least 20% globally over the next 15 years, with the largest increases expected in sub-Saharan Africa, south Asia and east Asia. But natural capital is being depleted at unprecedented rates and climate change could severely cut food production, especially in the world's most insecure regions.

Fertilizer usage

Africa is one of the few areas in the world where large tracts of land, suitable for agricultural development, remain as yet unexploited, but some of the biggest barriers to its development include:

- Poor condition of soils
- Poor infrastructure
- High costs

These have prevented farmers from applying sufficient nutrients and maintaining adequate soil fertility. Development of higher yielding agriculture is therefore starting from a disadvantaged position. Sub-Saharan Africa produced less than 10% of its own fertilizer nutrient requirements in 2015. To achieve higher fertilizer consumption targets, sub-Saharan Africa is developing fertilizer policies and regulations, including the use of subsidies and assistance with financing. The importance of supply corridors has also taken a higher profile, using improved entry ports and logistics development to improve access to fertilizers for farmers.

The challenge facing the agricultural sector in sub-Saharan Africa is weak infrastructure – including transportation networks – limited access to energy, and a lack of irrigation systems and stockholding facilities. But strategic investment by the public and private sectors has the ability to improve the agricultural prospects of the region.

Figure 2. Countries covered in Argus Fertilizers in Sub-Saharan Africa

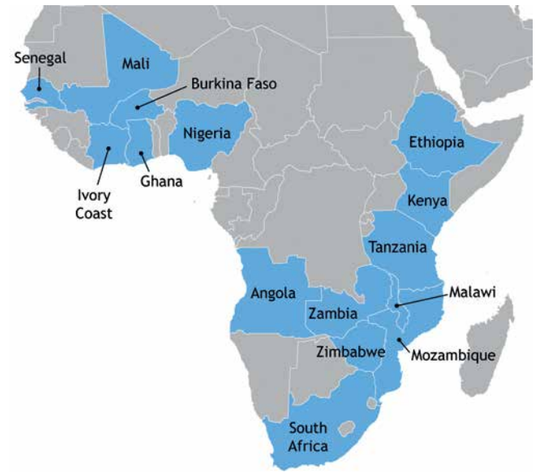
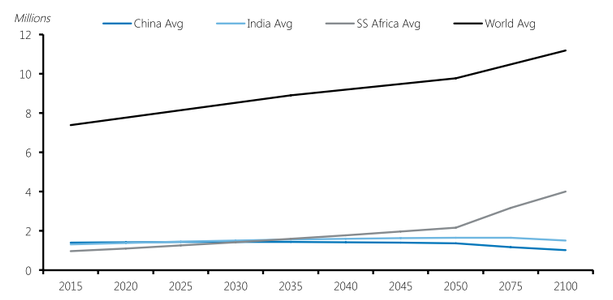


Figure 1. World population growth forecast to 2100



With this objective, Argus has launched a detailed strategy report Argus Fertilizers in Sub-Saharan Africa, illuminating the challenges and opportunities for this region. The service provides you with insight and information on:

- Raw material resources available for development in the region
- National and regional markets for fertilizer in sub-Saharan Africa
- Key market sectors, players and products
- Transport corridors essential for fertilizer trade in the region

Logistical corridors are a major driver for growth in fertilizer use – the import and supply hubs for sub-Saharan Africa. We concentrate on four separate key transport corridors:

1. Mombasa corridor
2. Dar-es-Salaam corridor
3. Beira corridor
4. Abidjan and Dakar corridors

Our chapters covering logistical corridors are designed to guide fertilizer suppliers by highlighting the best routes to deliver their products to target markets in the region, offering details on:

- Transport infrastructure (port, road and rail data)
- Infrastructure investment programmes
- Port and inland transport costs
- Agricultural data (crops and fertilizer markets along each corridor). ■

African port infrastructure

by **Ron Okello**, Director of Marketing, Lori Systems, Kenya

Kenya's port, in the coastal city of Mombasa, is constantly faced with the proverbial chicken and egg situation. What may appear as a simple matching of requests, ends up being the root cause of the pareto that is African logistics. Every time a ship berths, it is the responsibility of the port authority to deploy offloading gangs (groups of skillful labourious young men) to offload non-containerized cargo onto the ships. However, the situation on the ground is that all inbound trucks arrive at the port unannounced with only an estimated ETA on the cargo being discharged from the ship. This results in the trucks being delayed at the port for up to three days.

Joshua Sandler, CEO and Founder Lori Systems, saw that at the macro level, 25-40% of a product's cost in East Africa was allocated to logistics and up to 75% of a Rwandan export's cost was going to logistics. This is compared with just 6% in the US and so this greatly impacted the competitiveness of the African region. This cost paradigm further prevented efficient consumption and led to larger allocations of income from people at the base of the pyramid towards basic commodities rather than vital areas such as healthcare. If logistics in Africa cost the same as they did in the US, you would pay up to one third of the price currently paid for that product - whether it's cement, fertilizer or a bag of grain.

At a company level, the Lori team saw a very broken and disjointed model. For a consignment, they would see cargo owners contact over 20 transporters, then begin to engage with 16 of them, come to terms with six and in the end only having two show up on time (33% on time fulfillment rate). The cargo owners would often place all of the blame on the transporter for this model. On the other side of the market place, the Lori team saw that transporters would schedule their moves, but then emerging market externalities would occur (e.g. labour strikes) and the trucks would wait at the pick-up location for 2-3+ days, resulting in 7% asset utilization. There was a strong lack of centralized coordination and flexibility. This lack of centralized coordination greatly affected asset utilization and drove the significant cost constructs.

Although the African haulage market is massive with USD180bn of annual spend, shipping costs are three times higher than those in the US due to lack of flexibility or centralized coordination (e.g. a mechanical failure at loading site will delay trucks for 4+ days). Technology has enabled logistical optimization and Lori has reduced haulage costs by up to 10% and reduced the cost of goods on the continent at the same time. Logistics is a global cost issue and Africa is a massive, unpenetrated, rapidly growing market. Lori is unlocking the continent's potential through providing supply chain efficiency. ■

The changing face of digital farming in Africa

by **Ndubuisi Ekekwe**, Founder, Zenvus, Nigeria

Most African farmers rely on guesswork in their farming practices. Many make decisions based on the norms and dogmas which have been passed from one generation to another, over centuries. They believe that the method that worked for their ancestors will work for them, despite evidence that population growth has reduced the fallow period and impacted soil fertility. The farmers have limited knowledge on the nutritional requirements of crops with factors like rainfall, temperature, moisture, nutrients and other pertinent data rarely measured or tracked. This lack of deep insight results in poor decision-making and eventual low farm yields. For decades, the results have been consistent across most parts of the continent: severe hunger in farming communities. This poverty hurdle is not about to disappear soon, because of the expanding human population, even as the advancement in rural agriculture remains on stasis.

Zenvus with staff of the Federal Ministry of Agriculture, Nigeria

Crop yields

A few years ago, the Food and Agriculture Organization of the United Nations published a well-received article where it is estimated that the overall global food production will need to grow by 70% to feed a projected population of 9.1 bn people by 2050. The implication is that farming innovation must accelerate, not just in the most advanced economies, but also in places like Africa, where farming productivity lags the global average.

The improvement in crop yield must also occur in a period of severe deforestation which keeps reducing the available arable land across Africa. In addition, growing militancy and political upheavals, in some parts of the western and eastern Africa, make many portions of farmland inaccessible. The food sufficiency challenge is further exacerbated by agriculture attracting less than 1% of commercial lending (usually to the few large-scale farmers). Consequently, the smallholders and subsistence farmers, who represent the bulk of farming, have limited capacity to invest in inputs and new processes. Boosting farm yield across the continent will not be easy if the present agricultural system is not redesigned.

The African Development Bank understands this situation and has promised to invest more than USD24 billion to boost productivity and cushion African farm output from its present worth of USD330 billion to USD1 trillion by 2030. Agriculture accounts for more than 10% of the GDP and employs more than 60% of the working population in the continent.

Relying on guesswork

For decades, African governments have used many policy instruments to improve farm productivity, but for most farmers, while they work harder yields are only marginally improving. They continue to use their 'guesswork technology' and moon sighting, combined with appeasing the gods and ancestors through sacrifices for bumper harvests, which come sparingly. While they continue to practice these methods, the ingredients of the trade - the farm tools - remain primitive and have scarcely improved in centuries. The use of these primitive tools in the age of mechanized farming cannot be solved easily. With the land tenure system, the farm sizes are very small, just a mere 1.6 ha on average, to deploy technologies designed for large farms typical in US and Western Europe is difficult.

New developments

Therefore, agricultural redesign is important for new outcomes. It must be an Africa-inspired solution for the agro-sector requiring new thinking and evolution of new processes to drive efficiency across the food value chains. The technology must be affordable so that cash-challenged farmers can acquire them easily. Interestingly, there are lessons from other sectors which can be applied in this agricultural pivot. In the last three decades, major improvements in African industrial sectors have happened when innovative local entrepreneurs take actions. In banking, governments used to run the sector until African new generation banks, led by local entrepreneurs, emerged and transformed the sector from Lagos to Nairobi. In telecom, the lines used to be dead until icons from Zimbabwe to South Africa put mobile phones in the hands of African citizens where governments have failed for decades. For agriculture to experience the fusion of technology and smart business processes, the entrepreneurs must take action.

These African entrepreneurs are already working, offering generation-redefining developments in smart farming and financial solutions structured for African agriculture. ■

Zenvus, an agtech (agriculture technology) company based in Owerri, Nigeria. Zenvus is funded by USAID through a generous grant. www.zenvus.com

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The importance of bio-fertilizers in agriculture

by **Dr Venkatesh Devanur**, Managing Director, Agri Life, India

Agriculture can be practiced successfully if the soil health is positive. Organic carbon determines the soil health and facilitates an eco-system for growth and the proliferation of beneficial soil micro flora (bacteria and fungi). However, soil health is eroding drastically and if this continues at the current pace experts say soils will become bankrupt in 30-35 years' time. Soil organic matter is critical for augmenting organic carbon which has declined from 6-7% about 50-60 years ago to less than 1% now in many regions, after decades of industrial agriculture.

