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Fertilizer Focus
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Front cover image: Potash mine, Saskatchewan, Canada

EU agricultural policy: The future

The need for a focus on nutrient management

by **Tiffanie Stéphani**, Agriculture and Environment Manager, Fertilizers Europe

On 1 June 2018, the European Commission presented its legislative proposals on the future of food and farming, i.e. the Common Agriculture Policy (CAP). The new proposals are designed to support European farmers and ensure Europe's food security and a resilient, sustainable and competitive agricultural sector. In the light of the upcoming 'Brexit' and new priorities of the European Union, the European Commission proposed a reduction of around 5% of the budget for CAP for the period 2021-2027.

With its new legislative proposals, the EU Commission aims to grant more flexibility to European countries in the implementation of the policy and also sets higher ambitions on environment and climate objectives for the agricultural sector. As far as plant nutrition and fertilization are concerned, for the first time the EU Commission is proposing that EU countries introduce a 'Farm Sustainability Tool for Nutrients' for farmers.

But concretely, what do the Commission proposals mean for farmers and the European fertilizer industry?

Paradigm shift

Based on nine objectives, the intention of the European Commission is that the future CAP will continue to support the European farming model with an increased focus on the environment and climate, encouraging the transition towards a more sustainable agricultural sector and the development of vibrant rural areas. Further objectives are linked to ensuring a fair income to farmers, increase competitiveness and ensure a fairer functioning of the food chain (see figure 1).

Aiming to achieve such a diverse set of objectives at the same time, it is crucial that the new CAP provides a strong policy framework that supports EU governments and farmers in delivering on the expectations imposed on them. This is why the European Commission proposes a system, aiming at simplifying and modernising the way the CAP works for farmers and EU countries alike. The 'one-size-fits all' approach will be changed to give more freedom to EU countries, letting them decide on the way to meet common objectives set at EU level and on how to best respond to the needs of their farmers and rural communities.

In practice, each EU member country will carry out an extensive analysis of its specific needs and draw up a 'CAP strategic plan', on the basis of the 'SWOT analysis'. The plan will set out how each country will use CAP funding to meet their needs, including the tools to be used and establishing specific targets while complying with the overall objectives set by the EU.

However, this new approach naturally poses different concerns. It is questionable whether the new CAP will deliver the long-awaited simplification, which farmers have been asking for years, a concern that is shared by many stakeholders and especially farmers' organisations in Brussels. Also, the question arises whether the increased flexibility in the implementation of national strategies will be double-edged. In fact, there is a growing concern that it would compromise the current level-playing field for European farmers.

Focus on nutrient management

The 'Farm Sustainability Tool for Nutrients' was proposed by the EU regulators (as part of the legislative proposal on CAP strategic plans) with the aim to enable a platform for on-farm nutrient management that would help reduce ammonia and N_2O emissions from the agriculture sector and improve water quality in Europe. Such a tool would compile information from satellite data, soil sampling and land parcel information and would be directly accessible to farmers in order to help them make informed decisions on nutrient requirements. The principle of this tool should be agreed as part of the specific law setting the CAP strategic plans (one per EU member state), while the details should be fixed at a later stage by the EU Commission via further legislation.

Figure 1. Nine objectives of CAP 2021-2027

Source: Future of the common agricultural policy, European Commission

> *The tool should be based on the nutrient use efficiency*

Fertilizers Europe (the European association that represents the majority of fertilizers producers in Europe) sees the proposal of this tool as a positive step forward. For many years, the EU agricultural policy fell short in encouraging farmers' efforts towards good nutrient management, which is crucial if the agri-food sector wants to achieve the set of the EU's environmental objectives. Fertilization has often been criticized for causing pollution because some nutrients, such as nitrates and phosphorous, can be leached to surface and ground water when the plant cannot absorb them. However, it is not the use of fertilizers as such, being organic or mineral, that creates environmental problems, it is the inappropriate fertilization practices that usually result in negative environmental impacts. We must not forget that fertilization is deeply connected with agricultural productivity and food production - it plays a vital role in ensuring food security for today and tomorrow. Thus, a farm sustainability tool will definitely enhance agricultural management practices in Europe and enable farmers to meet the double challenge of producing food for all at an affordable price while reaching the environmental targets.

While the trend towards fewer nutrient losses to the environment is already very positive in the EU, there is still further room for improvement. In several EU countries, nutrient management plans are already considered an integral part of good agricultural practices. However, these strategies are often strict, targeting only the environmental aspects without enough focus on economic and agronomic impacts. This is where a 'Farm Sustainability Tool for Nutrients' can make the difference by being a decision-support instrument for farmers, and not a control mechanism. From the perspective of Fertilizers Europe, the tool should:

- Help farmers to reach better yields, and possibly savings on fertilizer application by focusing on the needs of the plants.
- Promote balanced plant nutrition, the improvement of crop quality and an increase of nutrient use efficiency.

The tool should not be based on the quantity of nutrients applied, but rather on the nutrient use efficiency. The 'Nitrogen Use Efficiency' indicator developed by the EU Nitrogen Expert Panel (for more information www.eunep.com) can be one of the metrics that would perfectly fit in the tool.

Furthermore, the CAP post-2020 could also support good nutrient stewardship by encouraging the

up-take of precision nutrition by farmers through the use of products with better formulations, micro-nutrients and agronomic additives (e.g. nitrification inhibitors) combined with a knowledge-based application of mineral fertilizers to support agronomic and environmental efficiency. The proposal of the EU Commission regarding nutrient management is quite ambitious, so it is unclear whether it will survive the upcoming legislative proposals. In addition, many EU countries are apprehensive about the new provisions, which they will have to implement as part of the paradigm shift for the CAP post-2020.

Stakeholder reactions

Since the publication of the Commission proposals, a permanent conversation is ongoing in Brussels. Many stakeholders are rather sceptical about the new framework. For instance, the European association of farmers and agri-cooperatives (Copa-Cogeca) stated it was "very concerned" about the impact of the proposals on farmers, citing an "erosion" in direct subsidies, which it said was crucial for farmers to continue producing food. Environmental non-governmental organizations are not convinced about the proposals either and warnings from their side were far starker. Greenpeace suggested that the reform "could spell disaster for the environment," while BirdLife Europe saw "nature in peril as Europe faces another decade of biodiversity-killing intensive farming." The European Environmental Bureau said that the EU's "timid farm 'reform' (ignored) environmental crisis on Europe's farmland."

Forum on fertilizers and nutrients for growth

The 'Forum on fertilizers and nutrients for growth' chaired by the Member of the European Parliament (MEP) Julie Girling (EPP, UK) and MEP Peter Jahr (EPP, Germany) and organized by Fertilizers Europe in July 2018 was an opportunity to bring together representatives from the European Parliament and the European Commission as well as some of the most relevant stakeholders related to CAP post 2020 to discuss about the policy just one month after the publication of the Commission's proposals. Amongst others, we heard Director-General, Rudolf Mögele (Directorate-General for agriculture of the EU Commission) and MEP Esther Herranz García (EPP, Spain), the recently appointed rapporteur of the European Parliament on the CAP strategic plans. The forum provided a unique platform where stakeholders could engage in open discussions, share their viewpoints and concerns and provide the European circle of agricultural stakeholders with concrete and creative solutions for the future (see figure 2).

Figure 2. Forum on Fertilizers and Nutrients for growth, 10 July 2018, European Parliament, Brussels

> *"CAP post-2020 must promote knowledge-intensive farming*

Moving forward

For the time being, Fertilizers Europe is strongly convinced the CAP post-2020 must maintain agricultural productivity growth and foster a better environmental performance of the farming sector. This reflects the intention of the Commission in its recent legislative proposals. The new approach will make the governments of the EU countries more accountable on how the EU budget is spent, and this is a good thing. Such a move also finally acknowledges that farmers, from Sweden to Corsica, and from Brittany to Romania, cannot all apply the same measures.

If Europe wants to be forward-looking, then the CAP post-2020 must promote knowledge-intensive farming and tap into the increasing amount of data available in order to enable all types of farmers in Europe to become more competitive and have a better environmental performance at the same time. For Fertilizers Europe, this means that the new CAP should include a focus on precision plant nutrition and the newly proposed 'Farm Sustainability Tool for Nutrients' – two approaches which will enable farmers to meet the plants' needs and the environmental expectations of European citizens. ■

Zinc: a crucial element that pays its way

by **Associate Professor Daniel Kaiser**, University of Minnesota, USA

All plants need zinc for growth and development. Zinc plays an important role in the various enzymes that are responsible for driving metabolic reactions in plants. Deficiencies of zinc can affect carbohydrate, protein and chlorophyll production, which can significantly reduce the yield of crops. Plants need zinc, a micronutrient, in small quantities. For example, high yielding corn takes up less than 0.5 lb of zinc annually. Roughly half the total uptake is in the grain, which is removed from a field at harvest. When deficient, small quantities of applied zinc can increase the yield enough to more than pay for the cost of the fertilizer.

> *Zinc is immobile in the soil and moves to plant roots by diffusion*

Zinc exists in the soil as the plant-available Zn^{2+} cation, as primary and secondary zinc minerals, and as adsorbed or labile zinc. Plant available zinc is a cation and can be held on clay surfaces with a cation exchange capacity. Topsoil removal and soil phosphorus concentration can also impact zinc availability.

Soil pH affects zinc solubility. As a metal, zinc solubility in the soil decreases with increasing soil pH due to precipitation of amorphous zinc or various zinc-oxide compounds. Not all neutral-to-alkaline soils are deficient in zinc. Chelation of zinc by organic compounds in the soil can increase the availability in neutral-to-alkaline soil, which maintains the availability to crops.

Zinc deficiency can occur in crop production over a wide range pH values, because some soils may be natively depleted of zinc. Assessing plant availability of zinc is critical to ensure enough is supplied without limiting the yield.

Assessing zinc availability

Zinc is immobile in the soil and moves to plant roots by diffusion. Zinc behaves similarly to phosphorus and potassium. Due to limited movement, it is taken up by the roots in a small area around the root surface and the roots need to continually exploit larger soil volumes to maintain an adequate zinc supply. Soil tests collected at a prescribed depth will accurately assess the availability of immobile nutrients. The majority of soil tests used for immobile nutrients do not measure the total amount of nutrients in the soil because the total nutrient content is less important than the relative bio-availability of a nutrient in the soil. Instead, they are correlated to crop response, giving an index of nutrient availability. Calibrations related to the relative availability are then utilized to direct a suggested rate of fertilizer in situations where a fertilizer is more likely to increase plant growth and yield.

Different soil extraction solutions are being used to determine zinc availability. The suggested soil test in the north central United States is the DTPA (diethylenetriaminepentaacetic acid) test. Other tests such as the Mehlich-III are also used. Research data has noted differences in soil samples extracted by these two procedures. The Mehlich-III test commonly results in higher soil test zinc values compared with the DTPA test for the same soil. Critical soil test levels must be changed to account for differences in zinc based on soil extraction solution and suggested zinc applications are not interchangeable among various soil test extractions. All soil tests for zinc suggested for use should be properly correlated and calibrated to local conditions to ensure suggestions based on the test are accurate and can predict where a response to zinc may occur.

Plant tissue analysis has become more popular recently and is being used as a tool to determine hidden hunger symptoms in crops. Zinc is increasingly reported as deficient in corn using tissue analysis and research

(left) Zinc deficient corn in southern Minnesota

has shown a link between tissue and soil zinc concentration. While farmers are getting reports of low tissue zinc concentration, there are discrepancies among sources in adequate tissue zinc concentration for corn and other crops. For example, recent surveys of zinc concentration in corn leaves collected from hybrid trials at mid-silking indicated that roughly three quarters of samples were zinc deficient assuming a critical level of 25 mg Zn kg^{-1} identified as sufficient in the 'Plant Analysis Handbook' which is a widely used source of information for tissue analysis. Other information states that 15 ppm is sufficient in most leaf tissue. In the case of the Minnesota survey over 95% of samples would be sufficient using 15 ppm as a critical level. Plant tissue analysis values are based on specific plant parts sampled at specific growth stages, but the interpretation of data used for sufficiency level identification is critical for ensuring an accurate assessment of availability.

Cool wet soils early in the growing season can affect zinc uptake and sampling too early can result in identifying deficiencies where none may exist. Zinc is important for plant growth and development, but temporary deficiencies early in the growing season will likely not result in yield reduction if enough zinc is available to the plant during critical periods of uptake.

Uptake of zinc is also impacted by the uptake of other plant nutrients. Competition between other micronutrients such as copper, iron and manganese can impact the uptake of zinc. There has been a long-established relationship between phosphorus and zinc. Soils with high phosphorus availability can induce zinc deficiencies in soils with marginal zinc availability. In the plant, high phosphorus concentrations can impact zinc metabolism. However, interactions between the two elements are not likely to be significant enough to make a difference, even in heavily manured soils with P concentrations well above 100 mg P kg^{-1}, because zinc is supplied with the manure as well. In demonstration plots, it has typically required well over 500 lb P_2O_5 (250 kg P ha^{-1}) to induce a zinc deficiency on soils with marginal zinc availability for crops sensitive to zinc deficiency.

Figure 1. Relationship between corn leaf zinc concentration from the leaf opposite and below the ear at silking versus soil DTPA zinc concentration

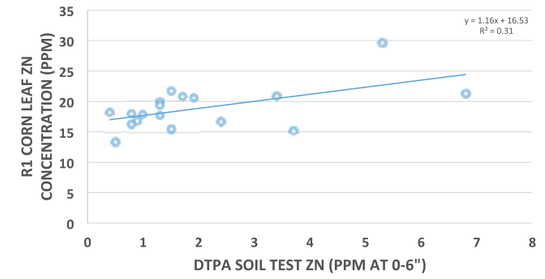


Table 1. Corn grain yield response to ammonium polyphosphate fertilizer (10-34-0) applied with and without 10% chelated liquid zinc.

Site	Control	10-34-0	10-34-0 + Zn	ST – Zinc
	bushels/ac			ppm
Murdock '12	194	192	192	2.8
St Charles '13	204	198	197	1.7
Willmar '13	159b	173a	172a	1.0
Prinsburg '14	200	209	204	2.6
Stewart '14	162	167	162	1.3
Becker '15	179	192	184	1.1
Lamberton '15	214	213	212	0.6

Notes: 2.5-6 gpa + 1 qt/ac Blue Tsunami [10% chelated zinc (citric acid/EDTA)]
Potential response to Zn - Individual plot yield was highly variable for the treatment (min 168 and max 228), no response for treatment with Zn only.

Sources of zinc

Zinc fertilizers range from dry materials containing zinc sulphate or zinc oxide to liquid sources of zinc sulphate or zinc chelates, which can be banded and used for in-furrow or banded starter fertilizer for corn. Blended fertilizer materials containing zinc are becoming more prevalent in the fertilizer market. Fertilizer sources containing zinc within each granule offer a way to distribute low rates of zinc over a larger area versus higher analysis zinc materials. The overall benefits of fertilizer sources with zinc in each granule are widely debated as the technology comes at an increased cost and not all soils are deficient in zinc and require application.

Liquid forms of zinc are applied directly on the seed with other liquid fertilizers as a starter fertilizer for corn. Liquid fertilizers can contain zinc compounds or chelates. Chelates are molecules that can bind with zinc and benefit plants by preventing zinc from forming insoluble compounds in the soil. They also prevent reaction of zinc and ortho-phosphate in starter fertilizer blends. Zinc phosphate can precipitate if the zinc is not protected. Not all chelate sources are equal in supplying zinc to the crop. Fully chelated sources of zinc tend to cost more and require a band application to concentrate the zinc in a small volume of soil but are a better alternative than non-chelated zinc in maintaining zinc availability. Band application of zinc on the corn seed still follows the same principles

at broadcast application as soil test concentration for zinc increases the likelihood of responses decrease. Studies in Minnesota in the northern US corn belt on corn have found no response to zinc chelates applied with ammonium polyphosphate liquid fertilizer on the corn seed at planting for soil test zinc ranging from 0.6 to 2.8 mg Zn kg^{-1}.

Zinc responses in corn production

Zinc is the micronutrient most frequently shown to reduce corn grain yield in the northern US corn belt. Research in northern Minnesota showed corn grain yield can be increased substantially for soils testing low in zinc. While a large increase in yield is possible, smaller yield increases are more difficult to detect for soils with marginal zinc availability and the increase in yield may cover the cost of the zinc fertilizer. Current guidelines for zinc use in Minnesota suggest application when a soil test in the top 15 cm is 0.5 mg Zn kg^{-1} (ppm) using the DTPA test. Research in the upper mid-west US has demonstrated inconsistencies with the DTPA soil test to predict where a zinc response will occur. Soil testing for zinc is still the best option pre-application because it allows for decisions to be made before planting.

It is possible that the crop may need zinc in spite of high soil test values. Colonization of roots by arbuscular mycorrhizal fungi help plants like corn take up zinc from the soil. Some plants are non-hosts for arbuscular mycorrizae and can reduce colonization for crops grown proceeding the non-host crop. Reduction in mychorrizal colonization also impacts the uptake of phosphorus, a process termed 'fallow syndrome'. One example of a non-host crop is sugarbeet. Growing corn following sugarbeet can, but does not always, result in a deficiency of phosphorus and zinc the following year during the early growing season.

Symptoms related to fallow syndrome can occur in crops over a wide range in soil test values. A broadcast application of phosphorus or zinc following a non-host crop has been shown to have little benefit in alleviating fallow syndrome when it occurs in a proceeding crop. Fallow syndrome can be best corrected using band application of phosphorus and zinc applied at planting. Application of liquid fertilizer directly on the seed is common in some areas of the northcentral US. Over-application of fertilizers directly on the corn seed can present risks for seeding damage and reduced germination. The rate of fertilizer required to reduce the effect of fallow syndrome may be more than can be safely applied directly on the seed with the planter.

Table 2. Corn grain yield response to broadcast zinc sulphate at three rates in the Red River Valley in Minnesota - 2009-2010.

	Corn Grain Yield (bu/ac)				
Zinc Rate (lb/ac)	**0**	**5**	**10**	**15**	LSD
Polk '09	171	164	169	167	ns
Mahnomen '10	168	169	179	191	13
Red Lake '10	211	199	195	194	ns
Marshall '10	134	132	143	135	ns

Notes: Soil test Zinc (DTPA): Polk '09 1.36ppm; Mahnomen '10 0.37 ppm; Red Lake '10 0.65 ppm; Marshall '10 0.55 ppm. Zinc rates applied as broadcast Zinc Sulfate (36% zinc)

Source: Severson – Unpublished data

Does zinc play a critical role in modern crop production?

Zinc is a required element for modern crops and increasing yields will result in a greater removal of zinc from soils. While important, there are still many soils that contain enough zinc for most crops. Identification of which crops are susceptible to a deficiency is critical to ensure zinc is being applied profitably. Since zinc is immobile in the soil, any application of zinc in excess of crop requirements will increase soil test over time. Increasing soil test is not a bad option, as it allows for a single application to have benefits over multiple years.

One consideration for farmers is how to apply zinc if needed. Current technology allows for a variable rate for the application of fertilizers. The ability to variable rate zinc with a broadcast application allows for correcting deficiencies on a site-specific basis and this targets zones that are more likely to get a response in yields. Other farmers may opt for liquid options applied with the planter over their entire acreage. Cost effectiveness and ensuring that there are no areas in the field where a greater rate must be applied to maximize yield is critical with this strategy.

The final option is foliar application of zinc which is commonly suggested when tissue samples suggest zinc concentration is low. The primary drawback of tissue samples is that more than one application may be required if zinc is truly deficient in the soil when applied to an actively growing crop. For annual crops pre- or at-planting options are better to ensure zinc is supplied continually to the roots and can be translocated to new growth. As mentioned, zinc is not mobile in the plant thus anything taken up through the foliage may not be translocated to new tissue.

While more reports of zinc deficiencies have occurred in the upper mid-west US, most of these reports come from plant tissue analysis. Soil testing is still the best option to address where a zinc response may occur. Zinc is immobile in the plant, and foliar applications may be effective at a single point in time, but multiple foliar applications will be required to correct a deficiency in the soil if it exists. If consistent deficiencies are reported by tissue analysis and zinc was applied before planting, then the sufficiency levels used should be questioned. Older data suggests 15 ppm tissue concentration should be sufficient for most crops. In order to refute this sufficiency value, yield response data is required to ensure plant tissue concentration values have meaning. Zinc is an important nutrient for crop production but with profit margins getting tighter it is still important to determine if application is warranted. ■

Slow and steady

The effects of different coatings on nitrogen release in soil

by **Job Fugice**, Coordinator, Analytical Services,
Dr. Christian Dimkpa, Scientist and
Lauren Johnson, Consultant, International Fertilizer Development Center (IFDC), USA

Nutrient losses from fertilizers contribute significantly to low fertilizer use efficiency. There are 14 major nutrients needed for optimum plant growth, however, nitrogen (N) is the most commonly used in fertilizers and accounts for nearly 50% of fertilizer nutrient losses, contributing to atmospheric greenhouse gas emissions, pollution of underground water, and eutrophication of surface water. Thus, most of the improvements needed and made to fertilizers have been on N-based fertilizers. One of the primary objectives of N management for improved fertilizer use is the development of slow or controlled release fertilizers. These efforts are designed to delay N release to synchronize with the crop's needs, primarily involving coating the fertilizer with a natural or synthetic material that can predict, to different degrees, the timing and rate of nutrient release from the encapsulation.

This article briefly explores examples of the materials and processes used to produce or formulate controlled release fertilizer coatings that are cost effective and that improve N uptake by plants.

Coating type

Inorganic - sulphur and polymers

Sulphur as a fertilizer coating forms an impermeable layer over urea that prevents water from penetrating to the urea granule and slowly decomposes as a result of microbial, chemical, and physical processes. Studies have shown that sulphur-coating urea could reduce ammonia volatilization from soil by as much as 43-78% and decrease soil ammonium content and nitrous oxide flux rate by 8% and 15%, respectively. Also, sulphur-induced N recovery of up to 70% from soil by plants has been demonstrated. Unfortunately, sulphur-only coatings are physically characterized by a brittle and relatively easily damaged surface, permitting water entry that dissolves the urea granules, resulting in nutrient leaching. Furthermore, sulphur is relatively acidic such that its use for coating can result in soil acidification and, thus, in nitrogen deficiency. However, these weakness in sulphur coatings can be corrected by applying a secondary coating or sealant onto the primary sulphur coated surface and liming the soil, respectively.

Compared with sulphur, synthetic polymers are reportedly more effective because they are less prone to coating disruptions caused by microbes, however, they may be subject to the deposition of residues, with hazard implications for the environment. Coating polymers are relatively hydrophobic, permitting controlled diffusion of moisture through their variably permeable membranes, thereby controlling the release of N at rates that vary with the degree of polymer permeability, composition, thickness, soil temperature, and soil moisture level.

Organic - biopolymers

On the organic spectrum of fertilizer coatings, the use of biopolymers allows for more environmentally friendly alternatives to chemical/organic polymers. Examples of biodegradable material that have been reported in literature include chitosan, neem and lignin. In a test of chitosan-starch beads for N release in water, between 70-92% of the total N was released after 14 days, dependent on chitosan-starch mass ratios.

Mode of action

Coating to inhibit urease activity

For many years, the restriction of urease activity has been viewed as the best option for reducing N losses and increasing N use efficiency, specifically the use of inhibitors to modify fertilizer release patterns based on altering the biological activities of urea-metabolizing enzymes of soil bacteria. Urease inhibitors are formulated into solid (e.g. by coating) or liquid fertilizer products or applied separately to the soil in order to reduce urea hydrolysis by ureases.

Coating for nitrification inhibition

Nitrification inhibition is based on the retardation of nitrifying bacteria that oxidizes ammonium to nitrate, which otherwise leads to both an increase in atmospheric nitrous oxide emission and nitrate leaching in soil. Because nitrification occurs for a longer period of time (20-28 days) compared to urea hydrolysis (5-7 days), nitrification inhibitors can provide a greater opportunity for synchronizing N release with crop demand, while reducing leaching and N2O emission. Examples of commonly used nitrification inhibitors include Dicyandiamide (DCD), 3,4,-dimethylpyrazole phosphate (DMPP), thiophosphoryl triamide (TPTA) and neem. It has been suggested that a combination of urease inhibitor and a nitrification inhibitor could enhance the benefits of improved fertilizers. Accordingly, patents have described slow release fertilizers simultaneously involving urease and nitrification inhibition. One particular invention involved formulating a range of macro and micro nutrients, including several N sources, among them urea, with lecithin and amidinothiourea. Release of nitrogen from the product in a cotton field was prolonged to 121 days, compared to 30 days from conventional urea. Furthermore, the uptake of N into the plants was improved by 37% over conventional fertilizer. This and other examples of nitrification inhibition provide further insight into the effects and benefits of nitrification inhibition and give building blocks for further research on the topic.

Four kinds of coating: zinc oxide and rice-bran wax (*top left*), gypsum (*top right*), polymer (*bottom left*), sulphur (*bottom right*)

(*left to right*) Zinc oxide and rice-bran wax, gypsum, sulphur, and a polymer are all types of coatings that control the release of nitrogen or other elements into the soil

Nitrogen management

Mineral nutrients

Minerals composed of nutrient elements can also play a role in reducing N loss from fertilizers when used in fertilizer coating or embedding. Such minerals include struvite and gypsum and dolomitic limestone. Gypsum is a calcium-sulphate mineral, and dolomitic limestone is composed of calcium and magnesium carbonate. In one experiment with gypsum-dolomite embedded in a N fertilizer product, Dependent on the gypsum-dolomite rate, between 10- 26% less N was released from urea, which was further reduced to 34% with addition of polyols as a sealant. Another example describes different variants of an extended release fertilizer composed of calcium (as sulphates) and nitrogen sources, with or without starch or other blocking or binding additives, absorbent materials, phosphorus, potassium and secondary and micronutrients. The solubility of this potentially balanced fertilizer product is regulated by the addition of starch, protein gel, gelling glues or other synthetic gelling compounds. The absorbent material can be derived from perlite, grind paper waste, plant bark, peat moss or other similar absorbent materials. One variant of this product containing ammonium sulphate (70%) as N source, corn starch (1%), potassium sulphate (20%), and gypsum (calcium sulphate dihydrate 20%) showed good results in terms of improving N uptake in crops, compared to another variant which N source was urea.

Nanotech

Nanotechnologies have recently been used to improve N-fertilizer use efficiency. Nanotechnology uses the polymer coating material or formulation active ingredient (nutrient element) at the nano-scale, where material size is reduced by between 1000 (1 nanometer (nm)) and 10 (100 nm) times of the size of conventional bulk (≥1000 nm) polymers or nutrient materials. Nanofilms, nanopolymers, or nanoscale additives of other nutrients have been used to modify N fertilizers, and such modifications have been shown to be able to control or slow the release of N, allowing for an increase in N uptake and plant productivity. In one example, a slow release fertilizer based on a hydroxyapatite (HAP)-urea-wood powder composite was produced. HAP is a naturally occurring phosphorus and calcium-rich mineral which can also be synthesized by wet chemistry. A subsequent N-release evaluation conducted in acidic and neutral soils showed that the nano urea-HAP composite releases the urea slowly, reducing N release rate by about 21% at pH 4.2, 27% at pH 5.2, and 44% at pH 7 after 60 days, compared with conventional urea.

Improved technologies

The reduction of N losses by increasing N uptake and use efficiency by crops is at the core of N-fertilizer improvement strategies. Reduction of N loss has the direct effects of increasing crop yields and lowering N-induced environmental abnormalities, including greenhouse gas emission and eutrophication of water bodies. As such, technologies that offer such improvements at an affordable cost to farmers, and are also profitable for the fertilizer industry, should continue to be identified and promoted in order to be able to feed the growing human population. ■

News in brief

EUROPEAN UNION

Sirius Minerals reports Q2 progress

The project remains on track to deliver first polyhalite and commercial production on time. The fully procured and financed capital estimate will be provided to the market once binding financing commitment letters have been executed.

This is a function of both the finalisation of procurement process and the finalisation of financing programmes finishing work with the independent expert from the banking group.

Initial responses received from banks participating in the stage 2 financing process are positive.

A supply agreement for Nigeria was signed during the period taking peak aggregate contract volumes from 4.4 Mntpa to 4.7 Mntpa. Active engagement on multiple commercial discussions for new supply agreements in Brazil and Europe.

Chris Fraser, Managing Director and CEO of Sirius, commented: “It has been a quarter of good progress as we continue to construct our Woodsmith Mine, as well as breaking-ground on Teesside. Work to deliver the stage two financing continues at pace and we are delighted to add a new, well established customer, in the high potential African region, to our growing list of partners.

“The economic and social benefits to our nationally significant infrastructure project are vast, as recently illustrated by QUOD’s independent economic impact assessment, and we look forward to delivering these important and long-lasting benefits to both national and local economies.

“With commercial momentum and the development of our world-class mine continuing to progress well, we remain confident of delivering on our key milestones for 2018 and ultimately delivering on our vision to be a world-class fertilizer business.”

Haldor Topsoe acquires full ownership of Ferrostaal Topsoe Projects GmbH

Denmark-headed Haldor Topsoe has announced that it has acquired full ownership of Ferrostaal Topsoe Projects GmbH, a 50/50 joint venture between Germany-headed global industrial project developer and service provider Ferrostaal GmbH and Haldor Topsoe.

The transaction adds strong project development competencies to Topsoe’s market-leading portfolio of high-performance catalyst and proprietary technologies for the chemical and refining industries.

“Adding the competency of project planning and development to our strong technology portfolio we can offer even better service to our customers. Going forward our complete offerings entail licensing, basic engineering, catalysts, proprietary equipment, services, and project development,” says Amy Hebert, Deputy CEO & EVP Chemicals, Haldor Topsoe.

Acquisitions support Topsoe’s growth strategy. The acquisition of Ferrostaal Topsoe Projects GmbH (FTP) will strengthen Topsoe’s existing business within ammonia, methanol, GTL and refinery, along with upcoming development projects.

“We look forward to welcoming our new colleagues in Germany. They are true experts, who offer proficient project development support to our customers from the very early stages of their projects. In addition, they have financial experience and bring with them a strong network and access to financial institutions, helping our customers finance and realize their projects,” says Amy Hebert.

OTHER EUROPE

EuroChem signs MOU with Heilongjiang Beidahuang Farms to supply potash and NPK fertilizers

EuroChem Group has announced the signing of a memorandum of understanding (MOU) with Heilongjiang Beidahuang Farms, part of Beidahuang Group, China’s largest agricultural company.

The MOU will see EuroChem supply potash and other NPK fertilizers to Heilongjiang Beidahuang Farms. Specific terms are to be agreed by the parties.

The MOU was signed during a visit by Beidahuang executives to EuroChem’s Usolskiy Potash Plant near Perm this week.

Dmitry Strashnov, EuroChem Group CEO, noted: “This memorandum underscores EuroChem’s commitment to China and highlights our determination to become a strategic supplier to one of the world’s most important agricultural markets.”

With the full ramp-up of potash production at EuroChem Usolskiy Potash and VolgaKaliy, EuroChem will become one of only three companies worldwide with capacity in all three key nutrient categories, providing farmers with all essential crop nutrient solutions.