> *Nature thrives in naturally available beneficial microbes*

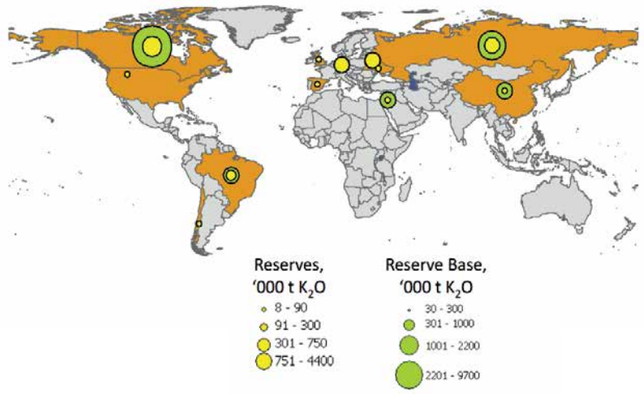
The major focus has been on NPK and micro-nutrients and soil micro-flora has often ignored. Beneficial soil bacteria help in atmospheric nitrogen fixation, solubilizing phosphorus and silica, mobilizing potassium and micro-nutrient bio-availability from hard to reach zones beyond the plant rhizosphere. These beneficial microbes help in the decomposition of biomass to organic fertilizers which adds organic carbon to soil. Therefore, organic carbon is indicative of soil health. If organic carbon is restored into the soil - soil texture, soil structure, water holding capacity, beneficial microbial population all improve and soil health gets restored.

Linear cycles

Nature thrives in naturally available beneficial microbes which can be tapped into to restore soil health. If nitrogen had to be quantified, there is an abundance of nitrogen hanging in the atmosphere. Production of urea is highly dependent on crude oil which is a cyclical commodity currently at one of its lowest cycles. In addition, the purchasing power of a large section of farmers is limited and so the bulk of urea supplied needs to be subsidised by the government in many countries, costing the economy billions of dollars. A bio-fertilizer formulated with nitrogen fixing bacteria can fix 50-60 Kg N per Ha from atmosphere. This makes athe case for Biological Nitrogen Fixation (BNF) as one of the key thrust areas for crop nutrition. AgriLife Nitrofix is a bio-fertilizer that contains nitrogen fixing bacteria such as azotobacter chroococum and paenibacillus azotofixans.

Phosphorus - a key element in the DNA of all living organisms and plants is important for crop nutrition. It is widely used in the form of di ammonium phosphate, mono-ammonium phosphate and many complex fertilizers. This is mined all over the world from rock phosphate which is a non-renewable resource and thereby not environmentally sustainable. In the past, the phosphorus cycle was closed – the plants were eaten, and excreta was replenished back to soil fertilizing it again. The current phosphorus cycle is broken or linear in which food gets transported to cities away from fields and the waste or excreta goes into the sewage, water bodies and sea. This way the soil is not replenished with phosphorus and instead the sea gets all the waste containing phosphorus, which harms precious marine life causing worldwide coastal death zones. Another factor to consider is that less than a third of phosphatic fertilizers get utilized by plants. It either gets leached, washed away or accumulates in the soil in the form of unavailable fixed phosphorus. The key is to make this fixed phosphorus into bio-available phosphorus to the plants. P Sol B Biofertilizer from Agri Life contains potent phosphorus solubilizing bacteria such as bacillus megaterium which releases enzymes and solubilizes the fixed phosphorus making it bio-available to the plant. This means that existing fixed phosphorus is utilized, subsequently reducing further mining of this limited non-renewable natural resource.

Figure 1. Global potash reserves - Supply available for next 250 years but tightly controlled



- 5 countries dominate 90% of the Potash reserves
- Cartelization forming with 70% reserves controlled by 3 MNCs *(Source: Economic Times)*
- Overcharge paid by India due to anti-competitive practices in the global potash market.
- India declared a 'Potash holiday' in 2011 – 12 which backfired

Source: U.S. Geological Survey, Mineral Commodity Summaries and Potash, January 2008

Micro-flora

Potassium is other key element is crop development. It is commonly used as MOP, SOP and is a component in complex fertilizers. Potassium is also a mined substance and an oligopoly. Therefore, the potential for price elasticity is very high. The loss of potassium on application is very high in the form of leachate losses. Among NPK resources P and K are expensive fertilizers. Therefore, conserving every bit of potash is critical. K Sol B from Agri Life contains potash mobilizing bacteria which helps mobilize unavailable potash bio-available to the plant

Silica plays a very critical growth in crop nutrition and development. The requirement of silica in some crops such as rice, sugarcane and other graminae crops is more than the combined requirement of nitrogen, phosphorus and potassium. Silica is available in abundance in soil and contributes to two-thirds of the soil composition. Silicates are in an insoluble form in the earth's crust. Silicate solubilizing bacteria play a role in solubilizing insoluble forms of silicates, help to increase soil fertility as well as enhance plant defence mechanisms. The constant use of herbicides and over use of chemical fertilizers has depleted soil micro-flora and beneficial microbes that solubilise silica. Labour shortage is a global problem and will continue. Therefore, the use of herbicides in fields will continue, depleting the soil of essential nutrients and beneficial soil microbes including silica bacteria.

Therefore, silica is less available due to the paucity of silica solubilizing bacteria which makes the fixed silica bio-available. The addition of Si Sol B containing silica solubilizing bacteria is important. Silica not only contributes to cell wall construction in plants, it also promotes drought tolerance and improves water economy. Silica bacteria also promotes induced resistance to biotic (pests and disease) and abiotic stress (drought, Al, Mn, Fe toxicity alleviation) conditions. Si Sol B contains a bacillus spp. which can be easily coated on any fertilizer and applied in combination with chemical fertilizers.

Micronutrients are as essential to crop growth and development as macronutrients. Many plants are unable to tap into nutrients that exist in zones beyond the rhizosphere. Soil that has been tilled or constantly abused with chemical fertilizers lack mycorrhiza. Mycorrhiza is the unique symbiotic fungi which forms associations with its host plant and in exchange for plant sugars, it makes essentials micronutrients and phosphorus bio-available and also extends the host plant root system so that the plant can tap into the required zone for nutrients and water. Even marginal improvement of rhizosphere with mycorhizha will make big difference.

Note: P Sol B®, K Sol B® and Si Sol B® Biofertilizers are trademarks of Agri Life ■

Shipping & freight news

Canpotex targets future demand

News of Canpotex's newly-opened sales office in Brazil will turn heads amongst the globe's muriate of potash (MOP) players, as the Canadian offshore marketing group further strengthens its position to supply the key potash-consuming agricultural powerhouse.

A multi-billion dollar industry, the global potash market is largely producer-controlled, and centred in just a few key producing nations, including Russia, Canada, Belarus, and Germany.

Canpotex handles offshore marketing for Saskatchewan potash producers Nutrien and Mosaic, and has been operating since 1972.

Brazil, meanwhile, cannot claim a burgeoning MOP industry of its own. In fact, despite being the world's largest net exporter of agricultural products, the country imports 94% of its MOP from mines as far afield as 20,000 km distant.

As such, with the majority of Brazil's MOP suppliers based far from its shores, Canpotex's in-country sales arm may allow the Canadian major to meet potential customers, smooth established relationships, and straighten supply lines faster than its distantly-headquartered rivals.

Canpotex also has the strength of a long-established trade route behind it, having exported 35m tonnes of potash to the nation since the company's inception.

The move to set up domestically is also a savvy one in light of news in January that the nation's former-largest MOP producer, Vale Fertilizantes, had sold its fertilizer division to US major Mosaic - removing a key competitor from the Brazilian domestic market.

Under a revised agreement, Mosaic bought Vale for USD1.15 bn in cash and USD34.2 mn in shares.

Underlining the company's thinking, Canpotex CEO Ken Seitz adds: "Brazil is among Canpotex's most important markets, with almost a quarter of our potash destined for Brazilian customers.

FREIGHT RATES

POTASH	Price type	Units	Timing	Low	High	Latest	Change*	Date
Dry potash Vancouver - China 60-65kt	outright	USD/t	prompt	19	22	20.5	-2	5-Apr-18
Dry potash Red Sea - WC India 25-30kt	outright	USD/t	prompt	19	21	20	-0.5	5-Apr-18
Dry potash Baltic Sea - Brazil 30-40kt	outright	USD/t	prompt	20	24	22	-0.5	5-Apr-18
Dry potash Baltic Sea - SE Asia 25-30kt	outright	USD/t	prompt	57	62	59.5	1	5-Apr-18
Dry potash Vancouver - SE Asia 25-30kt	outright	USD/t	prompt	41	43	42	0.5	5-Apr-18
Dry potash Baltic Sea - China 60-65kt	outright	USD/t	prompt	35	37	36	-2	5-Apr-18
Dry potash Baltic Sea - US Nola 50-55kt	outright	USD/t	prompt	17	19	18	0	5-Apr-18
Dry potash Vancouver - Brazil 30-35kt	outright	USD/t	prompt	29	31	30	-1	5-Apr-18
Dry potash Hamburg - Brazil 30-35kt	outright	USD/t	prompt	18	22	20	0	5-Apr-18

*from previous week

NPK	Price type	Units	Timing	Low	High	Latest	Change*	Date
Baltic-China 50-60kt	outright	USD/t	prompt	39	40	39.5	0	12-Apr-18
Morocco-WC Africa 15-20kt	outright	USD/t	prompt	32	34	33	0	12-Apr-18
Norway-Brazil 20-25kt	outright	USD/t	prompt	23	25	24	0	12-Apr-18

*from previous week

SULPHUR	Units	Low	High	Date
50-60kt – Vancouver-China	US$/t	20	22	5-Apr-18
Below all 30-35kt				5-Apr-18
Mid East – EC India	US$/t	16	18	5-Apr-18
Mid east – North/River China	US$/t	22	24	5-Apr-18
Mid East – South China	US$/t	20	22	5-Apr-18
Mid East – Brazil	US$/t	19	21	5-Apr-18
Mid East – North Africa	US$/t	22	24	5-Apr-18
Black Sea – North Africa	US$/t	24	26	5-Apr-18
Black Sea – Brazil	US$/t	23	25	5-Apr-18
Baltic – Brazil	US$/t	32	34	5-Apr-18
Baltic – North Africa	US$/t	30	32	5-Apr-18
35-40kt – US Gulf - Brazil	US$/t	20	22	5-Apr-18

Wilhelmsen, KONGSBERG launch autonomous shipping JV

The newly formed joint venture company, dubbed Massterly, will offer "a complete value chain for autonomous ships, from design and development, to control systems, logistics services and vessel operations," the firms said in a statement.