Yara reports improved deliveries but lower margins

Yara International ASA delivered lower second-quarter results compared with a year earlier. Net income after non-controlling interests was negative USD211 million (USD0.77 per share), compared with USD82 million (USD0.30 per share) a year earlier. The negative result includes a non-cash currency loss of USD302 million resulting from a strengthening US dollar through the quarter, which is fundamentally positive for Yara. Excluding currency loss and special items, the result was USD0.17 per share compared with USD0.34 per share in the second quarter 2017.

Second-quarter EBITDA excluding special items was USD321 million, down 5% compared with a year earlier as higher deliveries and sales prices were offset by higher European gas costs.

"Yara reports 13% higher deliveries, despite the truck-drivers' strike in Brazil. However, underlying EBITDA was five percent lower, as improved deliveries and sales prices were offset by increased energy cost," said Svein Tore Holsether, President and Chief Executive Officer of Yara.

"While the operating environment for our business is likely to remain tough for some time yet, the market balance looks set to gradually improve after 2018. We remain focused on our improvement and growth programmes, which have improved Yara's earnings by more than 25% in the last 12 months, and will deliver even higher earnings going forward," said Holsether.

Total fertilizer deliveries were 11% higher compared to a year earlier, driven by increased deliveries in Europe and inclusion of the Babrala acquisition in India and Cubatão acquisition in Brazil. Industrial deliveries were 16% higher than a year ago including the Cubatão acquisition. Excluding Babrala and Cubatão, fertilizer and Industrial deliveries were up 6% and 7%, respectively. Yara's ammonia production was 13% higher than second quarter last year, while finished fertilizer production increased by 10%. Adjusting for portfolio effects, production was in line with a year earlier. Margins were lower than a year ago as higher realized prices were offset by higher gas prices in Europe.

Beyond 2018, the global urea supply-demand balance looks set to gradually improve. Nitrogen supply growth is forecast to reduce significantly after 2018, and current nitrogen price levels do not provide economic incentives for new investment. Also, demand growth is likely to pick up compared with the last three years, as global grain stocks are relatively low, particularly excluding China, and increased production is needed to keep pace with growing consumption.

NORTH AMERICA

Fertilizer Canada partners with Québec's PACN

Fertilizer Canada and the Professional Association in Crop Nutrition (PACN) have announced a new partnership to help Québec growers maximize crop yields with minimal loss to the environment.

With a combined investment of USD300,000 over three years, the partnership will focus on implementing ‘4R Nutrient Stewardship’, a best management practice that involves fertilizer application using the right source at the right rate, right time and right place.

"The province of Québec represents a significant opportunity to advance sustainable agriculture in Canada. With over 28,000 farms, the Québec agri-food sector accounts for one out of eight jobs and contributes significantly to the provincial economy," said Yvan Lacroix, president and CEO of PACN. "We are looking forward to working with Fertilizer Canada on implementing ways for growers to reduce their environmental impacts while maintaining profitability."

Representing manufacturers, wholesale and retail distributors of nitrogen, phosphate, potash and sulphur fertilizers, Fertilizer Canada will work closely with Quebec-based PACN to help Quebec’s agri-retailers and growers easily adopt 4R Nutrient Stewardship best practices into their business operations.

Nutrien announces agreement to purchase Waypoint Analytical

Nutrien has announced that it has entered into a definitive agreement to acquire Waypoint Analytical, Inc. and its operating subsidiaries. Waypoint is the largest agriculture laboratory group in the US and among the top 25 US environmental lab groups. The company has approximately 250 employees across its operations, which include 11 US laboratories and six service centers that analyze approximately 1.8 mn soil samples for the agricultural market on an annual basis.

"Waypoint is the leading US provider of integrated agricultural sampling, testing and analytics that generate valuable insights into sustainable soil health and plant fertility for its customers," commented Mike Frank, President of Nutrien Ag Solutions. "Nutrien has been a significant customer of Waypoint for many years - and this acquisition will further strengthen our partnership. The combination of Waypoint's capabilities with Nutrien Ag Solutions' new, integrated digital platform will significantly enhance and accelerate our ability to provide integrated science-based insights, services and unique digital product offerings that will support optimal fertility advice for our customers globally."

The acquisition will occur in two tranches, with Nutrien initially acquiring 80% ownership of Waypoint upon closing of the transaction, and the remaining 20% to be acquired by Nutrien following the fifth anniversary of the initial closing. This transaction structure will enable Waypoint to continue supporting new and existing customer relationships under the ongoing leadership of its experienced and respected management team, while also providing for strong, sustainable growth of the business.

SOUTH AMERICA

EuroChem opens second new fertilizer plant in Brazil

EuroChem Group has announced the opening of its second new fertilizer blending plant in Brazil this year.

The latest opening is part of the ongoing expansion of EuroChem’s subsidiary Fertilizantes Tocantins (FTO), a major fertilizer distribution business in Brazil.

The new blending plant is strategically located in the city of Catalão in Goias State, part of the Brazilian Midwest, a region that accounts for about 3.2 mn t of fertilizer per year.

"Catalão has long figured in our expansion plans, and from here we can serve customers in this important agricultural region," said FTO’s CEO, José Eduardo Motta.

news in brief

The Catalão plant is one of the largest in Goias State, with a static storage capacity of 80,000 tonnes, 60 full-time workers and a production capability of 60,000 tonnes of fertilizer per month. It will produce a range of standard fertilizers and supply some specialty NPK fertilizers produced by EuroChem in Europe.

The opening of the Catalão plant comes weeks after a new blending plant at Sinop began operations in the commercially important northern region of Mato Grosso. In addition to Catalão and Sinop, FTO has six other plants across the country and sold more than 1.2 mn t of fertilizers in 2017, making it one of the biggest fertilizer providers in Brazil. Its other plants are located in Porto Nacional, São Luis, Querência, Rondonópolis, Barcarena, and Anápolis, with a corporate office in Goiânia.

“Our new plant at Catalão is further evidence of our determination to continue expanding in Latin America, and especially in Brazil,” said Dmitry Strashnov, CEO of EuroChem. “We see significant opportunities for us in this important growth market.”

The Group acquired a controlling interest (50%+1 share) in FTO in 2016 as part of its strategy to strengthen its presence in the fast-growing Latin American fertilizer market.

MIDDLE-EAST

Nutrien announces the sale of its equity position in Arab Potash Company

Nutrien has announced that it has entered into a definitive agreement with SDIC Mining Investment to sell 23,294,614 common shares of Arab Potash Company for gross proceeds of USD502 million. The announced transaction represents the entirety of Nutrien's holdings in APC.

Completion of the APC sale was required by the Competition Commission of India and Ministry of Commerce in China in providing their clearance for the merger of Agrium and PotashCorp to form Nutrien. The agreement is subject to customary closing conditions, including regulatory approvals and is expected to be completed by the fourth quarter of this year.

AFRICA

OCP Group and Fraunhofer IMWS sign memorandum of understanding for sustainable fertilizer industry

Mainstreaming Green Hydrogen and Green Ammonia as raw materials for the fertilizer industry: With this goal in mind, OCP Group, the world's largest exporter of phosphates, and the Fraunhofer Institute for Microstructure of Materials and Systems in Halle (Saale), will cooperate even more closely in the future. The two institutions signed a Memorandum of Understanding to work jointly on solutions for a sustainable fertilizer industry.

The Memorandum of Understanding provides for continued cooperation with the aim of boosting the use of renewable raw materials in the fertilizer industry. The focus is on two raw materials: Green Hydrogen, which is obtained by electrolysis using electricity from renewable energies, and which can be further processed into numerous products for the fertilizer industry; and Green Ammonia, consisting of Green Hydrogen and nitrogen, which can serve as a raw material for the production of fertilizers, amongst other uses.

ASIA

New orders cement Topsoe’s leading position in ammonia in India

TechnipFMC has awarded Topsoe a contract for license and basic engineering for two gas-based ammonia plants for Hindustan Urvarak and Rasayan Ltd. (HURL). The two fertilizer complexes in Sindri and Barauni will each comprise 2,200 MTPD ammonia and 3,850 MTPD urea plants and will be realized by TechnipFMC, France, along with their consortium partners L&T Hydrocarbon Engineering, India.

"We need the best available technologies to fulfill our vision of growth, efficiency, and national self-sufficiency. Technip has offered Topsoe’s ammonia technology which is considered one of the best technologies in the market and therefore, we are looking forward to a urea/ammonia plant which shall turn out to be one of the most energy-efficient, having reliable and safe operations,” said Mr. Arun Kumar Gupta, Managing Director, HURL.

He continues: “The HURL projects at Sindri and Barauni not only show the commitment and support of the Indian Government, NITI Aayog (National Institution for Transforming India), the Department of Fertilizer under the Indian Ministry of Chemicals and Fertilizers, but also the three promoter companies, all well-known in the area of mega-project management.”

“We are extremely pleased to be able to continue our long-standing support of the Indian Government’s efforts towards self-sufficiency in urea production and as a consequence: food security. Our world-leading ammonia technology and catalysts are the basis for three out of the four fertilizer plant revival projects in India right now,” says Amy Hebert, Executive Vice President and Deputy CEO, Topsoe.

The two new plants are part of the Indian government’s revival plans for the fertilizer sector to ensure Indian self-sufficiency in urea fertilizers. In 2015, Topsoe was awarded the ammonia technology license, basic engineering, technology, and catalysts for an ammonia plant for the Ramagundam Fertilizer Project. This 2,200 MTPD ammonia plant is also a revival project scheduled to begin operation in the fourth quarter of 2018.

Worldwide, Topsoe is the leading licensor of ammonia process technology with a market share of close to 50% of all new ammonia capacity contracted since 1990.

New partnership between China's XAG and Harper Adams University

The National Centre for Precision Farming (NCPF) at Harper Adams University and XAG, one of the world’s largest drone and robot company, have recently formed a strategic academic and research partnership.

XAG, a Chinese company which was founded in 2007, focuses on agricultural automation and research and development of unmanned devices. XAG is one of the world’s largest agricultural drone manufactures with a large-scale manufacturing and operational centre in China.

Over a period of 12 months XAG crop-spraying drones have flown 1.7 mn times in total, served more than 700,000 Chinese farmers covering two million hectares of land.

Justin Gong, Co-Founder and Vice President of XAG, said: “As the strategic partnership has been officially established, I am sincerely looking forward to the collaborations between XAG and Harper Adams University to develop localised done and robotic solutions which suit the UK and European farmers.

Ramagundam Fertilizers and Chemicals Limited (RFCL) to start production

Ramagundam Fertilizers and Chemicals Limited (RFCL) is likely to start production of fertilizers from December 31 2018.

Union Minister of State for Fertilizers and Chemicals Indrajit Singh had informed the Rajya Sabha on Friday that the gas-based RFCL would start production of fertilizers to meet the demand of the farmers by December 31 this year. Ever since, the government had announced the revival of the FCI into the gas-based RFCL, the pace of work had been intensified after the conduct of environmental public hearing in the year 2015.

The authorities removed all the old structures of the FCI and have replaced it with the new state-of-the-art machinery to produce less pollution and produce quality urea and ammonia. They were using the Italian technology for the production of urea and technology from Denmark for ammonia production.

The installation of urea reactor and compressors were being completed on a fast pace.

Since gas is the feedstock for fertilizers the government has signed an agreement for the supply of 2 million metric standard cubic meters per day (MMSCMD) with the Gas Authority of India Limited (GAIL) for the supply of gas from Mallavaram to Vijaypur gas line at Gummunur village of Manthani mandal. The crucial prilling tower, which is important in production of urea, is being constructed at a height of 134 meters.

The RFCL plant would have a 32.5 MW captive power plant, which is being set up at a cost of INR233 crore. Additional 5 MWs of power would be purchased from TSTransco. The necessary switch-yards and sub-stations were nearing completion.

On the other hand, the state government had announced supply of 0.55 tmcs of water to the plant from the Sripada Yellampalli project in Ramagundam. Besides, the government had taken up laying of roads and erection of electric towers etc at a cost of INR13 crore.

Officials have also said that the mechanical, electrical and instrumentation works were nearing completion to start the production of fertilizers by the end of this year. They had also opened an office at NFCL in Hyderabad for the marketing of the produce.

AUSTRALASIA

BHP sees no hurry on Jansen potash project

UK-Australian resources firm BHP said it is in no rush to make a decision on its 100% owned Jansen potash project in Saskatchewan, Canada and is looking for a partner to the potential 8mn t/yr project.

BHP also reiterated that it expected a supply gap to emerge in the potash market by he mid-2020 unless new supply is sanctioned. BHP also increased the capital expenditure (capex) budget for the Jansen project by USD122mn to USD2.7bn wit the increase to fund support services at the Jansen site, it said.

The majority of the capex on Jansen is on the exaction of the production and service shafts at the Jansen mine, BHP has said.

“So that increase in budget is simply as a result of having to provide for what it will take to complete the shafts,” BHP managing director Andrew Mackenzie told analysts after the company released its financial results for the 2017-18 fiscal year to 30 June.

“We had assumed, in our initial budget for the shaft, that we would have made a decision at this point, which, as you know, we have deferred, and we are not in a hurry to make a decision about a project,” Mackenzie said.

BHP first announced an investment of USD2.6bn on the Jansen project in August 2013 and at the time said the work would be complete by 2017. The firm said work on the Jansen project was 87% complete as of 30 June.

“In the meantime, we continue to work on the engineering of the project so that we can improve the returns. We’re looking for a partner, which, of course, could give you early monetisation, and we’re watching the market. But we’re not in a hurry to make a decision,” Mackenzie said.

Incitec signs 2019 deal for Gibson Island

Australian fertilizer and explosives firm Incitec Pivot said today that is has signed an interim gas supply agreement for its Gibson Island ammonia and urea plant in Queensland for calendar 2019 and is assessing options to secure gas supplies to the plant for 2020 and 2021 and beyond.

Incitec has signed a number of agreements for the supply of 20TJ/d of gas for 2019, including with gas Australian pipeline operators APA Group and Jemena; and Australian gas producers Macquarie Mereenie Pty Limited and Central Petroleum. ■

news in brief

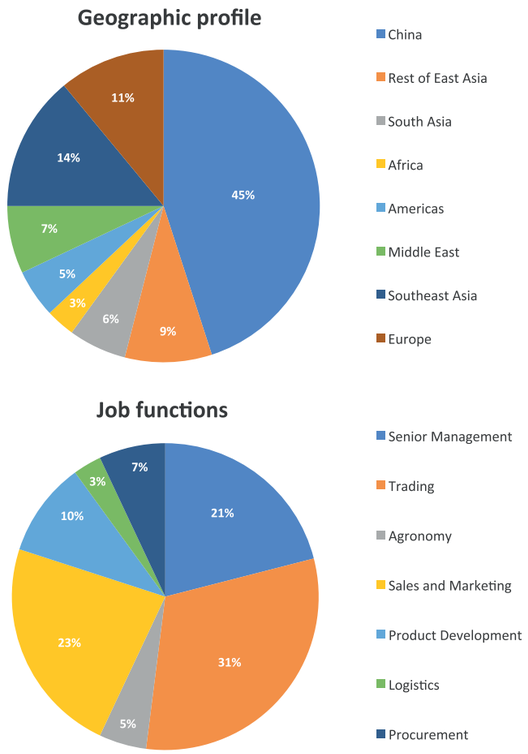
Conference preview:

Argus Asia Fertilizer 2019

Shanghai

The next Argus Asia Fertilizer - now in its 15th year - will take place in the cosmopolitan city of Shanghai, known as a thriving commercial and financial hub, and famous for its stunning skyline and world class restaurants and nightlife. The event will bring together all the key organisations doing business in Asia including global players, major Chinese suppliers and distributors from across Southeast Asia. Delegates will enjoy more opportunities to network with local market participants, in-depth market analysis and the opportunity to hold numerous meetings over three days.

Breakdown of attendees:



> *Delegates will enjoy more opportunities to network with local market participants*

Market insights and global trends

Delegates will hear from 30+ speakers over three days and gain insights from across the fertilizer supply chain. Topics to be discussed will include the fertilizer consumption trends in China, trade flows across Southeast Asia and the growth of new products and technologies in the region to improve agricultural productivity. Last year delegates included senior representatives from the industry including Kingenta, Luxi, Jiangsu Linggu, Stanley and Anhui Moith, as well as from the key associations including China Nitrogen Fertilizer Industry Association, China Phosphate Fertilizer Industry Association, China Inorganic Salt Industry Association and The Fertiliser Association of India.

Networking is key

As well as making new contacts during the breaks and lunches delegates are encouraged to make use of the networking app to identify potential suppliers and customers. There is also the opportunity to join moderated roundtable discussions where they can talk through shared industry challenges and exchange knowledge with colleagues working in the same field.

It's a great way to generate new ideas and meet potential suppliers, customers and partners!

For information on how you can participate, visit www.argusmedia.com/fertilizer-asia

Price watch

NITROGEN

Strong urea market through 2018

The urea market is very bullish. Prices jumped by about USD30/t in August and, unlike in June when prices also rose sharply, there is no obvious end to the run up.

In fact, if several factors play out as expected, the urea market has much further to go.

Argus' supply-demand forecasts show the urea market to be in deficit for every month through to April 2019. The cumulative supply deficit forecast for September-December 2018 is more than 1mn t.

Prices are above USD300/t fob Egypt and approaching that level from the Middle East. Increases of another USD10-20/t are seen as probable and there is already speculation about prices heading to USD350-400/t fob.

The main factors underlying these bullish forecasts are limited supply and active demand.

In previous years, increasing prices would bring forth additional supply, notably from China. This is unlikely to happen in 2018 because Chinese production levels are barely sufficient to cover domestic demand. Average operating rates are 53% today, equivalent to about 38mn t/yr, against domestic demand estimated at 48-49mn t/yr. Operating rates have not gone above 65% in China this year.

Producers are moving local market prices up, maintaining parity with exports. Exports totalled only 104,000t in July and were down 73% in the first seven months of 2018 at just over 800,000t.

Ukraine has idle capacity that will restart - now that prices have moved up tolling gas is more economic. But Ukraine has a large domestic market and exports are unlikely to amount to more than 100-150,000t/month.

Apart from Ukraine, there are no obvious idled plants that could add quickly to export supply.

If the urea market is strengthening on the back of one major market, that is generally unsustainable. At present, there is active demand from several.

European buyers are playing catch up. Brazilian imports are lagging 2017 going into the peak season. India delayed buying too long in June and July and is now caught in a bind with Iranian sanctions. Even the US, which is producing much more of its own urea, seems to be lacking imports for the fall. Bangladesh is in the market for 250,000t of urea and Ethiopia has launched its annual tender for 500,000t.

This demand gives the market solid support. The icing on the cake for suppliers could come from India, where US sanctions against Iran could oblige it to purchase non-Iranian tonnage in tenders held in September and October. At that stage, producers would take advantage of a captive buyer and lift prices further.

The answer to high prices is high prices, according an old adage. However, there is little sign of stiff price resistance from buyers yet and the seasonality argues against buyers postponing inquiries in most markets.

PHOSPHATES

Brazil MAP firms on tight supply

The Indian DAP cfr price remained comparatively flat in the high-USD420s/t cfr in June following the heavy buying in May. June imports increased to 1.13mn t, from 832,000t in May. But offers for DAP increased towards the end of the month as supply from producers tightened following the heavy import line-up. Offers into tenders from traders at the end of June indicated levels at USD434-435/t cfr Indian west coast, but the depreciating rupee capped import demand at this level. But in July, the increase in the phosphoric acid contracts between OCP and importers to USD758/t P2O5 cfr for the third quarter pushed more Indian buyers into the market, as domestic production was rendered loss-making. DAP cfr prices rose to USD430-432/t cfr, remaining at this level for the whole of July as importers booked a total of 883,000t for the month.

Elsewhere on the subcontinent, Pakistan import demand was soft as drought conditions in May and June weighed on buyers, delaying cotton and rice sowing. Sole business concluded in June was limited to importer Engro buying Chinese DAP in the mid-USD430s/t cfr via trader Fertisul. The importer returned to the market and bought another cargo in July at a similar level from a Swiss Singapore for August. Fellow importer Fauji also picked a large Australian vessel at around USD435/t cfr for July shipment. Meanwhile, the private importers - Agven, Pacific and Chawla - were in the market to buy but a drop in the rupee towards the end of July against the dollar deterred a purchase. The rupee was devalued to around INR128/USD, the currency dropped 14% since January as the current account deficit widened. There were no further purchases concluded in the month as the market waited for the outcome of the general election on 25 July.

Offers from Chinese DAP producers increased through June as suppliers were quickly sold out of material after India, Pakistan and Bangladesh had bought large volumes for the month. Major producers were sold out through to the first-half of July and offered up to USD420/t fob, but because of cfr values in India and Pakistan realistic prices were around USD417-418/t fob. But a Thai buyer bought 6,000t of DAP at equivalent USD420/t fob at the end of June. Suppliers consistently pushed for USD420/t fob, but bids were reportedly in the USD415-418/t fob range. Indian buyers stepped back into the market mid-July and bought over 200,000t of Chinese DAP for late July and August loading. Total shipments from China to India totalled over 500,000t in July.

In Morocco, DAP fob levels steadily increased through June as the producer placed more material into the Balkans, Brazil, India and the US in the USD405-425/t fob range. OCP sold more DAP into Romania and Bulgaria in mid-June, setting the upper-end of the range at USD425-431/t fob. OCP then placed more DAP to these markets at USD435-440/t fob at the end of June. The lack of supply in the US resulted in OCP lining up another two DAP/MAP panamaxes for July, priced under formula. Further sales to buyers in Spain brought the range up to USD435-450/t fob at the start of July. The DAP price remained in this range as the producer sold more product into India, Argentina, the US, Balkans and Brazil.

In terms of MAP, the Brazilian cfr price was supported by the supply deficit in the US, following Mosaic's decision to shutter its 1.7mn t/yr DAP facility in Florida. The MAP price in Brazil increased through June from USD431/t cfr to the mid/high-USD430s/t cfr as OCP, Mosaic and Russian producers Eurochem and Phosagro made sales but spot demand remained sluggish. The Brazilian price continued to increase the next month before tapering at USD447-450/t cfr after Eurochem sold more volumes at USD450/t cfr bringing its August shipments to 20,000-25,000t.

In the US, the closure of Mosaic's Plant City plant has continued to have an effect on the market, driving prices up west of Suez in June. OCP and Russian producers continued to load large DAP/MAP/NPS vessels for US buyers in recent months. The domestic DAP barge price at Nola rose from USD391/st to USD400-405/st Nola by the end of the month. Prices tapered in July, remaining approximately at that level for the rest of the month. The Tampa DAP/MAP export price increased as Mosaic continued to load volumes for Latin America. The export price rose from USD408/t fob Tampa at the start of June reaching USD420/t fob by the end of the month. In July, the price increased to USD433-434/t fob at the end of the month, driven by sales for August at USD434/t fob to Latin America.

AMMONIA

Production glitches raise prices

Ammonia prices climbed steadily over July-August, driven by constrained supply due to numerous plant shutdowns in Europe, the Middle East and Australia. Coupled with issues at existing plants, the anticipated new capacity from the PAU plant in Indonesia has been slow to come fully on-stream, leaving supply in east Asia tighter than expected. Although supply in during May-June was at similarly tight levels, prices over this period did not increase too sharply as buyers fulfilled their requirements by importing their maximum contract volume allowances. By July, some buyers in east Asia in particular had exhausted import contract volumes and were forced purchase cargoes in the spot market which was now trading at significantly higher prices. Prices in east Asia were in the USD300-400/t cfr range by mid-August, while delivered prices into India looked set to stay firm into October with FACT awarding a tender in August for two October-delivery cargoes in the USD399-408/t range.

In the Middle East, Ma'aden had some technical problems which reduced ammonia surplus availability from its ammonia facility which is dedicated toward its Wa'ad al-Shamal facility. As a result, the Saudi producer attempted to delay some of its customer's September vessel arrivals. However by late-August this issue was expected to be resolved and the vessel loadings at Ras al-Khair was only expected to face 1-2 week delays on original lay can dates. During recent weeks Sabic has also had slow loading rates due to maintenance work being carried out at its ammonia tanks in Jubail which resulted in Sabic's port storage capacity being reduced from 45,000t to 20,000t. Middle East prices were trading in the USD318-340/t fob range in mid-August, with pressure to the upside.

Mitsubishi's new PAU plant in Indonesia finally loaded its first cargo on the Pazific in July but the plant shut down shortly after for 1-2 weeks before it was restarted again. The lack of supply from the plant, coupled with the shutdown of the Pilbara ammonia plant in Australia in for two months starting in late-June, has led to a tight supply situation in the Asia region. This became even more acute as a severe typhoon season hit the region in August and shipment schedules were severely disrupted as ships were forced to reroute or wait in long queues to discharge at ports like Caojing in China.

Yuzhny spot availability was minimal by 2H August, with TogliattiAzot fully committed and only Rossosh having very small spot volumes to sell. Prices in Yuzhny were USD300-320/t fob in mid-August, with the next round of buying from Turkey for September/October expected to push levels up again in early-September as new spot prices are set.

In the US the Tampa price has risen each month since June, with the sharpest rise of USD30/t seen with the August settlement at USD310/t cfr, followed by a USD20 rise for September when the contract between Yara and Mosaic was settled at USD330/t cfr. There is plenty of demand for US and Caribbean product and in Trinidad suppliers are moving any available tonnage, outside contract shipments, towards east Asia.

From a demand perspective, it is still unclear how much major buyers like Morocco's phosphate producer OCP will require for the final quarter of 2018. The buyer will have imported just under 1mn t by the end of August – but if it is to hit its target of 1.6-1.8mn tonnes by the end of 2018, it will need to buy 150-000-200,000t/month for the final four months of the year, a much higher monthly volume than it has been receiving for the past few months.

POTASH

Potash prices firm globally over summer

Prices continued to firm in Brazil, Europe, the US and southeast Asia, because of high levels of demand and tight supply. Several producers said they were fully committed on orders for standard and granular MOP until October.

In Brazil, trucking issues have also contributed to rising prices, as well as early buying in order to mitigate long delays to warehouse from ports.

Brazil was the leading country for netbacks in June, ahead of northwest Europe, which typically commands the highest MOP netbacks for suppliers. And the country shows no sign of losing the position as of early August.

Granular MOP prices have risen steeply in Brazil in the past year. Prices were at USD260-270/t cfr in June last year, and at USD315-325/t in June this year. Since then, prices have continued to rise, and reached USD325-330/t cfr in August, the highest since July 2015.

Trucking issues continued to dominate market conversations, and price rises may have been linked to the logistical problems in Brazil that look set to remain until at least late August.

In Europe, demand for granular MOP went from strong to quiet, on seasonal weather conditions. Granular MOP prices were at EUR257-265/t cfr in early June, but offers were at around EUR270-275/t cfr for granular MOP. Some suppliers were unwilling to drop prices, preferring to allocate tonnages to Brazil, where netbacks were stronger. Northwest Europe's buying fell sharply shortly afterwards, which led prices to stick at around EUR260-270/t cfr for granular MOP. Although suppliers reported rising enquiries as of July, buyers were aiming for September delivery MOP at July prices, and suppliers have yet to accept these terms, since they argue supply is tight and they can sell at a higher rate when seasonal demand picks up again.

In Malaysia, plantation buying for second-half delivery was under way in June, but sellers struggled to secure desired price levels, leading to some erosion of standard MOP prices in the second quarter of 2018. Standard MOP prices languished at around USD280-285/t cfr in Malaysia, while Indonesia rose to USD290-300/t cfr. Plantation demand looks set to be strong this year in Indonesia, partly because of the maturity stage of the CPO crop, which has given farmers support for fertilizer purchases. Conversely, falling CPO futures prices on the Bursa Malaysia, as well as the introduction of a new government in Malaysia have both dampened demand and the acceptance of higher prices.

Granular MOP prices in Thailand and Vietnam hovered at USD290-310/t cfr in June and July. The fertilizer application season gathered pace in Vietnam during June, and sales ramped up. But prices were holding steady amid strong seller competition. In Thailand, prices have been steady, despite efforts by suppliers to lift levels in line with the rest of the world. First-half MOP imports to Thailand were down by 9% on the same period a year earlier, at 429,000t.

The US market saw prices rise sharply in June, after a fairly steady period of modest increases in the three months preceding it. Then the implementation in early June of summer-fill programmes by domestic producers increased buying activity, and lifted offers for imported product. The Argus assessment topped USD250/st fob Nola for the first time since December 2015.

Then prices continued to firm after the summer-fill programme closed, and barring a modest dip amid an influx of imported tonnage, continued to rise on strong demand. By early August, US granular MOP barge prices rose by USD1/st from the low end to USD256-270/st fob Nola, in part because of the drop in import availability.

SULPHUR

Disparate buyer and seller price targets

The bulls and bears of the sulphur spot market jostled on prices for much of June and July. Tighter supply fundamentals encouraged firmer monthly selling price announcements from producers in the Middle East, as well as firming offer levels from traders. But, low demand and healthy inventory levels kept end-user price targets low in most markets. In contrast to the spot price movements however, third quarter contract prices settled firmer in all markets on the previous quarter, with supply shortages and increased appetites from some of the biggest global consumers, driving the increases.

Official Selling Prices for June were announced at steep increases on the month. Qatari state-owned marketer Muntajat upped its monthly price by USD17/t on May; to USD132/t fob Ras Laffan/Mesaieed for June. Saudi Arabia's state-owned Aramco Trading upped its price by USD11/t, to USD133/t fob Jubail. The highest June price was set by Abu Dhabi state-owned Adnoc, at USD139/t fob Ruwais.

Increases were driven by Muntajat's spot tender award in May in the mid/high-USD130s/t fob, as well as enduring tightness from maintenance works at Adnoc's Shah gas plant, which began ramping up in June. Muntajat's June spot tender was again awarded in the mid/high-USD130s/t fob, encouraging July selling prices to be set within similar ranges; at USD132-139/t fob. Nonetheless, seasonally lower end-user demand, alongside healthy port inventory levels, kept buying activity at a minimum particularly within China as well as India and Brazil.

For China, prices trended flat in the low-USD150s/t cfr until late June. Offers where tabled at this level and higher, but bid levels remained largely below USD150s/t, with some south buyers even requesting orders in the mid-USD140s/t cfr and below. Despite continuing pressure from international traders, buyers continued to eschew cfr offers, preferring to rely on contract deliveries and secure sulphur from the domestic market at equivalent cfr prices below USD150/t cfr. Some sellers nonetheless capitulated by mid-July, and trades for international product were confirmed at levels in the high-USD140s/t cfr China. Rallies in prices were anticipated as end-user demand for pre-spring application season storage returned, but July closed with prices no higher than USD151/t cfr being concluded for international sulphur purchases.