Norwegian maritime service provider Wilhelmsen and KONGSBERG, a logistics technology firm also based in Norway, have partnered to create a new joint venture company dedicated to the development of autonomous shipping solutions.

Dubbed Massterly, the newly formed firm will offer "a complete value chain for autonomous ships, from design and development, to control systems, logistics services and vessel operations," Wilhelmsen and KONGSBERG said in a joint statement announcing its creation.

The company, which will be based in Lysaker, Norway, is expected to be fully operational from August 2018.

Massterly will begin by establishing land-side control centers designed to monitor and operate self-driving ocean vessels both in Norway and internationally.

The news follows the September 2017 announcement that Norwegian government enterprise Enova granted chemical and fertilizer company Yara NOK133.6 mn (USD16.8 mn) to build the world's first electric-powered containership. Yara had been collaborating with KONGSBERG since May 2017 on the design and construction of the vessel, which will be named the Yara Birkeland, after Yara founder Kristian Birkeland, and is expected to be fully autonomous by 2020.

The ship will transport fertilizer from Yara's production facilities in Herøya to the container ports of Brevik and Larvik, all of which are located in southeastern Norway.

According to the co-founders, Massterly will be capable of delivering and operating more vessels like the Yara Birkeland once it gets up and running.

"Currently, we are at the very beginning of this development, but we see and believe that there will be a significant market for these types of services in the near future," said Thomas Wilhelmsen, CEO of the Wilhelmsen group, said of the new joint venture. "At first, short sea shipping will use autonomous ships. This also implies increased competitiveness to move transport from road to sea.

"The gains are increased efficiency and reduction of emissions," he added. "For Norway as a maritime nation, this will be an important contribution to reach the UN sustainable development goals."

"Autonomy and remote operations are an important development for the maritime industry and Norway's lead has been made possible as a result of close cooperation between the Norwegian maritime cluster and the Norwegian authorities," said KONGSBERG President and CEO Geir Håøy. "In recent years there has been rapid development driven by a significant increase in demand from customers worldwide, from the traditional maritime industry and others. When autonomous ships soon are a reality, Massterly will be crucial for digitalizing the infrastructure and operations."

NITROGEN		Units	High	Low	Date
Middle East - US Gulf	45kt	US$/t	28	27	12-Apr-18
Middle East - Thailand	30kt	US$/t	21	20	12-Apr-18
Middle East - Brazil	35kt	US$/t	21	20	12-Apr-18
Baltic - Brazil	30kt	US$/t	26	25	12-Apr-18
China - India	60kt	US$/t	16	15	12-Apr-18
Algeria - Brazil	30kt	US$/t	19	18	12-Apr-18
Algeria - French bay	12kt	US$/t	18	17	12-Apr-18
Baltic - EC Mexico	30kt	US$/t	28	27	12-Apr-18
Baltic - WC Mexico	25kt	US$/t	39	38	12-Apr-18

PHOSPHATES		Units	High	Low	Date
Morocco – Brazil	30kt	US$/t	18	16	5-Apr-18
Tampa – Brazil	30kt	US$/t	27	25	5-Apr-18
Baltic – Brazil	30kt	US$/t	29	27	5-Apr-18
KSA – EC India	30kt	US$/t	20	18	5-Apr-18

Krishnapatnam port records 88% rise In container handling

Krishnapatnam Port Company Limited (KPCL), the country's largest all-weather; deep water port, on the east-coast of India, today announced that it has handled 45 mn t of cargo in 2017-18 (FY18) thus, achieving a 25% growth over 36.10 mn t handled in the previous fiscal.

The company witnessed a record 88% rise in the number of containers it handled. Total bulk cargo handled by the port stood at 37 mn t.

Coal, Iron ore and Granite dominated the cargo portfolio handled at Krishnapatnam Port. It is now aspiring to achieve an impressive 52 mn t in Bulk and 2 Lakh TEU in Containers this fiscal. The port has planned a total investment of USD3 bn of which 1.23 bn has already been invested for development till date with second phase of expansion underway.

On the occasion, Mr. Anil Yendluri – Director and CEO said, "Favourable government policies and handling of new cargo such as sand, steel products and agri-commodities have added to the growth of our shipments. Cargo in Andhra-Telangana, north and east Karnataka, besides eastern parts of Maharashtra which were earlier going to other ports have witnessed an instant cost advantage availing route optimization, multi-modal and competitive pricing after they switched to Krishnapatnam Port."

"Our world-class technology driven infrastructure further reiterates our claim to offer the most convenient and trade efficient gateway on the eastern periphery of the country," he further added.

The number of vessels visiting the Port rose by 22% to 1290 vessel calls in 2017-18 as against 1061 vessels registered during the same period, last year.

With government's push towards solar energy, the port has also witnessed a sharp rise in solar related shipments. It has success fully concluded 13,084 FEUs of solar cargo for the year FY17-18

With excellent rail connectivity in the states like Telengana and Bangalore the new connectivity from Nagpur, Maharashtra beginning this May 2018, will offer an additional spurt in shipments.

Belships ASA : Report 1st quarter 2018

Belships operating income in 1st quarter 2018 was USD8.2 mn (Q4: USD7.6 mn), while EBITDA amounted to USD3.3 mn (USD3.7 mn). The Group's operating result amounted to USD3.1 mn (USD4.6 mn), while net result for 1st quarter 2018 was USD2.1 mn (USD3.2 mn). The figures for 1st quarter includes impairment reversal of USD1.3 mn. Impairment reversal in 4th quarter 2017 amounted to USD2.0 mn.

The Board proposes a dividend of NOK 0.10 per share for 2017.

Belships concentrates on the dry bulk market, with 6 modern Supramax/ Ultramax in service.

M/S Belstar, M/S Belnor and M/S Belisland have continued the long-term contracts to Canpotex of Canada. Canpotex is one of the world's largest exporters of potash, a fertilizer product imported in large volumes by countries such as China, India and Brazil. M/S Belforest and M/S Belocean are both on time charter to Cargill, and will be open around October-November. M/S Belnippon, which was delivered from Imabari Shipbuilding in January, is on time charter to Cargill for 10-13 months. All ships have sailed without significant off-hire. Technical management is handled by Belships Management (Singapore), with a total fleet of 11 ships under technical management. ■

Understanding bio-stimulants

by **Eva Sánchez Rodríguez**, Managing Director,
InnoPlant-Tecnología e Investigación Agrícola, Spain

The elucidation of the biological basis of bio-stimulant function is a prerequisite for the development of a bio-stimulant-product. The task of defining the role of each kind of bio-stimulant in plants is complex due to the diverse sources of bio-stimulants present in the market. These include bacteria, fungi, seaweeds, higher plants, animals and humic raw materials. There is also a wide diversity of industrial processes utilized in their preparation. To distinguish bio-stimulants from the existing legislative product categories it has been proposed that the definition of a bio-stimulant is 'a formulated product of biological origin that improves plant productivity as a consequence of the novel or emergent properties of the complex of constituents, and not as a sole consequence of the presence of known essential plant nutrients, plant growth regulators, or plant protective compounds.'

Understanding the modes of action of an agricultural chemical is a fundamental requirement for effective marketing. However, the mechanism of action of bio-stimulants is often not known precisely. For a small subset of bio-stimulants, a demonstrated impact on general biochemical, molecular pathways and physiological processes has been identified, but the explicit 'mode of action' may not be known. An example of a mechanism of action would be a stimulation of photosynthesis or an increase in germination ratio. Therefore, we consider it essential to define the appropriate tests to identify the mode of action of bio-stimulant products. These tests will give us an answer, which would be useful from a commercial point of view.

Bio-stimulant classifications

There are several classifications for different classes of bio-stimulants according to different authors. We are going to distinguish four categories (see table 1):

Table 1. Bio-stimulant categories: Sources and effects

Categories	Source	Biological effect
Plant Growth Promoting Microorganism and Mycorrhizal Fungi	• Preparations of living microorganisms • Preparations on the basis of non-living microorganisms and their metabolites	Increase germination rate, growth characters (length, fresh, dry weight) of shoots and roots, plant quality, productivity, yield. Vegetative growth, number of flowers, number of fruits.
Seaweed extracts	Algae	Increase number of fruit per plant and size of fruit, fruit and crop yield, fruit quality, development of a vigorous root system and improved growth, increase in fresh weight; root formation, growth characters (length, fresh, dry weight) of shoots and roots; quality, induce rooting.
Hydrolized proteins and Amino Acids	Animal raw materials, higher plants	Better growth and development, effects on foliar growth. Increase root and leaf growth. Root formation. Induce flowering. Improve good fruit setting and reduce fruit drop. High yield.
Humic Acids and Fulvic Acids	Compost, humic-like substances, leonardite, lignin, peat	Activation of growing processes. Increase root and leaf growth. Increase growth characters (length, fresh, dry weight) of shoots and roots. Increase root size, branching. Increase yield.

Plant growth promoting microorganism and mycorrhizal fungi. To fulfil the above desired practices, one possibility is the use of soil microorganisms that increase the nutrient- and water-use efficiency and uptake capacity. Among these potential soil microorganisms, plant growth-promoting rhizobacteria (PGPR) are the most promising. The term PGPR includes three types of soil bacteria, depending on their lifestyle: free-living bacteria inhabiting the zone around the root (rhizosphere), those that colonize the root surface (rhizo-plane) and the endophytic bacteria that live within the roots. However, this division is not exclusive, since any individual bacterial strain might adopt all three lifestyles, depending on the soil environment conditions and the host-root partner involved. The modes of action of PGPR are clearly diverse and not all bacteria possess the same mechanisms. These mechanisms vary from changes in hormonal content, the production of volatile compounds, increasing nutrient availability and enhancing abiotic stress tolerance.