Escalations in the trade dispute between China and the US impacted the domestic currency. Depreciating Yuan values turned buyers to the domestic market, with cfr prices deemed unworkable. The rise in domestic demand encouraged spikes in ex-port prices, which firmed Yn180/t from June to early August, peaking at Yn1,320-1330/t ex-port despite ample inventory levels, which were at 20 month highs – at around 1.6 -1.7 mn t – across the reported period. Traders also supported the firming ex-port prices, targeting higher numbers to ensure that stocks could be replenished following sales against the increase in demand for Yn/t priced sulphur. In the molten market, discharging restrictions because of environmental legislations saw prices tumble USD12/t from June levels; from USD112/t cfr China to USD100/t cfr China by August.

India's buying activity was decidedly muted across June, with prices holding at a midpoint of USD147/t cfr India through to July on no business. Paradeep Phosphates (PPL) broke the deadlock at the beginning of July, awarding a purchase tender for 30,000t in the mid/high-USD150s/t cfr to trader BGN. Prices nonetheless softened to the low/mid-USD150s/t within a period of weeks, with IFFCO securing ex-Iranian product later into July at this level. Cfr India prices remained in the low/mid-USD150s/t in to August amid slim buying interest.

Confirmed cfr purchases from north Africa where absent throughout June, keeping prices flat at USD125-135/t over the month. However, news of Russia's Gazprom Export (GPE) having no contract shipments available to north Africa for 3Q aided increases in July spot prices, with OCP purchasing a cargo in the low-USD140s/t near the start of the month. Additional ex-Middle East product was sold into north Africa in the high-USD140s/t cfr by the middle of July and – by the end of July – a purchase from Tunisia's GCT against tender increased north Africa cfr prices to the mid-USD150s/t. North Africa's contract prices for 3Q settled up USD15/t higher than 2Q, at USD127-147/t, with tighter global availability on top of increased demand from the region spurring the increase. Additional volumes from the Middle East's Adnoc were allocated to OCP, which further contributed to a tighter supply situation in the Middle East for 3Q. Fob Middle East prices settled at an USD11/t increase on the midpoint of 2Q prices, at USD119-135/t fob.

Brazil's 3Q prices firmed USD12/t on the quarter, to range USD145-149/t, in line with spot Brazil prices. Spot trading was minimal throughout June and July, with Mosaic largely covered by on-going contract shipments. Copebras' monthly tenders tested prices in July, with the company securing 40,000t from the FSU in the mid-USD140s/t cfr Brazil. Cfr prices stayed at that level for the remainder of the month on limited demand.

For west Europe's molten contract market, ongoing supply tightness ushered in the fourth consecutive increase in cfr Benelux and cpt NW Europe quarterly prices. Alongside refinery maintenance works and the growing switch towards lower sulphur content crudes, a force majeure at the 140,000t/yr sulphur producing Gossenkneten gas field was implemented in late-May, which significantly reduced regional molten sulphur availability. Spot inquiries rose in the market amid the shortages and a purchase of around 500t of ex-Italian product was completed at around USD300/t cfr in July to the German market. 3Q contract prices settled USD10/t above 2Q; at USD118-138/t cfr Benelux and USD160-177/t cpt NW Europe. ■

The Iranian fertilizer market:

Status and outlook

by **Mohammad Ali Vadikheil**, CEO, Phoenix Vision Consultant Group, Iran

The Iranian fertilizer industry is relatively old compared with other countries in Middle East and Southeast Asia. The first fertilizer plant came into operation in 1963 commissioned by the Shiraz petrochemical company. The plant was a small unit producing urea and ammonia with a capacity of 50 t per day.

Western Iran (formerly Persia) was the first frontier for agricultural activities in a place named Chogha Golan almost 10,000 years ago. This is one of the first locations to employ agricultural methods instead of hunting and gathering. It allowed people to make a permanent residence, which was a precursor to building up civilizations.

Overview

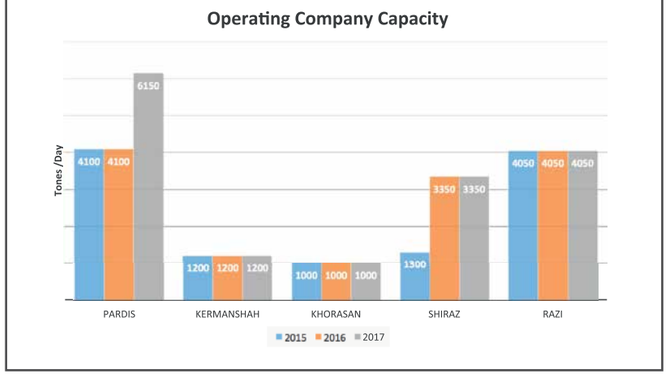
Iran is rich in oil, gas and minerals and has good access to the resources the fertilizer industry needs to support local consumption and exports.

Nitrogen-based fertilizer

Urea/ammonia

Thanks to the relatively cheap natural gas feedstock, Iran is among the top 10 nitrogen producers in the world. The production capacity of urea has increased up to almost 6.5 mn t per annum (2017). For ammonia, the installed capacity has reached around 5.2 mn t per annum. The supply is mostly being fed to the urea plants, although 20% is sold on the local and overseas markets. Figure 1 and figure 2 show the latest developments in production of urea and ammonia in Iran for the various operation companies.

Figure 1. Local production capacity (ammonia)



Production technologies

KBR (previously M.W. Kellogg) has the largest share of the ammonia production market with nine operating units. Seven units are working under KBR technology and two other units under Casale technology. Neither Topsoe nor Uhde are operating plants in the country for the time being.

Stamicarbon accounts for the lion's share of urea production with seven out of eight units working under Stamicarbon license. Stamicarbon has had a continuous presence in the country since the 1970s.

Operational status

The operational rates of Iranian fertilizer companies have increased during the last five years due to following reasons:

- Problems in developing the big South Pars gas reserve (the largest gas reserve in the world shared with Qatar)
- The implementation of the 'Joint Comprehensive Plan of Action' (JCPOA) led to the need for changes, such as altering specific catalysts

Upcoming capacities

In 2019, two key projects, each producing 1 mn t of urea, will come on stream. These two projects are Massjed Soleyman PC (MIS Project) and Lordegan Fertilizer Industries. The MIS Project is under license of Casale and Toyo for production of ammonia and urea respectively. The Lordegan project is built on Casale technology for ammonia and Stamicarbon technology for urea production (see figure 4).

Other nitrogen-based fertilizers

Local agricultural grade ammonium nitrate is being produced by the Shiraz petrochemical company with a capacity of almost 800 t per day or 250,000 t per year. Due to the economic advantage of urea, ammonium nitrate is not an attractive option for investors for the time being.

Figure 2. Local production capacity (urea)

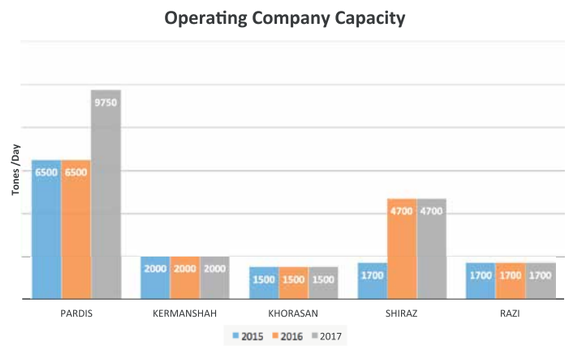


Figure 3. Changes in operation rates in recent years.

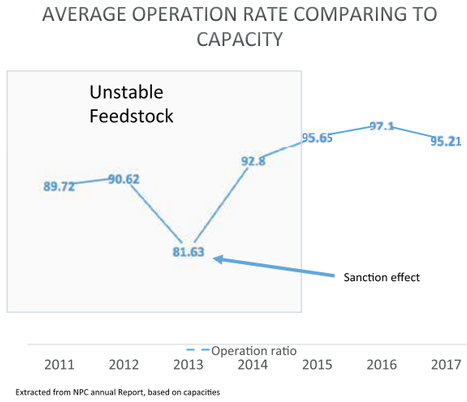


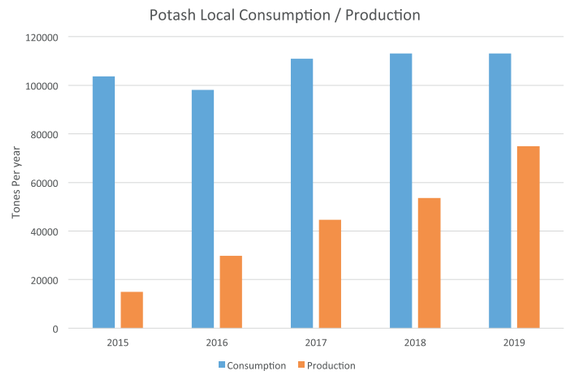
Figure 4. The development of Iran urea and ammonia projects in Iran

Figure 5. Accessing water from the desert

Figure 6. evaporation ponds in the desert

> *In 2019, two key projects will come on stream*

Figure 7. Local market demand and supply outlook for potash-based fertilizers.



An ammonium sulphate unit with the capacity of 27,000 t per year is run by the Urumia petrochemical company and production is mostly consumed locally.

UAN is also producing on a very small scale in order to get feedback from farmers.

Potash-based fertilizers

Chlorine potash is available in Iran from salt or salty water using evaporation and separation extraction processes. There are several mines and factories in the country, the largest one is Iran Potash which is located in middle of the country. The salty water is sourced from the desert (see figures 5 and 6).

There are also some small factories which are producing potash sulphate by utilizing sulphuric acid, but the total capacity of these small plants only supports the limited local market.

Positive growth is expected for potash-based fertilizers because many farmers

would like to add this fertilizer to their portfolio. While the outlook for market is good, the market size remains small on a global basis (see figure 7).

Phosphate-based fertilizers

Razi petrochemical, which is located in south-west of Iran, has the potential for producing DAP in two lines with a total capacity of 450,000 t per year. This plant also produces sulphuric acid and imports phosphate rocks from other countries.

There are several phosphate rock mines in Iran, but due to the high capex for phosphate concentration, the mines are not well developed, therefore Razi is mostly importing the required phosphate rocks.

Phosphate market

Phosphate fertilizers are essential for many agricultural producers and the market is looking very positive. However, due to some operational problems and the high price of phosphate rock, Razi is only operating at 30% capacity, therefore the market is mostly dependent on imports.

Added value fertilizers

'Added value fertilizers' are based on new developments by the fertilizer industry. These are not very prevalent in Iran at present, but a few small companies are trying to produce NPK fertilizers based on available materials. The shortage of water in Iran is one of the main reasons for this emerging market.

The challenge of water shortage in Iran

Around 12% of the land in Iran is suitable for agricultural production. While this is almost the same size of the Netherlands, agriculture production is almost one-third of the Netherlands output. The shortfall is mainly due to water management and yield performance.

Recently yields have been increasing due to the application of added value fertilizers – a trend that is expected to continue (see figure 9).

Figure 8. Local market demand and supply outlook for phosphate-based fertilizers

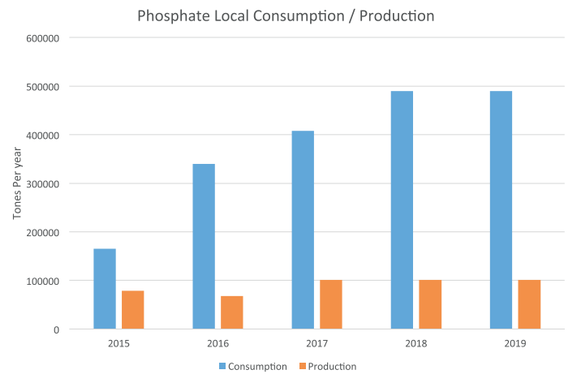
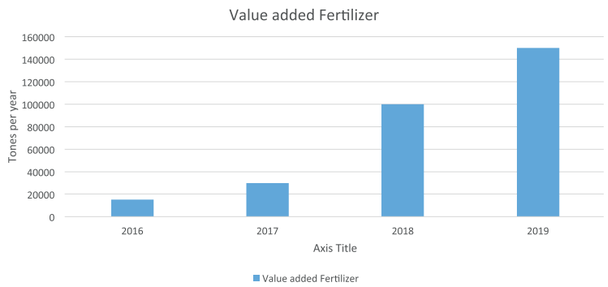


Figure 9: The development of the added value fertilizer market



Impact of US sanctions

In spite of Iran's commitment to JCPOA, the US President has withdrawn from the nuclear deal and said that all waivered US sanctions will be re-imposed. These US sanctions will have an impact on exports and imports on the Iranian fertilizer market.

The impact will be felt in three major areas:

- Petrochemical products
- Shipment of products
- Movement of money

Based on previous sanction experience, the amount of exports could be reduced by around 20% and there will also be difficulties with imports. ■

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New potash technologies

by **Davide Ciceri**, Research scientist, Department of materials science and Engineering. Massachusetts Institute of Technology, USA

The continued increase in world population is generating and increasing demand for fertilizers. Potassium (K) is not an exception with production at approximately 34 mn t in 2017. While nitrogen (N) and phosphorous (P) fertilizers are the focus of much product development and innovation, K has remained largely limited to one single source; potassium chloride (KCl). An overview of K-bearing materials and technologies, however, reveals intriguing opportunities for the synthesis and formulation of novel K fertilizers with soil-tailored properties.

> *The most exciting fertilizer technologies are yet to come*

Potassium (K) is a key agricultural element considered as an essential plant macronutrient together with nitrogen (N) and phosphorous (P). The sources of K used by the fertilizer industry are substantially two: potassium chloride (KCl), which is a soluble salt, and potassium sulphate (K_2SO_4) - still a salt, but with lower solubility. Although farmers can use these salts in agricultural fields, they are also frequently blended into formulations with variable ratios to fit specific crop requirements or customer needs.

KCl is the most common source of K, representing approximately 95% of the global potassium supply used in agriculture. It is obtained either from underground mining operations or through concentration and purification of brines. Currently, there are twelve countries that have active KCl operations, although Canada, Russia and Belarus are the key global players in terms of production output. In 2017 Canada produced approximately 12 mn t of equivalent K_2O, Russia 7.2 mn t and Belarus 6.4 mn t. China is a large KCl producer too (approximately 6.2 mn t of equivalent K_2O), but interestingly China is also a major importer due to very high demand from the local farming industry. Other producers include Germany, Israel, Jordan and Chile. Smaller productions (< 1 mn t) occur in Spain, Germany, the UK and Brazil.

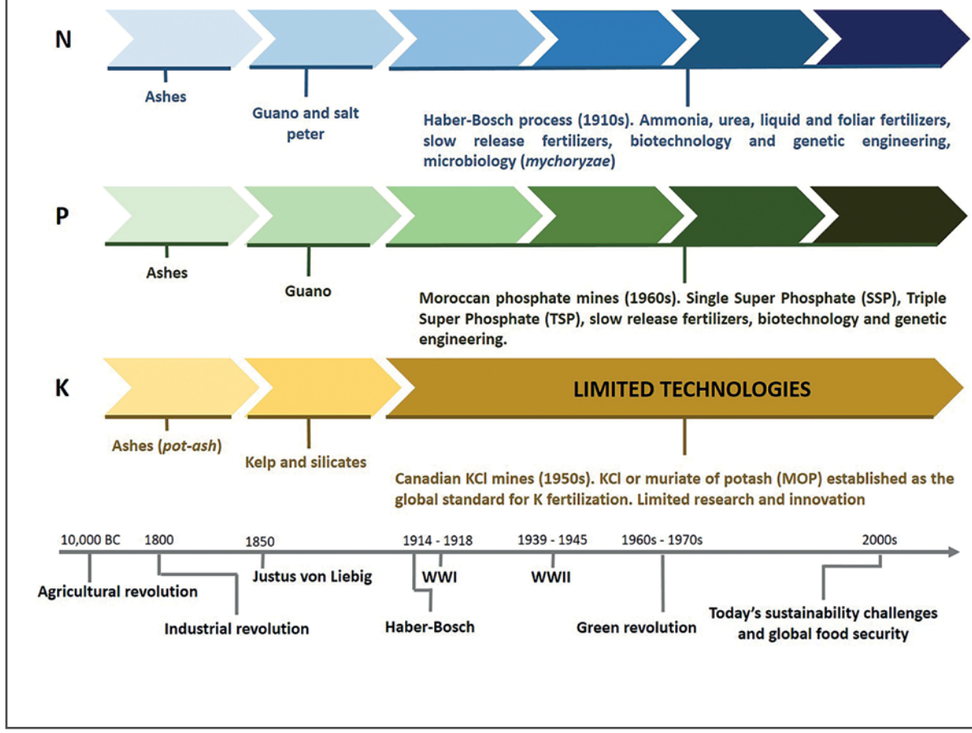
The total production of K_2SO_4 is significantly less than KCl, roughly 5% of the global market. One of the main advantages of K_2SO_4 is the lack of chlorine counterion, which can be detrimental for certain crops. These chloride-sensitive crops include some citrus and stone fruits, strawberries, avocados, some variety of potatoes and tobacco. While K_2SO_4 helps to avoid chlorine, it also provides sulphur in the form of sulphate ions (SO_4^{2-}), which are beneficial for many crops. In certain cases, farmers need to apply sulphur fertilizers regardless of the K status of the soil. Because K_2SO_4 is not mined but obtained from chemical processing its cost is generally higher than that of KCl.