Among beneficial microorganisms, arbuscular mycorrhizal fungi (AMF) play a key role in plant performance and nutrition due to their capacity to improve plant mineral uptake. AMF can only be grown in the presence of host plants (i.e. obligate symbionts) and are widely used in horticulture. In fact, while the majority of inoculants presented on the market are mostly nitrogen-fixing bacteria products, it is expected that phosphorus-mobilising products including AMF will see an increase in demand. AMF symbiosis is particularly important for enhancing the uptake of the relatively immobile and insoluble phosphate ions in soil, due to interactions with soil bi- and trivalent cations, principally Ca_2^+, Fe_3^+, and Al_3^+. The basis of this symbiosis is the capacity of AMF to develop a network of external hyphae capable of extending the surface area (up to 40 times) and also the explorable soil volume for nutrient uptake for the production of enzymes and/or excretions of organic substances.

Figure 1a. Key physiological response targeted by microorganisms based biostimulants

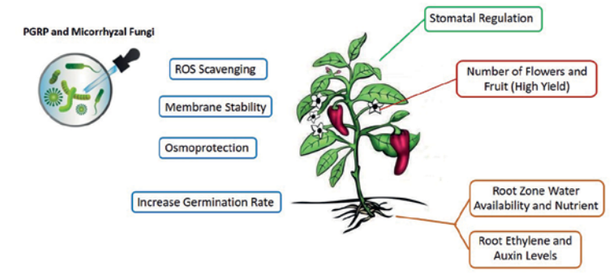
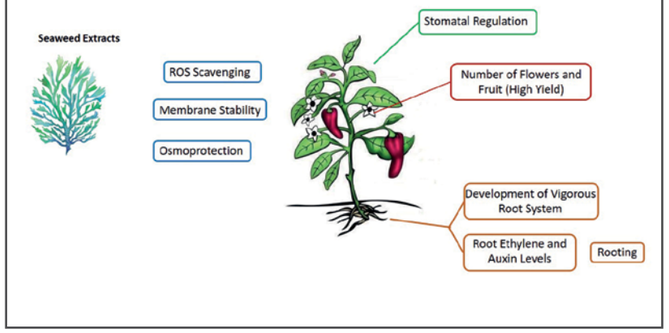


Figure 1b. Key physiological response targeted by seaweeds based biostimulants



> *Seaweeds are reported to possess plant-growth promoting activity*

Seaweed extracts. A number of seaweeds are reported to possess plant-growth promoting activity and thus they have found one of their more universal and continuing relevancies in agriculture and horticulture as organic manures and fertilizers. Use of varied seaweeds in agriculture, as many other popular practices, has been evaluated and established by practical experiences and farm trials. In general, seaweed extracts, even at low concentrations, are capable of inducing an array of physiological, plant responses, such as promotion of plant growth, improvement of flowering and yield, enhanced quality of products, improved nutritional content of edible product, as well as shelf life. Furthermore, applications of different extract types have been reported to enhance plants' tolerance to a wide range of abiotic stresses, i.e. salinity, drought and temperature extremes. Extensive studies on the chemical composition

of various extracts made from a diversity seaweeds revealed that the nutrient content (typically macronutrients including N, P, K) of the extracts were insufficient to elicit physiological responses at the typical concentrations that the seaweed extracts were applied in the field.

Hydrolized proteins and amino acids. Protein hydrolysates (PHs) are a category of plant bio-stimulants defined as 'mixtures of polypeptides, oligopeptides and amino acids that are manufactured from protein sources using partial hydrolysis.' There has been growing interest in PHs during recent years due to their positive effects on crop performances, especially under environmental stress conditions. PHs are mainly produced by chemical (with strong acids or alkalis) and/or enzymatic hydrolysis of proteins contained in agro-industrial by-products from animal (e.g. leather, viscera, feathers and blood) or plant origin (e.g. vegetable by-products) and in biomass of dedicated legume crops (e.g. seeds and hay). PHs obtained by agro-industrial by-products represent a sustainable solution to the problem of waste disposal, making their production interesting from both environmental and economical points of view. PHs have been identified to improve the performance of several horticultural crops, including increasing shoot and root biomass and productivity. The application of PHs to plant leaves and roots has been shown to increase Fe and N metabolism, nutrient uptake, and water and nutrient use efficiencies for both macro and microelements. The higher nutrient uptake in PH-treated plants has been attributed to (i) an increase in soil microbial activity and soil enzymatic activities, (ii) improvement of micronutrient mobility and solubility, in particular Fe, Zn, Mn and Cu, (iii) modifications in the root architecture of plants, in particular root length, density and number of lateral roots and, (iv) an increase in nitrate reductase, glutamine synthetase and Fe(III)-chelate reductase activities.

Humic acids and fulvic acids. Humic substances (HS) are formed by chemical and biological

Figure 2a. Key physiological response targeted by hydrolized protein based biostimulants

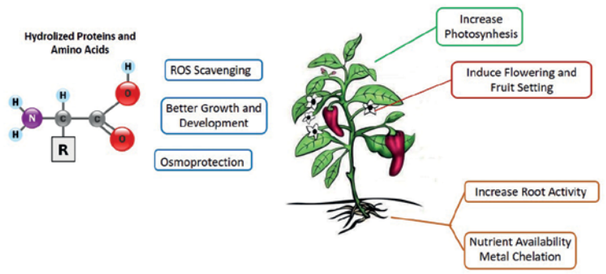
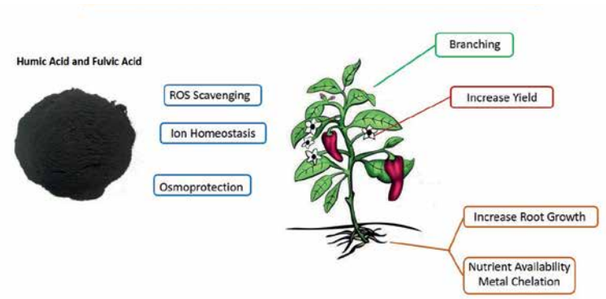


Figure 2b. Key physiological response targeted by humic acids based biostimulants



> *There has been growing interest in protein hydrolysates*

transformations of plant and animal matter and from microbial metabolism and represent the major pool of organic carbon at the earth's surface. They contribute to the regulation of many crucial ecological and environmental processes. For example, HS sustain plant growth and terrestrial life in general, regulate both soil carbon and nitrogen cycling, the growth of plants and microorganisms, the transport of anthropogenic-derived compounds and heavy metals and the stabilization of soil structure. It is not surprising that most reported beneficial effects of HS on plant growth appear to be related to their positive influence on changes in root architecture. Enhanced plant growth in response to HS addition therefore appears not to be related to the nutrient content of HS directly but to interactions of HS with plant membrane transporters responsible for nutrient uptake and membrane associated signal transduction cascades which regulate growth and development. ■

Supporting responsible and profitable

use of fertilizer nutrients in Myanmar

by **Thomas Oberthür**, Director and **Tin Aye Maung**, Advisor, International Plant Nutrition Institute (IPNI) Southeast Asia Programme

Since 2013, Canpotex and IPNI have been engaged in Myanmar to introduce concepts and principles of responsible crop nutrition. This was initially achieved through a series of seminars dedicated to agricultural decision-makers in government, universities and crop associations. Subsequently, commodity-specific field handbooks were produced in Burmese language to further disseminate basic crop nutrition knowledge among fertilizer dealers and farmers. As part of this engagement, in 2017, we conducted an assessment of opportunities for responsible fertilizer market development. The assessment was informed by secondary land use and production statistics and, deep field intelligence, generated using a participatory approach adapted by IPNI to the local conditions.

The authors with a local agricultural expert. Ginger in Southern Shan State (Photo: T. Oberthür)

Myanmar is an agricultural country and agriculture is the backbone of its economy. The agricultural sector including livestock contributes 28.6% of GDP and employs 61.2% of the labour force. Total land area is about 67.7 mn hectares and the total arable land area is 17.7 mn hectares. There are about 12 mn hectares of net agricultural land area in Myanmar. Under varying topography, climate and soil types, more than 60 crops are grown, mainly by smallholders. Fertilizer and manure are not commonly applied in smallholder cropping systems, although in recent years, fertilizer use is increasing.

There are three seasons; (1) hot season from mid-February to mid-May, (2) rainy season from mid-May to mid-October and (3) cold and dry season from mid-October to mid-February. The annual precipitation varies between about 5,000 mm along the coastal regions and less than 1,000 mm in the centre of the country. In many parts, the temperature rises above 38°C during the hot season and, averages between 21-26°C during the cold season. The three seasons enable farmers to cultivate various crops at different times of the year. The main farming season for most of the country is the monsoon period.

Potatoes have been placed by hand, fertilizer added manually, before field workers cover both (Photo: T. Oberthür)

> *Agricultural land can be grouped into lowlands and uplands*

Crop portfolio

Agricultural land can be grouped into (1) lowlands and (2) uplands. Farmers grow mostly rice in the lowlands. Rain-fed agriculture is predominant in Myanmar, but irrigation is used when available. The irrigable area is about 2.14 mn hectares, or about 16% of net sown area. Uplands are characterized by diverse land use systems and often low soil fertility. Large parts of the uplands have low pH soils with low phosphorus (P) status and potential for aluminum toxicity. However, the greatest potential for future increases in agriculture production lies in the uplands. Maize, sugarcane, groundnut, potato, chili, tomato and onion are the most important upland crops, but farmers also grow upland rice for home consumption.

Approximately 7.2 mn ha of rice, 4.4 mn ha of pulses, 1.6 mn ha of sesame, and 0.95 mn ha of groundnut and 0.47 mn ha of maize are grown in the country. Rice is cultivated twice a year in many parts of major rice-growing regions such as Ayeyarwaddy, Bago and Mandalay. Rice-rice and rice-pulses-rice are common cropping systems. Management priority until now is usually given to rice. Farmers may also grow sesame and groundnut before rice with little inputs. Pulses are the largest exported agricultural commodity from Myanmar: mainly black gram, green gram, pigeon peas and chickpeas. Crop yields are low. The average national yields are 3.8 t/ha for rice, 1.1 t/ha for pulses, 0.59 t/ha for sesame, 1.6 t/ha for groundnut and 3.9 t/ha for maize respectively.

Deep market intelligence approach

There are several ways to generate agricultural indicators, ranging from a single criterion to long lists

of variables to criteria elicited from the stakeholders themselves. We used locally appropriate indicators and criteria elicited from farmers, extension agents and fertilizer dealers to generate deep market intelligence (DMI). Facilitated by representatives of local government organizations, we visited agricultural communities in the Irrawaddy Delta, the Mandalay agricultural production area and Southern Shan State.

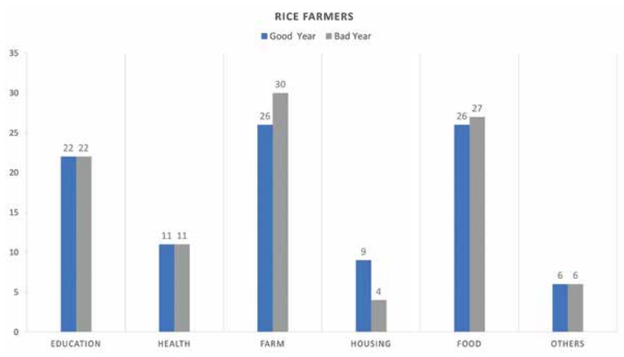
Emphasis was given to the most important crops in each region, eliciting knowledge related to the management of these crops within the cropping system. We focused on resource use in good and bad years, with 'good' and 'bad' defined in terms of agricultural production and price. Responses identified different farm enterprises and income sources that farmers relied upon, and their relative importance in good and bad years. Fertilizer market development activities have the potential to reduce 'bad' year outcomes and increase return on investment in years approximating what farmers describe as 'good'. Solutions for prioritized problems related to crop production, processing and marketing can then be identified with clear, positive impacts on the ability of farmers to use fertilizer to improve their income.

The data also helped us understand farmers' motivations to improve agriculture, willingness to invest in fertilizer and obstacles to such investment. Farmers also reported on the relative income earned from key crops and the cost to produce them, as well as the relative importance of pest and diseases, lack of water, soil quality to key crops and the relative allocation of fertilizer to key crops. Farmer generated insights were complemented with those from small group interviews of extension agents. One-to-one interviews with fertilizer dealers/retailers were conducted to understand the currently available fertilizer product portfolio, the supply chain structure, and the dealer business model. Responses provided clarity in nutrient sales vis-à-vis nutrient demand by main crops grown in the region, and customer support provided by the dealers (financing and knowledge).

Table 1. Estimated nutrients removed by rice, maize, potato, chili and watermelon in 2015/16

Crops	Estimated nutrient removal by focused crops (t) in Myanmar					
	N	P	K	Ca	Mg	S
Rice	393150	73388	99598	7863	26210	20968
Maize	27268.8	5069.2	6642.4	699.2	1573.2	2272.4
Potato	1512	168	2016	168	168	168
Chili (dry)	3024	352.8	3326.4	302.4	151.2	100.8
Watermelon	1990.4	373.2	2114.8	248.8	124.4	248.8

Figure 1. Resource allocation (%) towards education, health, farm, housing, food and others by rice farmers in Pyin Oo Lwin Township, Mandalay.



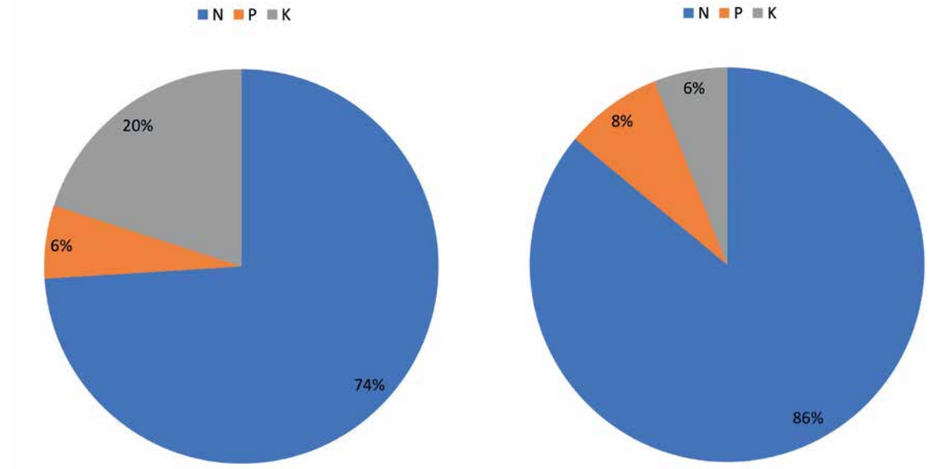
Nutrient removal

The target crops included maize and watermelon (Mandalay region), rice, pulses and chili (Ayeyarwady Region), and potato and maize (Southern Shan State). When other important crops were identified in the field, we included them in the interviews. Table 1 shows the national potential for nutrient use in target crops, estimated by the amount of nutrient removal (derived from total production and nutrient content in harvested parts).

In Figure 1 we give an example of data collection from rice growers in the township of Pyin Oo Lwin (Mandalay), where cereal-based cropping systems are common. Cropping systems include Monsoon rice (irrigated/rainfed), wheat, Monsoon maize, niger (*Guizotia abyssinica*) and flowers/vegetables. Of the participating farmers, 100% grow rice and 90% maize. About 40% also grow vegetables, chili and flowers and some grow groundnut (35%).

It shows that rice farmers allocated most resources to their farm and food regardless of 'good' and 'bad' income years. Their resource allocation towards education, health and others tended to remain constant in 'good' and 'bad' income years. In 'bad' years resource allocation towards farm operation was increased at the expense of housing, indicating a willingness and understanding to maintain the farm business sustainable. This behavioral pattern is consistent across regions and farming systems, indicating a first, clear opportunity for responsible, joint market development between the fertilizer industry and the farming community.

Figure 2. Relative quantities of N, P, and K fertilizers sold in dealer shops in Zalun town (a, left) and Ingapu town (b, right), in the Ayeryarwaddy region of Myanmar.



An example of responses from interviews with fertilizer dealers is summarized in Figure 2a and 2b. Dealers in Ayeyarwaddy townships usually sell a variety of agri-inputs including fertilizers. The narrow fertilizer product portfolio commonly includes urea, low density NPK compounds, TSP and KCl. Best sellers are urea and NPK compounds, usually 10-10-5 and 15-15-15. The graphs illustrate the relative proportions of N, P, K nutrients sold by fertilizer dealers: nutrient proportions delivered by a typical dealer are not adequate to supply the demand by most crops grown in the respective regions. Again, this is a common trend across major agricultural production areas in the country.

Market development opportunities

Joint analyses and interpretation of secondary context information (official and unofficial data on fundamentals in land use, production, markets) and quantitative / qualitative insights from the DMI (nutrient use and availability, on-farm cash flows, respective knowledge by farmers, extension agents and dealers) allows us to generate potential opportunities that support the development of sustainable fertilizer markets.

Nutrient supply opportunities: Table 2 summarizes the fertilizers / nutrients supplied by agri-input dealers. Urea and NPK compounds

Table 2. Sales portfolios of selected fertilizer dealers visited, and proportions of N, P and K in these portfolios (Scenario 1, 15-15-15 NPK, Scenario 2, 10-10-05 NPK).

	Fertilizers Sold (%)				Scenario 1			Scenario 2		
	Urea	TSP	KCl	NPK	% of N	% of P	% of K	% of N	% of P	% of K
Dealer 1	60	7	3	30	78.8	8.2	13.0	84.8	7.4	7.8
Dealer 2	40	0	5	55	67.1	9.1	23.8	76.6	7.7	15.7
Dealer 3	60	10	5	15	80.1	7.9	12.0	83.2	7.5	9.3
Dealer 4	45	10	5	40	66.7	12.5	20.8	73.7	12.2	14.1
Dealer 5	45	0	5	30	75.2	5.9	19.0	82.1	4.5	13.4
Dealer 6	70	10	0	20	85.9	8.0	6.1	90.3	7.5	2.2
Dealer 7	50	5	5	40	72.1	8.9	18.9	79.4	8.0	12.6
Dealer 8	40	10	10	40	62.2	11.7	26.1	67.9	11.2	20.9

Table 3: Nutrient requirements by major Myanmar agricultural crops at an achievable yield level, and the proportions of N, P and K of total removals.

Crop	Yield (t/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	% of N	% of P	% of K
Rice	6	120	15.3	41.5	67.9	8.6	23.5
Maize	8	130	17.4	49.8	65.9	8.8	25.2
Sugarcane	100	300	39.2	249.0	51.0	6.7	42.3
Groundnut	2.5	50	34.9	49.8	37.1	25.9	37.0
Mung bean	2	40	34.9	49.8	32.1	28.0	39.9
Potato	35	100	34.9	83.0	45.9	16	38.1
Chili	3	120	47.1	114.5	42.6	16.7	40.7
Cabbage	20	200	52.4	99.6	56.8	14.9	28.3

are popular, TSP reaches up to 10%, while the availability of KCl is low. Sales of other products are even less. Actual percentages of nutrients (N, P, K) within these portfolios are given for two scenarios: Scenario 1 contains 15-15-15, scenario 2 the more popular 10-10-05. In portfolio 1, N ranges from 60% to more than 85% and in portfolio 2, 68% to over 90%. Potassium seldom makes up more than 20% of nutrients sold. On the other hand, most crops require at least 20% of potassium (see table 3). Many in fact, require between 25-40% of potassium in a balanced application. Likewise, crops require more than 50kg of N per hectare, even at low yield levels (except for N fixing mung beans and groundnuts). Higher yields require more than 100 kg of N per hectare to replace the removed nitrogen. Requirements for P within a fertilizer application range between 10-50 kg per hectare. At low yield levels, all crops benefit from at least 25 kg of potassium per hectare. At higher yield levels, all crops require more than 40 kg of K per ha in a balanced application.

We therefore suggest:

- For bulk commodities such as rice and maize, to focus first on balanced nutrition, then after two or three cropping seasons, on increasing nutrient rates. This provides the opportunity to introduce improved low-density compound fertilizers for rice and maize with adequate nutrient composition.
- For cash crops, including chili, sugarcane and cabbage, a parallel strategy of adequate rates and proportions of nutrients. For these crops, higher density/higher value compounds may be used and or low-density compounds complemented with potassium.
- Cash crops including pulses are likely to benefit from the introduction of a fertilization regime comprising low density compounds complemented with potassium.
- All crops will benefit from concerted efforts with focus on the role of potassium, with other nutrients supplied in adequate amounts. In general, potassium is severely under supplied, and likely to generate the highest return on investment.