Potassium inputs

Further to KCl and K_2SO_4 specific agronomic needs may require specialty K chemicals and premium fertilizers, most notably potassium nitrate (KNO_3), potassium carbonate (K_2CO_3), potassium hydroxide (KOH) and even potassium thiosulfate ($K_2S_2O_3$). Although such chemicals are available in the market, they remain confined to smaller or niche applications generally due to cost, but also due to limited production volumes with respect to that necessary for agricultural purposes and a lack of enough agronomic knowledge on the crop response to those chemicals.

Similar to the Haber-Bosch process that produces ammonia (NH_3) at the base of the nitrogen fertilizer

Figure 1. Overview of fertilizers technical developments.



industry, the mining of KCl resources has been a particularly successful global enterprise. Although K is seldom considered as the limiting nutrient in most soils, global production tonnage demonstrates the importance of this element in the food supply chain. However, in a changing world, three major pushes may reshape the production of potassium fertilizers over the next three decades to 2050, when the population on the planet is expected to peak at nine billion.

Global logistics

The first challenge comes from the contribution to global population from the tropical region of the world. Because most of the K production is in the northern hemisphere, the cost of the fertilizer in the tropics is determined by the transportation to the local farmers. The local cost is often prohibitive with respect to the purchasing power. New fertilizer materials derived from local resources, and that therefore circumvent the need of costly long-distance transportation, may become increasingly important products. The second challenge derives from the continuing growth in demand for organic food. Because the definition of organic fertilizer is somewhat blurred and changes across regions of the world, some countries do not allow KCl as a source of K in their organic farms. A notable example is the USA, where the organic food market is currently valued at USD47 bn. The third challenge is simply due to the increasing scientific knowledge of the crop-soil-fertilizer system, which may push toward the development of soil-tailored fertilizers. KCl is soluble, so it can leach away before uptake by the plant can take place. The leaching of N and P towards rivers and seas is known to result in adverse environmental effects, but KCl is considered benign. However, the desire to engineer slow K-releasing materials, similar to the efforts pursued for N and P, may soon become an important issue for the scientific community, because it may prevent economic losses from leaching. Other problems of a fundamental nature, such as the chloride role in the soil or the interaction between the fertilizer and the soil microbial communities, will also increasingly interest the academic communities. Some of that

Figure 2. A sample of K-feldspar. This mineral contains approximately 15 wt% of K_2O and is widely abundant in the Earth crust.

knowledge is expected to influence a generation of new potassium technologies in the future.

Interestingly, over the past fifty years product development and research has focused on N and P rather than K (see figure 1). Examples of strategies that have pushed forward our knowledge of N fertilization included the study of the rhizosphere (that area of the soil in proximity of the roots known for interactions between bacteria, fertilizers and roots) and consequent advances of engineered seeds and crops. Additionally, although somewhat standard molecules such as ammonia (NH_3) and urea (NH_2CONH_2) are considered staples of the nitrogen market, several other products are available at scale such as calcium-mmmonium-nitrate (CAN), ammonium sulphate ($(NH_4)_2SO_4$) and ammonium chloride (NH_4Cl). For phosphorous, most innovation has focused on biotechnological developments and again several products can be found in the market, for example mono-ammonium-phosphate (MAP) and triple-super-phosphate (SSP).

> *Product R&D has traditionally focused on N and P rather than K*

Future applications

For potassium, the most exciting fertilizer materials technologies are yet to come. K is approximately 20 times more concentrated than P in the earth crust and can be found in a variety of natural sources, the evaporitic salts such as KCl, but also framework and sheet silicates, such as feldspar and micas, respectively. Additionally, because of its high solubility, K can be found in a variety of other organic materials such as in by-product liquors from the sugar cane and sugar beet industry, in biomasses and in their ashes, in composted residue and even in algae, most notably those known under the name of 'kelp.' Some of these options face issues of scalability and implementation to industrial production, although may be successful at small scales, for example among the poorest smallholder farmers of tropical countries. However, some of these materials may also offer some distinct advantages and thanks to specific co-nutrients, pH properties or lower solubility, they can suit better certain soil and crops than KCl does. K-bearing minerals alternative to the soluble salts, for example, offer the opportunity of scalability and global distribution (see figure 2). In this case mining occurs at the earth's surface. Still, a critical issue is that the K solubility may be too low with respect to traditional sources such as KCl. Processing methods need therefore to be developed. Scholars in China have extensively studied these opportunities, and we (MIT) have been reporting recently on hydrothermal processing of K-feldspar to make its K content plant-available. Because feldspar is among the most abundant mineral in the world, its processing into a fertilizer could impact the global market.

Alternative sources

Micas and other K-bearing clays may be equally important sources of potassium. Several clay-based soil amendments are already available in the market and are often successfully deployed in horticulture and gardening, though mostly as moisture regulators rather than K releasers. Although a solid agronomic understanding is generally missing, some of these solutions can already be found in our supermarkets and are increasingly important in some areas of the world. For example, kelp algae are processed into a potassium fertilizer along the coasts of India. Polyhalite ($K_2Ca_2Mg(SO_4)_4{\cdot}2H_2O$) is becoming an increasingly acknowledged K-bearing fertilizer that brings the additional benefits of the co-micronutrients. Langbeinite ($K_2Mg_2(SO_4)_3$) is an additional sulphate compound worth mentioning. Agronomic studies have been underway for several years with promising results.

In summary, the traditional K fertilizers, KCl and K_2SO_4, may see competition from new products in our changing planet. Although most technologies that focus on alternative potassium materials are confined to a research stage at the moment, it is likely that more products will be increasingly available in future markets.

As our understanding of all these potassium sources progresses we may be soon able to identify with precision what is the 'right source' of potassium for a specific crop and soil type. ■

Recent advances in agricultural nanotechnology:

NPK-nanofertilizers

by **Professor Mohammed Nagib Abdel-Ghany Hasaneen** and **Professor Dr. Heba Mahmoud Mohammad Abdel-Aziz**, Faculty of Science, Mansoura University, Egypt

Nanotechnology has evolved over the last few decades to occupy everyday life and agriculture is one of the areas where nano-applications have recently reached.

The massive increase in human populations all over the globe means that we need to provide more food from the same area of cultivated lands. This means that we need to produce better crops and increase supplies with the same resources present. For this reason, new methods to increase crop productivity and lower fertilizer consumption are now being researched.

Artificial fertilizers are identified as inorganic fertilizers which are formed in appropriate concentrations to supply three chief elements: nitrogen, phosphorus and potassium (N, P, and K) for different crops and growing conditions. NPK-inorganic fertilizers are vital for plant growth and development. N (nitrogen) stimulates leaf growth and is found in proteins and chlorophyll, P (phosphorus) improves root, flower and fruit development and K (potassium) enhances stem and root growth and the production of proteins. However, about 30-60% of N, 10-20% of P and 30-50% of K of the applied dose is utilized by plants and the rest is lost to the environment. This causes substantial economic and resource losses as well as serious soil and water contamination. With the application of nanotechnology, these demerits of conventional fertilizers can be minimized so as to utilize the major proportion of the applied dose of the chemical. This can be achieved by encapsulating the nutrients in nanomaterials, coated with a thin protective film or delivered as emulsions or nanoparticles.

What is a nanofertilizer?

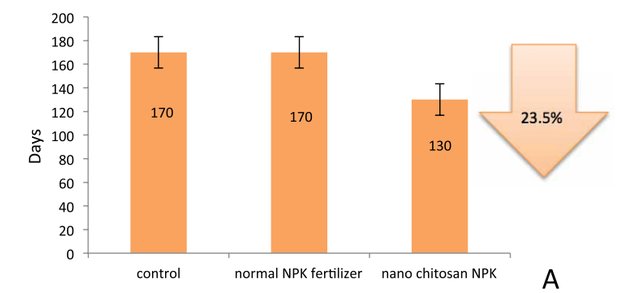
Nanofertilizers are nutrient carriers in the dimension of 1-100 nm. 'Nano' refers to one-billionth of a metre or one-millionth of a millimetre. When the size gets reduced, the surface area has tremendously increased. Nanofertilizers are a nano-structured formulation of fertilizers that release nutrients into the soil gradually and in a controlled way. The nano-based slow-release or controlled release fertilizers have the potential to increase the efficiency of nutrient uptake and to significantly reduce the wastage of nutrients. The nanotechnology may be applied in the soil nutrition or by foliar application by developing the formulations, i.e. coated, encapsulated, or buried in the nanomaterials.

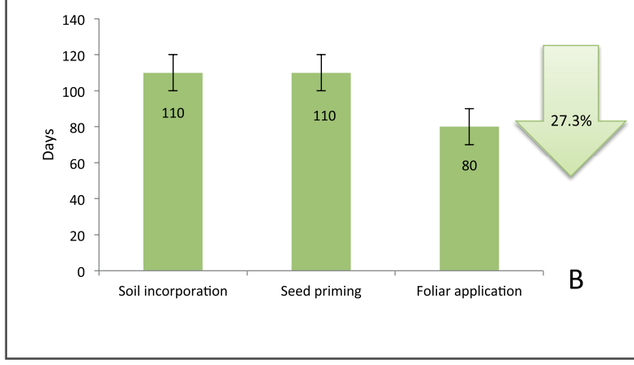
NPK-fertilizers coated or encapsulated with nanoparticles

In our research work, we used chitosan nanoparticles loaded with NPK as foliar fertilizer for wheat plants. We used three concentrations of the nanofertilizer which are 10, 25 and 100%. During foliar application, all pots were covered to prevent the entry of nanofertilizers to the soil. The results showed that nanofertilizers induced significant increases in all growth and yield variables determined when compared with the control (water) or normal-fertilized wheat plants. To our surprise, nanofertilizers decreased the life span of the crop from 170 days for control and normal-fertilized plants to just 130 days (a decrease of 23.5%). In addition, these results enabled wheat plants to grow in pure sandy soil with efficient crop productivity.

When we studied the uptake of the nanoparticles by the plant through transmission electron microscopy, nanoparticles were found to accumulate in sieve tubes of phloem tissue, while xylem vessels appeared with zero nanoparticles. The lowest concentration (10%) produced the best results as a nanofertilizer for wheat plants. Foliar application of nanofertilizers showed a significant increase in total saccharide content of wheat grains. The magnitude of increase was most pronounced in the grains of nanofertilized plants than in normal fertilized wheat plants, particularly at 10% nanofertilizer. When compared with the control, treatment of wheat plants with increasing levels of either normal or nanofertilizer induced significant decrease in protein content and nitrogen content of the wheat grains. Treatment of wheat plants with nanofertilizers significantly increased the element content, especially potassium and phosphorus contents in the wheat grains.

Figure 1. **A:** Effects of normal NPK fertilizer and nanoengineered chitosan NPK fertilizer on the life span of wheat plants grown in sandy soil. **B:** Effects of different methods of application of NPK nanofertilizers on the life span of French bean plants grown in clay-sandy soil.





> *NPK-nanofertilizers will be a revolution in the fertilizer industry*

Foliar application

In another trial, we used carbon nanotubes loaded with NPK and compared them with chitosan nanoparticles loaded with NPK and used both of these types as fertilizers for French bean. In this trial, we tried three different application methods of the nanofertilizers used: soil incorporation, seed priming and foliar application. For soil incorporation, nanoparticles were mixed with the soil. For seed priming, the seeds were soaked in nanosolutions for 30 minutes prior to planting. For foliar application, nanofertilizers were foliary sprayed on the sixteenth day after planting. The results showed that foliar application gave the best results for growth and yield of the plants. Also, foliar application of both nanofertilizers reduced the life span of the plant to 80 days when compared with 110 days for soil and seed priming treatments. For uptake and translocation studies, chitosan nanoparticles appeared in the phloem tissue only and were absent from the xylem vessels. However, carbon nanotubes appeared in both xylem and phloem tissues. Foliar application of nanofertilizers resulted in progressive significant increases in total carbohydrate, protein and vitamin C contents of the yielded French bean seeds, when compared with the control seeds and with the seeds of French bean plants treated by seed priming and soil incorporation. The best nanofertilizer in this trial appeared to be chitosan nanoparticles loaded with NPK (10%), compared with carbon nanotubes NPK (20 µg/L).

Pros and cons

NPK-nanofertilizers promise to be a revolution in the fertilizer industry. The high efficiency of crop production, better seed quality, better yield attributes and productivity are key

Figure 2. Effects of different methods of application of NPK nanofertilizers on total carbohydrates (mg glucose equivalent/g dry weight), total protein (mg/g dry weight) and vitamin C (mmole/g dry weight) contents of French bean yielded seeds. (Data from experiments in 2016 in the plant physiology laboratory, Faculty of Science, Mansoura University, Egypt)

Parameter / Treatment	Soil incorporation			Seed priming			Foliar application		
	Total carbo-hydrates	Total protein	Vitamin C	Total carbo-hydrates	Total protein	Vitamin C	Total carbo-hydrates	Total protein	Vitamin C
Control	159.88	14.00	6.07	159.88	14.00	6.07	159.88	14.00	6.07
Nano Chitosan NPK (10%)	Dead (no yield)			150.80	13.15	5.50	227.34	22.80	10.00
Carbon nanotubes NPK (20µg/L)	152.50	13.38	5.72	155.60	13.85	6.00	220.10	20.00	8.38

elements when we consider the application of NPK-nanofertilizers.

But, until now, few studies have dealt with the possible phytotoxic effects of nanofertilizers to plants. The major threat here is that plants, especially food crops, enter the food chain and the bioaccumulation of nanoparticles may reach animals or humans or may reside in the environment. Possible ways to study the phytotoxic effects of nanofertilizers are now under research. Also, the safety of long-term nanofertilizer consumption is yet to be confirmed. Possible measures and safety levels must be defined for each nanofertilizer used.

> *Nanoparticle bioaccumulation in plants is species specific*

Current research

Up-to-date studies have found that depending on the type of nanoparticles, and the type of plant and soil, nanoparticles can have negative, insignificant or positive effect on plants. Starting with plant morphology, nanoparticles were found to alter morphological features of plants in vital organs such as the roots and leaves. Also, they can influence seed germination. A few studies report on genetic alterations due to plant–nanoparticle interactions. Nanoparticle bioaccumulation in plants is species specific and depends on the nanoparticle physicochemical properties. While some studies report beneficial effects on some plant species, the overall negative effect of the accumulation of these nanoparticles in the soil and plants might exceed the minor beneficial temporary effects. The main negative effects uncovered involve growth inhibition, oxidative stress and genetic alteration, among others. Many nanoparticles are translocated within plants and are likely to enter the food chain, be available for trophic transfer and become available in food for humans and animals. Many nanoparticles are already shown to be toxic to humans, and uptake of nanoparticles in plants poses major safety concerns. If these safety concerns are not properly addressed now, nanomaterials can become an environmental pollutant that might be conducive to irreversible or undesirable modifications with potentially harmful consequences on plants, animals and humans alike. ■

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Potash mining:

New projects in Russia

by **Guy Dresser**, Head of Communications, EuroChem Group, Switzerland

This year EuroChem adds potash production to that of nitrogen and phosphates, becoming one of only three fertilizer producers globally with capacity in all three primary nutrient categories - nitrogen (N), phosphate (P) and potash (K).

The company's two key potash assets are VolgaKaliy, near Volgograd and Usolskiy in the Perm region. The projects involve developing two potash deposits in Russia: some sections of the Verkhnekamskoe deposit in the Perm region and some sections of the Gremyachinskoe deposit in the Volgograd region.

The two sites equate to more than 10 billion tonnes of potash reserves and once fully operational, are set to be among the most cost-efficient potash operations globally.

In phase 1, the combined Usolskiy and VolgaKaliy sites will have over 4.6 mn t in annual potash production capacity.

Average KCl content is 30.8% KCl at Usolskiy and 39.5% at VolgaKaliy. Usolskiy is the first greenfield potash mining project to emerge in Russia and Europe in 30 years.

EUROCHEM-USOLSKIY POTASH (PERM REGION)

Deposit characteristics

Depth	~500 metres
Nutrient content, KCl %	30.8%
Distance to port	~1,600 km

- JORC proven and probable reserves: 420 mn t
- Useful life of mine +35 years
- Usolskiy has had a successful test production and marketable product is available this year

Phase I (completed)
- Capacity of 2.3 mn t p.a. Involves the construction of social infrastructure, cage shaft, skip shaft #1 and processing facility

Phase II: (expected)
- Additional capacity of 1.4 mn t p.a. Involves construction of skip shaft and expansion of processing facility
- Total estimated investment in both phases: USD3.21 bn
- Usolskiy is currently aiming at a 2018 potash production target of around 450,000 tonnes.
- The project will reach its full operational capacity of 2.3 mn t p.a. in 2021, under EuroChem's first phase development plans.

EUROCHEM-USOLSKIY POTASH (PERM REGION)

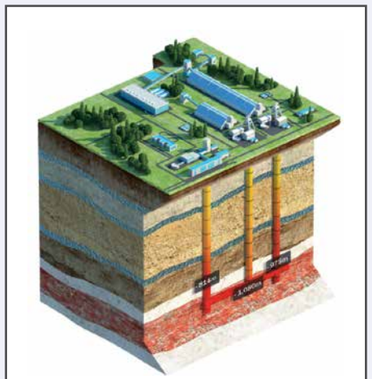
Deposit characteristics

Depth	1,147 metres
Nutrient content, KCl %	39.5%
Distance to port	~500 km

- JORC proven and probable reserves: 492 mn t
- Useful life of mine +40 years
- Production at VolgaKaliy is set to start in late 2018

Phase I (nearing completion)
- Capacity of 2.3 mn t p.a. Involves construction of social infrastructure, cage shaft, skip shaft and processing facility

Phase II: (expected)
- Additional capacity of 2.3 mn t p.a. Involves construction of skip shaft and expansion of processing facility
- Total estimated investment in all phases: USD3.92 bn
- EuroChem expects VolgaKaliy to produce 130,000-140,000 t of potash in 2018
- Production from VolgaKaliy will ramp up to 2.3 mn t p.a. of capacity by 2021 as part of the project's first phase.



Potash is any salt, mined or manufactured, which contains the element potassium (K) in water-soluble form. One of the primary potash minerals is potassium chloride (KCl or sylvite). As a fertilizer, potash strengthens crops. When applied to plants, potash activates more than 60 enzymes – substances that play a key role in carbohydrate and protein synthesis. It improves a plant's water regime regulation and increases tolerance to disease, drought and frost. It also bolsters stems and roots while adding flavour, texture and colour to food crops. ■

Revamping processing plants

by **Joey Dobrée**, Product Portfolio Manager,
Huub Geurts, Senior Process Engineer and
Wilfried Dirkx, Licensing Manager, Stamicarbon, The Netherlands

The challenge for urea producers in 2018 is shifting more and more towards environmental improvement, driven by regulations and the desire from stakeholders to improve the energy footprint of production and thus reduce the environmental load. The struggle to meet these expectations lies in the issue that investments in environmentally friendly plant improvements typically provide a low or even negative financial return for plant owners.

This article describes how urea plants can reduce their environmental footprint with a payback period within five years of their investment. The aim of the revamp solution is to turn a seemingly disadvantage - the need for environmental investments - into a substantial reduction in energy costs combined with a production increase with the option for product diversification.

Approach and experience

Stamicarbon suggests it is more cost-effective to have a thorough assessment and a potential revamp of the plant, rather than carrying out multiple quick fixes. The company has successfully completed more than 100 revamp projects, improving plant performance and/or capacities. They offer several revamping concepts for all types of available urea technologies to increase urea production with their 'Evolve' portfolio. 'Evolve Capacity', 'Evolve Energy' and 'Evolve Emission' are aimed at saving energy and reducing emissions, while minimizing investment in additional resources and infrastructure.

> *"Modifications in the urea synthesis are complex and capital intensive*

Energy reduction

When optimizing the energy balance of a urea plant, the main focus is on the urea synthesis and steam, because the main high pressure steam (25 bara) consumption and low pressure steam (4 bara) production are directly linked. The urea synthesis is the heart of the urea plant and it is a common understanding that modifications in the urea synthesis are complex and capital intensive.

Revamp case 1: Energy reduction with an attractive return

This revamp case addresses the main issue that results from a 'one-on-one' replacement of an HP stripper, which is a falling liquid film evaporation leading to direct loss of production capacity. This loss is the result of the phenomenon that aged HP strippers have due to an increased internal tube diameter resulting from corrosion of the tubes and so they can handle an increased liquid load at constant liquid film thickness which allows higher production capacity without flooding issues.

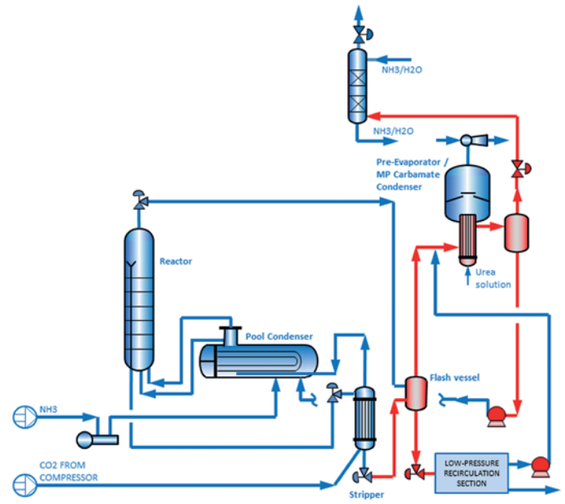
Once the HP stripper is replaced, the original internal diameter is smaller and therefore carries a lower liquid load at constant liquid film thickness. The immediate consequence is a capacity loss of around 6% compared with the performance of the aged HP stripper at the moment it is replaced. This results in a direct loss of income for the plant owner.

Using 'Safurex Star' as stripper material will ensure:

- **No loss but an increase of capacity** – It resolves the loss of capacity, as the liquid load can be increased by 18%, compared with a new HP stripper of the original design by installing more tubes with a thinner wall thickness in an optimized shell configuration of the HP stripper. The loss of heat exchange surface can be compensated, while adding additional capacity of around 12% at limited cost and effort.
- **Higher safety level** - 'Safurex Star' material is less sensitive for corrosion. In combination with radar level measurement optimally safe operation is secured.
- **Lower weight** - The weight of the HP stripper is lower compared with a new original HP stripper with duplex tubes, because of the superior material properties. Hence, no structural modifications and fortifications are required, meaning that the HP stripper exchange has the characteristics of a 'one-on-one' replacement, without the need to modify HP piping.
- **Higher synthesis load** - Usage allows for the reduction of oxygen content of the urea synthesis section when the materials of the existing HP equipment are suitable for low oxygen operation. The low oxygen operation of the synthesis results in a higher urea conversion or synthesis load. The use of the 'Safurex Star' HP stripper therefore allows for an increase of the production capacity.

The additional tubes in the new configuration will result in a net capacity increase of around 12% compared with the performance of the aged HP stripper. It is this capacity increase that secures a substantial part of the business case - to reach the desired return on investment.

Figure 1. Stamicarbon's 'Flash' design



The second part of the solution lies in the achievement of the required energy saving. For this reason the combination has been made with Stamicarbon's Flash Design technology, which consists of an adiabatic flash step with heat recovery (see figure 1).

Stamicarbon's 'Flash Design' offers the following benefits:

- **Saving on steam** - The HP stripper is operated at lower stripping efficiency resulting in lower HP steam demand of the stripper and corresponding lower pressure steam production in the HP pool condenser. The overall energy demand of the plant is balanced by applying the Stamicarbon's 'Flash' design in such a way that low pressure steam export is almost zero. This is realized by the re-utilization of the heat generated by the off-gasses from the urea synthesis and from the flashed vapours from the urea solution from the HP stripper in a pre-evaporator to optimize the energy balance of the plant. The savings related to the reduced need to import 25 bara HP steam generates an advantage of around 100-150kg of HP steam per ton of urea, which corresponds with saving over USD3 mn per year for a world scale urea plant.
- **Other urea grades** - Complementary effect of the 'Flash' design technology is that the urea solution is further concentrated and purified during pre-evaporation. The result is that the urea solution has less ammonia in the new configuration, which makes it suitable for direct high value AdBlue/diesel exhaust fluid production allowing for the production of automotive, marine and intermediate grades.
- **Investment** - Looking at the investment related to this plant improvement, the major advantage is that regular replacement of the HP stripper has been accounted for in the plant maintenance budget. The addition for the required modification of the 'Flash' design typically only consist of three pieces

> *Every project needs a tailor-made approach and close cooperation with the plant owner*

of equipment, mainly a flash vessel with a design pressure of 30 bara and low pressure pre-evaporator with corresponding condenser. The new equipment can often be installed outside the existing structure, due to the lean plant design of Stamicarbon urea plants. The investment cost of such modification is relatively modest compared with typical modifications in the urea synthesis.

- **Safety level** - The safety level of the HP synthesis improves in case the off gases of the HP reactor are sent to the flash section directly, so an HP scrubber is not needed anymore. This flash technology generates good opportunities from cost, energy and safety perspectives in case the existing HP scrubber is at the end of its life time and needs to be replaced.
- **Capacity increase** - The 'Flash' design can also be applied to other revamp concepts such as Stamicarbon's medium pressure add-on for higher capacity increase with low energy consumption figures.

The company also has a high-fidelity process simulator available to train operators to use the new configuration.

The flash design technology has been in operation since 2015 in various plants, for example in a plant of 2860 mtpd in China and a plant of 2200 mtpd in the USA, while having various other plants in operation and under construction.

Results

The result of the 'Evolve Energy' revamp is that the replacement of the HP stripper has been used to optimize the performance of the urea plant by substantially reducing the environmental footprint, while increasing the production capacity. The modifications can be implemented in a regular turnaround in order to achieve the desired 12% additional capacity and 10-15% energy saving, while having an attractive payback period within five years. This actual case demonstrates that a smaller environmental footprint can be a profitable and safe investment.

Emission reduction

With regards to emission legislation there is not a fixed list of worldwide emission limits. They differ per region as local authorities set the standards. In addition, the operating costs of running pollution control equipment can be substantial and so there is a simultaneous demand for economically efficient emission control technologies. This means that every project needs a tailor-made approach and close cooperation with the plant owner, the engineering contractor and the local authorities.

Scrubber technology

Stamicarbon and EnviroCare International (ECI) have co-developed the 'MicroMist Venturi' scrubber (MMV), a multi-stage gas scrubber for granulators and the 'Jet Venturi' scrubber for prill towers. These innovative, high-performance scrubbers do not only remove coarse urea particles, but also submicron dust as well as ammonia at extremely high efficiencies, via the injection of an acid solution.

The MMV granulation scrubber can achieve a dust removal efficiency in excess of 99.9%. Even lower emissions can be obtained, if desired, by the additional integration of a wet electrostatic precipitator (WESP).

Revamping granulation installations

The same kind of scrubber technology can also be applied in retrofits, thereby replacing parts of the previously installed granulator and/or granulator cooler scrubber vessels fitted with multiple tray stages and mist eliminators.

Essentially, the base of the existing scrubber is left in place during a retrofit while the upper part is replaced by inserting a new modular MMV section. The spool scrubber shell (including design and engineering, venturi tubes, DOI trays, nozzles and mist eliminator) and the extra pumps, valves and instruments required can be provided by Stamicarbon. This scrubber dust revamp option, without any additional ammonia scrubbing stage, can achieve a dust removal efficiency in excess of 99.9%.

All of the scrubber's internals can be pre-installed and trial fitted. This allows the total assembly to be inspected and tested before being shipped to site. The downtime of the plant will be minimum, since this complete spool piece can be installed during a scheduled maintenance period.

Revamping prill tower scrubbers

The off-gas discharged from prilling towers contains urea dust with an extremely large surface area. This creates a highly visible, persistent purple-white plume that does not mix well with the atmosphere nor dissipate easily. Because of this, environmental regulations for prill tower emissions are becoming stricter. Allowable emission levels are currently below 50 mg/Nm3 maximum for dust and 50 mg/Nm3 maximum for ammonia within Europe, and are even more stringent in other continents. Exceeding these levels could result in a forced plant closure.

Therefore Stamicarbon and ECI have newly developed a 'Jet Venturi' scrubber design for prill towers, which can be placed on top the roof of the prill tower. This option is a more reliable and less expensive option than a placing it on ground level, as the technology is much lighter and does not require an additional fan.

Figure 2. The pilot 'Jet Venturi' prilling scrubber

The off-gas is progressively treated and cleaned in three compact stages with a high efficiency mist eliminator placed between each stage.

Revamp case 2: Jet Venturi scrubber on prill towers

An industrial scrubber pilot test was carried out on the roof of a forced draft urea prill tower using a single jet scrubber. The aim was to be in compliance with the current European emission legislation. As a consequence, opacity of the waste gas was dramatically reduced. To achieve this objective, a dust collection efficiency of more than 85% was accomplished.

The pilot unit (see figure 2) included the two dust capture stages (concentrated urea and dilute urea sections) but omitted the third ammonia capture stage, which is considered straightforward to achieve compared to dust emission.

The scrubber's jet effect cleaned the dust in the off-gases without pressure loss in the gas flow. This eliminated the mechanical ventilator usually needed to convey off-gases. The quenching effect at the entrance of the jet scrubber also cools down the off-gas. The lack of movable parts makes the jet scrubber very simple to operate. It is also very easy to clean, inspect and repair. The concentrated urea blow down solution can also be circulated for reuse and returned to the urea manufacturing plant.

With the new technology ammonia and dust emission figures below 10 mg/Nm3 were realized, which is considered a substantial improvement in relation to existing best available technologies (BAT) and it also meets stringent environmental regulations.