Chili is carefully being planted (Photo: T. Oberthür).

Cropping systems opportunities: For the identification of promising cropping systems, we use relative return on investment in fertilizer, production input/output cost ratios, perceived cropping risks and unrealized yield potential. Achievable increases in rice yield are in most cases between 1.0-2.0 t per hectare, with highest potential in the Ayeyarwaddy Delta. Possible yield increases for pulses are in the range of 0.5-1.0 t per hectare, which is significant. Yield gaps in maize range from 1.0-4.0 t per hectare. Highest return on investment in improved nutrition is expected for these crops in Southern Shan State and the Ayeyarwaddy Delta. Considering these findings, we suggest that robust market development opportunities for nutrition exist in: (1) rice, pulse system development in the Ayeyarwaddy Delta and (2) maize development in Southern Shan State. Both opportunities provide an economy of scale, the possibility to rapidly adapt and deploy fertilizer recommendation software (IPNI Nutrient Expert Software). They also provide scope for significant potassium and phosphorus market development. Here, it is important to note, that we advocate pulses as the entry point for change in nutrition management. Pulses provide a robust return on investment and allow rice to benefit from systematic pulse nutrition. This is in contrast to current management strategies, which in our opinion are not favorable for farmers.

Cash crop opportunities: Potential yield increases in chili are in most cases between 1.0-1.5 t dry chili per hectare. Yield gaps are largest in the Ayeyarwaddy Delta. Possible yield increases for potato are expected in the range of 10.0-15.0 t per hectare, which is significant. Yield gaps in cabbage are about 2.0 t per hectare. Increasing tomato yields by about 10.0 t per hectare is feasible in both Southern Shan State and Ayeyarwaddy Delta. Sugarcane yields may be increased by about 1.5 t per hectare. Current ratios of input costs to output returns are favorable for chili, potato and tomato. Returns on investment in potato are consistent and stable. Favorable returns on investment are also expected for cabbage, potato and sugarcane. Cropping risks for chili farmers are low in Southern Shan State but moderate to high in the Ayeyarwaddy Delta. Potato and tomato have particularly high cropping risks. Cabbage and sugarcane cropping risks are low and occasionally moderate. Considering the potential return on investment, the magnitude of exploitable yield gaps and cropping risks, we conclude that market development opportunities exist in chili and cabbage, and potentially tomato if nearby markets are accessible - pest and diseases can be controlled. Sugarcane may be considered where labour and markets are no constraints. Most of these crops appreciate higher density/higher value compound fertilizers, while sugarcane provides an opportunity for low density compounds coupled with potassium sources. A potassium awareness campaign is considered useful in these systems.

Tomatoes are being sorted and packed for the nearby market (Photo: T. Oberthür)

> *Farmers are aware that significant yield increases depend on both cultural and technological changes*

Knowledge development opportunities: Farmers' attitude towards fertilizer use is positive. Deep intelligence reveals that resource allocation into farming is considered important even under difficult conditions. Farmers are aware that significant yield increases depend on both cultural and technological changes. Field missions also reveal that farmers are brand and quality conscious. At the same time, insights show that farmers find it difficult to manage their farms as a business. For any change process to be successful, farmers need more knowledge as to how to manage fertilizer in such a way that return on investment is likely. The required knowledge base must be: (1) locally specific, (2) relevant to the needs of small-scale farmers and their suppliers, and (3) reflect the complexities farmers face.

However, where will this knowledge come from? Conventionally, it is 'passed down' to farmers from experts in the department of agriculture or similar organizations. Field missions show however, that nutrition knowledge of extension agents and fertilizer dealers is limited and patchy, and 'top-down' knowledge transfer inadequate. Hence, farmers must be the hub of knowledge generation and growth in the production system because they currently bear most of the risk. Hence, risk sharing is essential for successful and deep market penetration. Suppliers must engage with farmers as partners in the development of improved fertilizer use strategies and the underlying knowledge base. Farmers need suppliers to work with them to reduce the uncertainty of investment. This is most likely achieved through on-farm trials that support joint learning by farmers and suppliers. ■

The role of magnesium

...in maximizing crop yields, enhancing quality and improving crop tolerance to stress conditions

by **Rolf Härdter**, Head of Agricultural Services, K+S KALI, Germany

With the intensification of plant production, driven by a large population with growing food demands and very limited available land resources for agricultural use, the question whether current soil fertility management practices are sufficient to meet these demands in a sustainable way is persistent. It is not only global food production that went through an unprecedented growth during the last decade, but also fertilizer nutrient consumption, which fuelled this development.

Nevertheless, there are increasing indications that following the traditional concept of balanced fertilization' with the three nutrients N, P and K, high productivity of most crops and cropping systems cannot be sustained. Reasons for this are manifold, the first is that only under a certain level of productivity other nutrients in addition to the three become limiting. Secondly, some of those nutrients have been provided 'free of charge' as component of those carriers supplying N, P and K, e.g. the nutrients Ca and S. The latter is also delivered as a natural deposit from the atmosphere in regions where high air pollution prevails.

> *From a plant's perspective - all nutrients are primary*

Another important reason for the lack awareness may be the fact that historically, primary nutrient status has only been attached to N, P and K, whereas all the other nutrients, essential for crop production, are continuously treated as secondary. This is in clear contrast to the nutrients that crops demand. From a plant's perspective, all nutrients are primary as a plant cannot grow normally and cannot complete its life cycle in their absence, a plant nutrient cannot be substituted by another one and is directly or indirectly involved in metabolic functions (deficiency induces specific symptoms). With respect to demand, plants distinguish between macronutrients (uptake of several kilogrammes per hectare) and micronutrients (uptake of several grammes per hectare). The former group consist of N, P, K, Ca, Mg and S (Table 1) and the latter of B, Cl, Cu, Fe, Mn, Mo, Ni and Zn.

Magnesium and Sulphur are needed by plants in the same magnitude as phosphorus, although nobody in the fertilizer industry would call the latter a secondary nutrient.

Table 1: Macronutrient uptake of selected crops per unit of yield.

	N (kg/t)	P (kg/t)	K (kg/t)	Mg (kg/t)	S (kg/t)
Maize	18.0	4.2	20.0	4.0	4.2
Wheat	35.0	5.2	27.5	2.0	5.0
Soybean	82.0	7.8	32.0	8.0	6.7
Oil palm	24.0	3.2	41.0	7.3	6.0

Figure 1. Root growth of bean plants as affected by K and Mg. Numbers shown indicate carbohydrates in percent of total.
Source: Cakmak et al., 1994

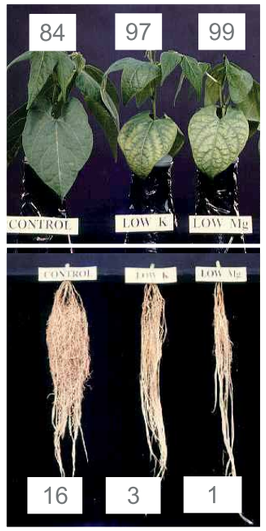
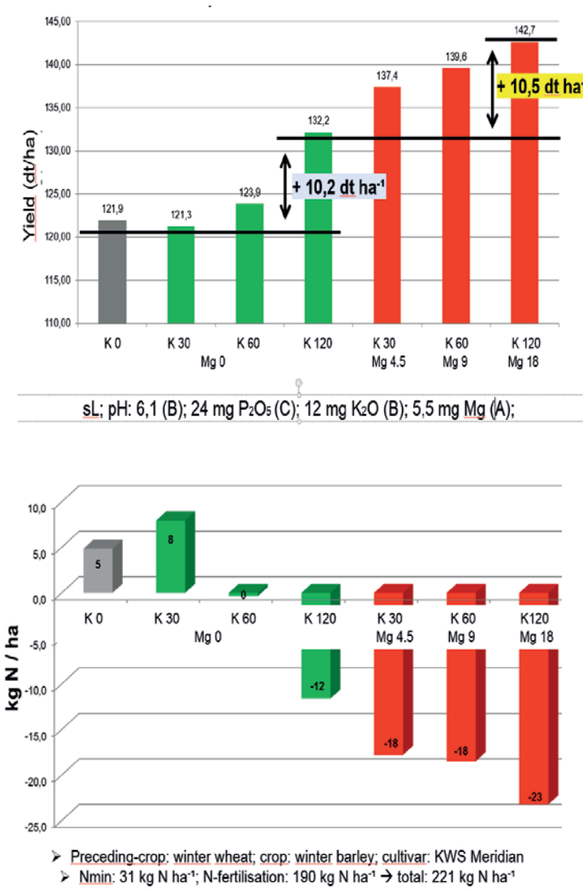


Figure 2. Typical magnesium deficiency symptoms

Interveinal chlorisis in maize leaves | **Unfilled maize cobs due to restricted carbohydrate supply** | **Interveinal chlorosis in potato leaves**

Figure 3. Effect of Mg application on winter barley yield and nitrogen balance at different levels of K supply. *Source: Weidemann, 2016*



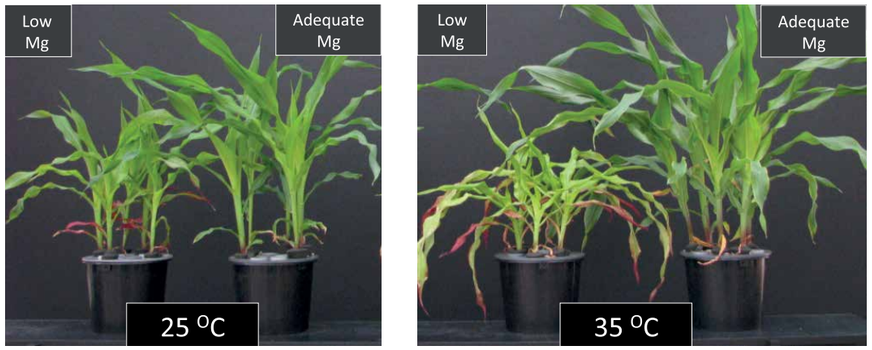
Role of magnesium in plant metabolism

Magnesium is involved in a number of metabolic processes of plants of which its role as central atom of the chlorophyll molecule is probably the most prominent one in photosynthesis. It is involved in enzyme reactions and in the protein and RNA synthesis, the translation of genetic information into proteins. Mg is crucial for the partitioning of carbohydrates from source leaves to sinks, storage organs and roots. Low supply of Mg leads to an accumulation of carbohydrates in the leaves and to reduced supply to especially roots (see figure 1).

The poor carbohydrate supply leads to a distinct reduction in root growth and root activity so that both nutrient and water uptake are drastically inhibited.

Visible symptoms which occur usually at later and more severe

Figure 4. Improved magnesium supply alleviates negative effects on growth of maize, exposed to high temperatures. *Source: Mengutay et al, 2013*



stages of deficiency are shown as interveinal chlorosis of the older leaves because Mg is highly mobile and translocated from the older to the younger leaves (see figure 2).

Magnesium for increased yields and better nutrient use efficiency

In a number of field experiments carried out by K+S KALI over many years on a variety of different soil types have shown that balanced nutrition with N, P, K and omitting the nutrient Mg drastically limited the realization of genetic yield potential of the crop and also led to a reduced efficiency of the nutrients applied, especially nitrogen (see figure 3).

Application of Mg to winter barley at different levels of K supply 0-120 kg K_2O/ha led to a significant increase of grain yield and at the same time improved the utilization of applied and soil derived (Nmin) nitrogen.

Magnesium for stress alleviation

Plants can be exposed to various kinds stresses during growth which in the end can depress the expression of yield and quality of the harvested crop. The aspect has increasingly received attention in the process of climate change, with more frequent and often extended dry-spells causing detrimental effects on crop growth. As shown above, root penetration to lower soil depths and exploitation of optimum soil volume by plants is strongly inhibited by lack of Mg due to the very limited carbohydrate supply to the roots (see figure 1). These climatic changes may also lead to increased heat and stronger radiation which both have an impact on plants (see figure 4).

Plants exposed to high temperatures are showing an imbalanced root:shoot ratio in favour of the shoot so that growth depressions might be explained by reduced nutrient and water uptake. The observed chlorosis may be explained by formation of oxygen radicals causing cellular damage. Ensuring a sufficiently high

Figure 5. Magnesium overcomes sunburn under high radiation. *Source: Cakmak et al., 1994*

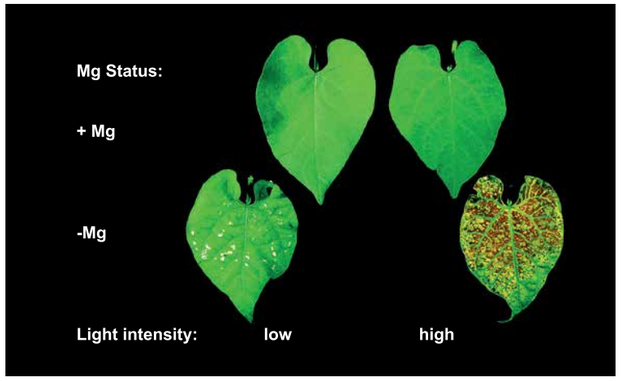
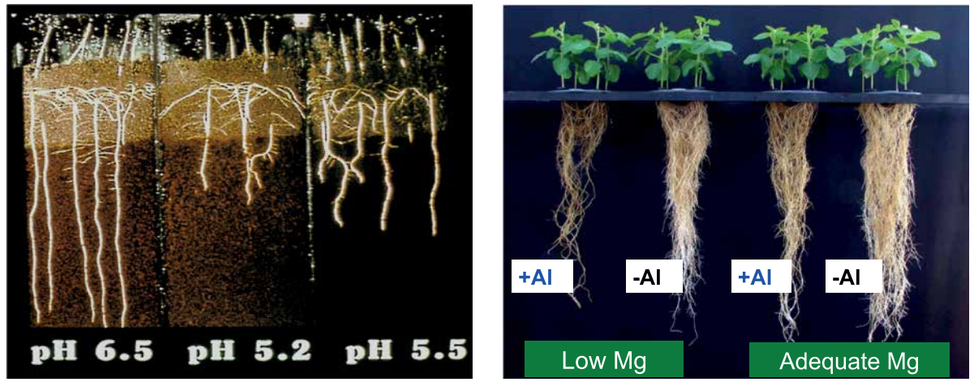


Figure 6. The effect of soil pH on root growth caused by Al toxicity (left) and alleviation by improved Mg supply (right). *Source: Hakli et al., 2011 (unpublished)*



Mg supply can compensate for growth depressions under heat stress.

Formation of oxygen radicals in leaves exposed to high radiation also explain typical disorders in plants which are not adequately supplied by magnesium. These reactive oxygen species occurring in the leaf chloroplast manifest at the expense of inhibited CO_2 fixation during photosynthesis. It is interesting to note that plants suffering from latent Mg deficiency do not show symptoms under situations of low light intensity (see figure 5). This could be during overcast conditions, e.g. during the rainy season or when plantings overlap of leaf canopy limits the penetration of light. However, the visible symptoms are weak indicators for assessing the plants need for magnesium because other processes depend on a sufficient Mg supply, e.g. mobilization and translocation of carbohydrates to roots occur before visible symptoms become evident with negative consequences on growth and yield formation. Plants exposed to high radiation also seem to have a higher requirement for magnesium.

Another abiotic stress is caused by aluminium toxicity a widespread phenomenon on acid mineral soils. The primary effect of Al toxicity is reduction of root growth or even crippling of the roots (see figure 6).

> ***Ensuring a sufficiently high magnesium supply can compensate for growth depressions***

Results in pot and field trials have shown that applying Mg in the form of kieserite ($MgSO_4 H_2O$) alleviated the Al toxicity in low pH soils without changing the pH. With this soluble form of Mg, the toxic Al can be displaced at a lower soil depth so that the roots can better penetrate the lower levels to absorb nutrients. Furthermore, good Mg supply also promotes the release of organic acids which can complex the Al to non-toxic complexes. Although Ca can also alleviate Al toxicity, Mg appears to be much more efficient and much lower quantities are needed, especially when the attempt is undertaken to precipitate Al by raising pH though liming.

Reducing risks

Magnesium as a constant component in standard fertilizer recommendations and practices is still the exception rather than the rule, even though plants require very similar amounts of Mg as P for a successful crop production. Mg provides essential functions in a plant's metabolism, i.e. photosynthesis, protein synthesis and translocation of carbohydrates into roots (improved nutrient absorption) and storage organs, i.e. seeds, tubers and fruits, but growers forego yields and risk inefficient utilization of applied N, P and K, whist omitting Mg application.

Furthermore, particularly under conditions expected from climate change, magnesium, through its central role in stress alleviation, increasingly takes over the role of a risk insuring macronutrient that deserves more attention from growers in the future. This especially true when under limited land availability and more food needs to be produced on the existing or even shrinking land available for cultivation in more efficient systems whilst protecting and saving resources. ■

People & events

Expanded board at Koppert Biological Systems

Koppert Biological Systems has increased the size of its board in response to the projected growth of the Dutch family company. Koppert is a global specialist in biological crop protection.

The new composition allows for more focus on specific areas of operation. The original board that includes CEOs Paul Koppert and Henri Oosthoek, and CFO Robert Pathuis, has grown to include Peter Maes to be Director Corporate Marketing, Martin Koppert Director Agri, and Joram Oosthoek Director Finance and Control. René Koppert and René Ruiter will take up the position of Director Horti. The new roles are much more specific in nature and, together, cover all areas in which the company operates.

In addition to the expansion, there is also a shift within the management. Founder Peter Koppert and advisor John Budé, formerly non-executive board members, are now taking place on the Advisory Board.

'Our rapid growth and the need for specific divisions like Horti, Agri and live stock, made us realize that it was time for change within the top tier of the company', says CEO Paul Koppert. 'Three of the original board members will stay on to ensure continuity and pass on their valuable experience in leading the company. The new board represents a healthy balance between experienced family members who are ready to take on additional responsibilities, and non-family members who have earned their spurs over the years. The new members of the board each have their areas of expertise and we have every confidence that they will perform well in their new roles.'

New managing director appointed at Dunns

Chris Guest has been appointed as managing director of Dunns (Long Sutton) Ltd.

Wholly owned by Gleadell Agriculture Ltd since 2012, Dunns is one of the UK's leading pulse and seed trading and processing businesses.

Mr Guest joined Gleadell in 2008 and began his career in the trading department before becoming Gleadell's seed manager in 2010, a role he will continue to fulfil from the date of his new appointment at Dunns.

Alfred Stern to replace Mark Garrett as Borealis CEO

Borealis chief executive Mark Garrett has decided to leave the company after eleven years, appointing executive vice president Alfred Stern to the position.

Stern, who is currently responsible for the company's polyolefin business and innovation, will take over from Garrett on 2 July 2018.

Borealis is 64% owned by Abu Dhabi state-owned investment fund Mubadala, and 36% owned by Austrian oil and gas company OMV.

OMV chief executive Rainer Seele said that the appointment of an internal candidate will be beneficial for continuity.

Borealis has several major investment projects in the pipeline, including plans to construct a propane dehydrogenation (PDH) unit in Kallo, Belgium – currently in the front-end engineering and design (FEED) phase, a project in the pre-FEED phase to extend its Abu Dhabi-based Borouge joint venture, and US Gulf Coast petrochemicals joint venture with Total and Canada-based Nova Chemicals.

H.E. Suhail Mohamed Al Mazrouei, Chairman of Borealis' Supervisory Board and Minister of Energy and Industry of the United Arab Emirates, said "We have been fortunate to have had Mark Garrett in this position for over a decade, as his leadership has been beneficial to both Borealis and the wider group of Mubadala companies."

Yara International ASA announces organizational and management changes

Yara has announced the following changes to Yara's organization structure and corporate management:

Petter Østbø will take up the position of EVP and Chief Financial Officer (CFO). Østbø currently serves as EVP Production. Torgeir Kvidal will take up the position of Head of Mining operations, reporting to EVP Production.

Tove Andersen will take up the position of EVP Production. Andersen currently serves as EVP Supply Chain. Pablo Barrera Lopez, currently Country Manager Yara Chile, will take up the position of EVP Supply Chain.

Corporate Innovation will be moved to Industrial and report to EVP Industrial, Yves Bonte. Consequently, Pierre Herben will no longer be part of the executive management team.

Alvin Rosvoll will continue to be responsible for our partner operations and will from now on report to EVP People & Global Functions, Lene Trollnes.

Following these changes, the executive management team of Yara International ASA will be as follows:

Svein Tore Holsether, President and CEO
Tove Andersen, EVP Production
Yves Bonte, EVP Industrial
Lair Hanzen, EVP Yara Brazil
Pablo Barrera Lopez, EVP Supply Chain
Terje Knutsen, EVP Crop Nutrition
Kristine Ryssdal, EVP General Counsel
Terje M. Tollefsen, EVP Strategy & Business Development
Lene Trollnes, EVP People & Global Functions
Petter Østbø, EVP Chief Financial Officer

"The changes we make today will strengthen our ability to deliver on our strategy - meeting global challenges with value-creating business opportunities. I would like to express my gratitude to the colleagues who now leave the management team for their considerable efforts and dedication to Yara," said Svein Tore Holsether.

Gensource appoints of John Ryan as Independent Director

Gensource Potash Corporation has announced that John Ryan has joined the board of directors of the company.

Mr. Ryan is a proven leader in the corporate finance industry, with a focus on the agricultural sector. He brings a depth of knowledge of the linkages between agricultural producers and their suppliers, drawing on experience gained in a professional career spanning more than 40 years beginning in 1972 with the Business Development Bank of Canada, where he spent 25 years and rose to post of Executive Vice President responsible for the effective operation of BDC's 83 branch Canadian network. From there, Mr. Ryan relocated to Saskatchewan to assume the role of CEO at Farm Credit Canada, where he oversaw improvements to all aspects of the business, most notably the re-invention of the corporate culture to a positive, outward-looking one that focused on customers and employees. In 2008, Mr. Ryan accepted a challenging post-Great Recession role at Rabobank North America, initially as CEO of Rabo AgriFinance and finally as CEO of Rabobank North America. There, he oversaw all activities of the bank while, at the same time, implementing his focus on high performance teams, to the benefit of the organization and its clients. During his tenure, Rabo Agrifinance became the preferred lender to agricultural producers throughout the USA.

Mike Ferguson, Gensource's Chairman of the Board and President & CEO, commented, "We are so pleased to have John join us as a director with Gensource.

"With its vision of creating vertical integration between fertilizer production and the farmer, Gensource has always seen itself as an agricultural supplier rather than a miner. John's impressive career in the agri-finance business in North America is another step towards realizing that vision and comes on the heels of Gensource signing two MOUs with major North American agricultural players, the first step in negotiating binding off-take agreements that will trigger financing for construction of Gensource's first potash production module.

Phosphogypsum

Agricultural utilization and implications

by **Professor C. S. K. Mishra** and **Ms Suryasikha Samal**,
Orissa University of Agriculture and Technology, India

Soil nutrients essential for optimal plant growth are conventionally obtained from organic manures and chemical fertilizers. The three major nutrients are nitrogen (N), phosphorus (P) and potassium (K). Together they make up the trio known as NPK. Other important nutrients are calcium, magnesium and sulphur. Plants also need small quantities of iron, manganese, zinc, copper, boron and molybdenum, known as trace elements. Nutrient deficiency in soil affects soil biota as well as plant growth. In agricultural soil, optimal nutrient non-availability could adversely impact soil health and significantly reduce crop yield.

> *The fertilizer industry has observed a growth of 10% over that past 20 years*

Although worldwide soil nutrient deficiency is addressed by the application of requisite quantities of soil nutrients at recommended doses from various sources, of late, the utilization of industrial solid wastes as soil amendments in agriculture has gained popularity as a cost-effective alternative to chemical fertilizers. Production in the fertilizer sector has been increasing over the last few decades due to the consistent demand for chemical fertilizers in agricultural fields in a bid to achieve a high rate of productivity and food security, especially in developing countries. The fertilizer industry has observed a growth of roughly 10.1% over that past 20 years. Industrial growth has a closed linkage with waste generation which has had considerable environmental implications. Therefore, evolution of sustainable technology for the bulk utilization of these wastes has become a priority.

Why phosphogypsum?

One of these industrial solid wastes, phosphogypsum (PG) is generated in considerable quantity in phosphate fertilizer plants and has been reported to cause serious environmental problems during and after its disposal near the industry site. PG is produced as a waste by-product from processing phosphate rock by the 'wet acid' method for phosphoric acid production. Sulphuric acid is reacted with phosphate rock to produce phosphoric acid, to produce calcium sulphate (gypsum), a by-product. This by-product gypsum is called phosphogypsum, like natural gypsum, it is calcium sulphate, but it contains a small amount of radioactivity due to the radium that naturally occurs in phosphate rock. Because of this trace amount of radioactivity, a 1992 US Environmental Protection Agency (EPA) rule bans most uses of PG. The generation of PG occurs through the following chemical process. $Ca5(PO_4)3X + 5\ H_2SO_4 + 10\ H_2O \rightarrow 3\ H_3PO_4 + 5\ (CaSO_4 \bullet 2\ H_2O) + HX$, where X may include OH, F, Cl, or Br. PG is radioactive due to the presence of naturally occurring uranium and thorium, and their daughter isotopes radium, radon, polonium, etc.

About 5 tons of PG are generated for every ton of phosphoric acid used. World PG production is variously estimated to be in the region of 100-280 mn t per annum.

Agricultural uses of PG as soil amendment

PG has been one of the most serious problems faced by the phosphate fertilizer industry. Only 15% of the world's production is recycled as an agricultural fertilizer, building material or soil stabilization amendment. The remaining 85% is dumped near the industry, thus demanding a large disposal area. Consistent piling of PG could cause soil, water and air pollution problems. In the western countries, accumulation of untreated PG is associated with release of uranium series radionuclide which is originally present in the phosphate rock used as a raw material. There has been a consistent effort to reduce the radionuclide level in the PG stacks. In many countries, including the US, restrictions are enforced for a limited use of PG in agriculture. The US Environmental Protection Agency has permitted the controlled use of PG if radium-226 levels are less than 10 pCi/g. This restriction essentially eliminates the use of southern Florida PG because its radium-226 is in the range of 15-25 pCi/g. PG from northern Florida and North Carolina, with lower levels of radionuclides, however, are recommended for agricultural use. In developing nations such as India, radionuclide levels are invariably low and therefore the use of PG as soil amendment is in practice as a cheaper source of calcium and sulphur to address nutrient deficiency in agricultural fields. Calcium is essential for root health, growth of new roots and root hairs, and the development of leaves.

Sulphur is a constituent of amino acids in plant proteins and is involved in energy-producing processes in plants. It is responsible for many flavour and odour compounds in plants such as the aroma of onions and cabbage. Sulphur deficiency is not a problem in soils high in organic matter, but it leaches easily. However, in these countries there are reports of soil contamination due to elevated concentrations of PG in soil causing contamination problems and a subsequent decline in crop productivity.

PG applications

During agricultural applications PG and lime can significantly increase rooting density in the surface of soil rich in aluminium, which is extended to the depth of 60 cm with PG application. PG and lime positively influence fruit size and yield in peaches. PG has been used for quite some time to prepare acidic soil for agricultural purpose and/or to prevent soil becoming acidic where irrigation water contains small quantities of salts. For example, PG could prove to be an excellent treatment for soils reclaimed from the sea in the Netherlands. However, PG has probably been more widely used on acidic soils in arid regions in Israel and in the western US. It is reported that PG speeds up the leaching of salts from soil. The addition of PG to clay-rich soils creates a more open porous soil texture that tends to soak up rainfall thus minimizing soil erosion.

PG has the potential to reduce the concentration of metal ions in the soil, either by a fixation mechanism or by promoting condition that favour leaching of these ions from the soil. This property of PG is particularly valuable where farming and/or fertilization practices have resulted in toxic levels of ions in the soil.

It has long been recognised that sulphur is almost, if not equally, as essential for proper plant growth as nitrogen, phosphorous and potassium. PG is an ideal sulphur source, slightly soluble in water and therefore long lasting in the soil. The sulphur is present in sulphate form and can be utilized directly by the plants. It is neutral in the soil reaction and does not change the soil pH. As an added bonus, it contains calcium that is also readily available to the plants. While there are many other fertilizer sulphur sources, none of them have all the agronomic advantages of PG. Elemental sulphur must undergo bacterial conversion to sulphate before the plant can utilize it. Organic sources of sulphur must be decomposed bacterially for plant utilization. While both sulphur and organic sulphur are long lasting, PG demonstrates the same desirable characteristics due to its low solubility. Unlike PG, most other sulphate salts used as fertilizer are highly soluble and the sulphate may be leached from the soil before plant utilization.

High-magnesium soils can be brought back to a highly productive state by increasing the levels of calcium to counteract the deleterious effects of magnesium. This is accomplished through the application of a source of calcium to the soil in sufficient amounts. PG contains 1.3-2.9% phosphate, including 0.2-0.9% in soluble forms that acidify soil and accelerate the exchange reactions. In addition, PG has a positive effect by providing mobile phosphorus. Acids within PG increase the solubility and provide a significant improvement of agronomic properties of fused soil, so crop yields could double in the first year of its application.

Environmental implications

Optimal application of PG is likely to positively influence soil health in terms of essential nutrient availability, microbial population, other soil biota and plant growth. In developing nations, due to non-mechanization of fertilizer application methods in agricultural fields, there is a strong probability of application of PG at higher than the recommended doses. Elevated concentration of PG in soil could create unfavourable ecological conditions which may not be congenial for useful soil organisms and plants. For example, experimental results in India have shown that a higher than the recommended dose of PG suppresses microbial exoenzyme activity, population of useful bacteria and fungi and causes a negative impact on organic matter decomposition and soil respiration. Research has also indicated that elevated PG concentration could result in significant debility and reduced ecological functions in major groups of soil fauna including earthworms. ... With the consistent rise in demand for phosphatic fertilizers during agricultural practices, the generation of solid waste such as PG is likely to increase manifold in the near future. Therefore, efforts are in progress for large scale recycling of PG so as to minimize its adverse environmental impact. PG amendment in deficient soil as sulphur and calcium supplement and a soil conditioner need to be carried out judiciously with utmost care so that excessive application does not cause undesirable soil toxicity and deleteriously impact soil biota. ■

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