The above cases are just examples of the broad revamping options Stamicarbon offers. They will continue developing new technologies and materials to improve the footprint of the fertilizer industry. ■

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The School of Athens, Raffaello Sanzio 1509-1511
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Acron increases fertilizer transshipment through Russian ports

Acron Group, one of the leading vertically integrated mineral fertilizer producers in Russia and worldwide, signed a long-term agreement with European Sulphur Terminal LLC to transship up to 700,000 t of mineral fertilizers annually.

European Sulphur Terminal LLC owns an up-to-date transshipment complex at the commercial seaport of Ust Luga. Under the agreement, it will build a separate warehouse for Acron to store and transship its products intended for export.

This agreement was concluded as part of Acron Group's strategy aimed at reallocating transshipment capacity from Baltic Sea ports to Russian ports.

Acron Vice President for Logistics and Transportation Igor Bogdan noted: "Our choice of European Sulphur Terminal LLC as a long-term partner was determined by the fact that it is a reliable supplier of high-quality mineral fertilizer transshipment services. It is conveniently located in a deep-water area suitable for Panamax vessels.

European Sulphur Terminal LLC offers state-of-the-art equipment, a team of highly qualified personnel and prompt loading services". European Sulphur Terminal LLC Executive Director Yury Golubnichenko welcomed the new agreement and commented: "We are always happy to build long-term relationships with responsible customers like Acron. We have already started designing a new warehouse and conveyor systems to transship Acron's fertilizers. The terminal operates two berths and two shiploaders with sufficient capacity to transship the estimated cargo volumes. We are pleased to provide Acron Group with our high-quality services".

Under the agreement, fertilizer transshipment will start in 2019, following the commissioning of the new warehouse unit.

Sirius signs materials handling agreement and lease with Redcar Bulk Terminal

Sirius Minerals Plc has announced that its subsidiary York Potash Ltd and Redcar Bulk Terminal (RBT) Limited have entered into a materials handling agreement under which RBT will provide port and ship loading services from its existing Redcar Bulk Terminal port facility. RBT and York Potash Processing and Ports Ltd (YPPPL), another Sirius subsidiary, have also entered into a long-term lease for land adjacent to the Company's existing port facilities for the Company's finished product storage facilities.

Chris Fraser, Managing Director and CEO of Sirius, comments:

"We are pleased to enter into this arrangement which reduces the complexity of our construction programme and ultimately helps to simplify our stage two financing plan which is being finalised over the coming months.

"By working with a local partner, we can develop our project and also deliver benefits to an existing established business in the Tees Valley. The RBT facility has been underutilised since the closure of the steel works and this agreement will ultimately help us deliver tremendous economic benefits for the region."

Garry O'Malley, RBT's General Manager, said:

FREIGHT RATES

POTASH	Price type	Units	Timing	Low	High	Date
Dry potash Vancouver - China 60-65kt	outright	USD/t	prompt	20	22	8-Aug-18
Dry potash Red Sea - WC India 25-30kt	outright	USD/t	prompt	18	20	8-Aug-18
Dry potash Baltic Sea - Brazil 30-40kt	outright	USD/t	prompt	21	23	8-Aug-18
Dry potash Baltic Sea - SE Asia 25-30kt	outright	USD/t	prompt	50	60	8-Aug-18
Dry potash Vancouver - SE Asia 25-30kt	outright	USD/t	prompt	42	44	8-Aug-18
Dry potash Baltic Sea - China 60-65kt	outright	USD/t	prompt	40	42	8-Aug-18
Dry potash Baltic Sea - US Nola 50-55kt	outright	USD/t	prompt	18	20	8-Aug-18
Dry potash Vancouver - Brazil 30-35kt	outright	USD/t	prompt	30	32	8-Aug-18
Dry potash Hamburg - Brazil 30-35kt	outright	USD/t	prompt	18	20	8-Aug-18

NPK	Price type	Units	Timing	Low	High	Latest	Change*	Date
Baltic-China 50-60kt	outright	USD/t	prompt	41	43	42	2.5	7-Aug-18
Morocco-WC Africa 15-20kt	outright	USD/t	prompt	34	36	35	2	7-Aug-18
Norway-Brazil 20-25kt	outright	USD/t	prompt	24	26	25	1	7-Aug-18

**from previous week*

SULPHUR	Units	Low	High	Date
50-60kt – Vancouver-China	US$/t	20	22	16-Aug-18
Below all 30-35kt				
Mid East – EC India	US$/t	17	19	16-Aug-18
Mid east – North/River China	US$/t	22	24	16-Aug-18
Mid East – South China	US$/t	20	22	16-Aug-18
Mid East – Brazil	US$/t	20	22	16-Aug-18
Mid East – North Africa	US$/t	22	24	16-Aug-18
Black Sea – North Africa	US$/t	25	27	16-Aug-18
Black Sea – Brazil	US$/t	24	26	16-Aug-18
Baltic – Brazil	US$/t	27	29	16-Aug-18
Baltic – North Africa	US$/t	25	27	16-Aug-18
35-40kt – US Gulf - Brazi	US$/t	18	20	16-Aug-18

"This is excellent news for Teesside and we're delighted to be working with Sirius Minerals on a project of such regional magnitude.

"It's another significant step forward in the continued resurgence of Redcar Bulk Terminal (RBT) and demonstrates the integral role we're playing in the regeneration of the South Tees site."

Materials Handling Agreement

RBT's port facility is located adjacent to the Company's Bran Sands site and is also a deep-water terminal capable of handling up to Capesize vessels. RBT has historically operated as a bulk import terminal in connection with the adjacent steel works that closed in 2015. Following the closure of the steelworks, RBT continued to operate, invest and grow into a multi-model terminal attracting a number of new customers and products. However, in order to handle POLY4 exports, some capital expenditure, predominantly ship loaders and conveyors, is required at RBT to facilitate the loading of ships with POLY4.

Pursuant to the agreement with RBT, Sirius will, as part of the Company's procurement plan that is currently being finalised, procure and install the necessary ship loading equipment and systems onto the RBT owned facility. RBT will operate and maintain the new equipment installed and owned by Sirius. The services are to be provided for a period of ten years from first shipment of POLY4, subject to customary extension and termination rights for YPL.

The agreement is for up to 10 mn t per annum of production from Sirius. From the third year of production YPL will guarantee certain payments to RBT for a minimum volume of materials handling. The minimum volumes for such are set in line with the Company's POLY4 sales expectations. The rate

payable to RBT for the materials handling services are based on flat rates (linked to inflation) with incentives for Sirius to utilise larger vessels. The rates are in line with Sirius' existing operating cost expectations.

The arrangements with RBT provide flexibility for the Company through the utilisation of existing port infrastructure which leads to capital expenditure savings and reduces construction risk during the current construction programme. Sirius has retained the right to develop its Bran Sands facility at a future date of its choosing, which it continues to plan to do in due course. As the Company looks to expand beyond the initial production levels, the agreement with RBT provides the flexibility to continue to utilise RBT and to bring on-stream Bran Sands. This provides Sirius with maximum shipping flexibility and opportunities for berth optimisation for the long-term.

Product Storage Facilities

Via YPPPL the Company has also secured a 30-year lease (with rights to renew) over 40 acres of land adjacent to the RBT port facilities and the Company's Bran Sands port site. This land will be used to develop the Company's finished product storage facilities. Locating the storage facilities adjacent to both port locations provides the Company with a more efficient loading circuit by substantially decreasing the distance from the warehouse (previously planning to be located at the materials handling facility at Wilton) to the ship loader. The Company received planning permission from Redcar Cleveland Borough Council for locating the storage facilities on the RBT site on 30 April 2018.

NITROGEN		Units	High	Low	Date
Middle East - US Gulf	45kt	US$/t	27	26	23-Aug-18
Middle East - Thailand	30kt	US$/t	22	21	23-Aug-18
Middle East - Brazil	35kt	US$/t	22	21	23-Aug-18
Baltic - Brazil	30kt	US$/t	26	25	23-Aug-18
China - India	60kt	US$/t	15	14	23-Aug-18
Algeria - Brazil	30kt	US$/t	17	16	23-Aug-18
Algeria - French bay	12kt	US$/t	20	19	23-Aug-18
Baltic - EC Mexico	30kt	US$/t	28	27	23-Aug-18
Baltic - WC Mexico	25kt	US$/t	44	43	23-Aug-18

PHOSPHATES		Units	High	Low	Date
Morocco – Brazil	30kt	US$/t	19	17	16-Aug-18
Tampa – Brazil	30kt	US$/t	27	25	16-Aug-18
Baltic – Brazil	30kt	US$/t	31	29	16-Aug-18
KSA – EC India	30kt	US$/t	22	20	16-Aug-18

AMMONIA	Units	High	Low	Date
Yuzhny - NW Europe, 23kt	US$/t	53	43	23-Aug-18
Yuzhny - Morocco , 23kt	US$/t	42	35	23-Aug-18
Ras al Khair - South Korea, 23kt	US$/t	65	55	23-Aug-18
Ras al Khair - WC India, 23kt	US$/t	30	24	23-Aug-18
Ras al Khair - EC India, 23kt	US$/t	40	33	23-Aug-18
Point Lisas - East Asia, 23kt	US$/t	96	85	23-Aug-18
Point Lisas - US Gulf, 23kt	US$/t	46	36	23-Aug-18
Point Lisas - NW Europe, 23kt	US$/t	54	42	23-Aug-18
Bontang - East Asia , 23kt	US$/t	45	30	23-Aug-18

Yara selects Norwegian shipbuilder Vard for zero-emission vessel Yara Birkeland

The world's first autonomous and electric container vessel is one step closer to launch, as Yara signs a deal with Vard worth appr NOK250 mn to build the vessel. Vard will deliver Yara Birkeland for launch in early 2020, and the vessel will gradually move from manned operation to fully autonomous operation by 2022.

In May 2017, Yara and technology company Kongsberg announced a partnership to build the world's first autonomous, electric container vessel. Replacing 40,000 truck journeys a year, Yara Birkeland will reduce emissions and improve road safety in a densely populated urban area. Now the shipyard has been selected and construction will begin.

"A vessel like Yara Birkeland has never been built before, and we rely on teaming up with partners with an entrepreneurial mindset and cutting edge expertise. Vard combines experience in customized ship building with leading innovation, and will deliver a game-changing vessel which will help us lower our emissions, and contribute to feeding the world while protecting the planet," says Svein Tore Holsether, President and CEO of Yara.

Vard is a leading global shipbuilder of specialized vessels. Yara Birkeland is scheduled to be delivered from Vard Brevik in Norway in Q1 2020. The hull will be delivered from Vard Braila in Romania.

Mr. Roy Reite, CEO and Executive Director of Vard, commented: "We are honoured to be chosen as Yara's partner in this innovative and exciting project. With a longstanding experience in building state-of-the-art and tailor-made specialized vessels, we are excited to be given the opportunity to build the world's first autonomous and electric-driven container vessel. It is a pleasure to welcome Yara and Kongsberg to Vard, and we look forward to working closely with all parties involved."

The project has received NOK133.6 mn in support from the Norwegian government enterprise Enova. Prime Minister Erna Solberg was present for the signing at the ship yard in Brevik, Norway.

"This is a good example of how Norwegian industry can collaborate to create new solutions and green jobs. Yara, Kongsberg and Vard have built on their knowledge about technology, logistics and ship building with an ambition to create sustainable innovation together. The result is exciting pioneer projects like this one. I am proud that the Government has supported the development of Yara Birkeland through Enova and send my best wishes for the construction," says Prime Minister Solberg.

Technology company Kongsberg is a key partner in the project, responsible for the enabling technologies including the sensors and integration required for remote and autonomous operations. The company is leading the way in an industry transformation which at first will impact short sea and inland waterway operations and holds potential for further segments.

"Yara Birkeland represents an important next step for the entire maritime industry, representing a major technological and sustainable advancement. The Norwegian maritime cluster has taken a leading position within technology, design, legislation, testing and all other aspects of the development", says Geir Håøy, CEO of Kongsberg.

The project was initiated in an effort to improve the logistics at Yara's Porsgrunn fertilizer plant. Every day, more than 100 diesel truck journeys are needed to transport products from Yara's Porsgrunn plant to ports in Brevik and Larvik where the company ships products to customers around the world. With this new autonomous battery-driven container vessel Yara moves transport from road to sea and thereby reduces noise and dust emissions, improves the safety of local roads, and reduces emissions.

Krishnapatnam Port commissions five new e-RTGCs

Krishnapatnam Port Container Terminal (KPCT), a deep drafted container terminal on the east-coast of India, has commissioned five 'Electrical Rubber Tyred Gantry Cranes' (e-RTGC) further bolstering its container handling capacity in the backdrop of a strong year-on-year container volume growth of 88% in FY 2017-18

An environmentally sustainable growth is one of the key foundations of Krishnapatnam Port and it received a shot in the arm with the commissioning of these five new e-RTGs which have the potential to reduce energy costs by 80% and operating noise level by 65% whilst cutting down more than 1400 tons of Greenhouse Gases (GHG) emissions vis-à-vis the traditional diesel run RTGs.

Designed to offer significant operational performance, the new e-RTGs are expected to infuse further pace to the yard side container handling activities resulting in faster turnaround time for both the container vessels as well as the by-road trailers.

Commenting on the development, Mr. Anil Yendluri, Director and CEO, KPCT, said: "We are proud and excited to welcome the new e-RTG fleet which will further strengthen our 'clean air' initiative through drastic cut in the emissions and will also boost our operational efficiencies multifold offering enhanced productivity for our customers and partners."

Mr. Jithendra Nimmagadda, Chief Operating Officer, KPCT commented: "The addition of the new e-RTGs is in-line with our philosophy of 'Creating capacity ahead of the demand' whilst we are in the process transforming KPCT from being a gateway container terminal on the east coast of India into a Transshipment hub in South Asia."

Krishnapatnam Port Container Terminal is the country's fastest growing container terminal and is planning to increase its container handling capacity from the current 1.2 mn TEUs per annum to 2 mn TEUs in its quest to emerge as the Global Transshipment hub. ■

Communicating actionable nutrition science to farmers

by **Dr. Kaushik Majumdar**, Vice President Africa and Asia,
Dr. Mirasol Pampolino, Deputy Director Southeast Asia and
Dr. Thomas Oberthür, Director Southeast Asia, The International Plant Nutrition Institute (IPNI)

Food security is a global challenge facing humanity. Rising population, diminishing natural resources and the impact of climate change exacerbates the complex relationship between food supply and demand. Sustainable production of food and associated commodities from limited land and other resources to feed a 10 billion population would require frontier technologies and practices adopted at scale. The global food and nutritional security are intrinsically hinged to balanced plant nutrition.

Numerous studies, at global, regional and local scale, provide evidences that balanced fertilizer application improves quantity and quality of agricultural products. Many such studies have underscored that on-farm site-specific application of fertilizer at the right climate-soil-plant context reduces environmental impact of agricultural nutrient use and helps adapt to climate change impacts.

This article focuses on how the International Plant Nutrition Institute (IPNI) communicates plant nutrition knowledge to smallholder farmers in Asia and Africa, and the unique challenges associated with reaching large number of farmers for visible impact.

The challenge

A recent estimate based on 167 countries, which represents 96% of the world's population, 97% of the population active in agriculture and 90% of agricultural land worldwide, reported that there are about 570 million farms in the world. Of the estimated 570 million farms, 84% or over 475 million farms are less than two hectares in size. A large number of these farms are located in Asia and Africa. Smallholder farmers are a major part of the food security equation because they cultivate 80% of farmland and provide up to 80% of the food in Asia and sub-Saharan Africa. In general, they have less resources, low access to knowledge and are risk averse. Transfer of crop nutrition knowledge in such scenarios requires continuous contact with many farmers who have variable resources, awareness of plant nutrition, production orientation and risk perception. There is rarely a silver bullet that caters to the need of all farmers, therefore continuous improvisation and multiple channels of contact are necessary for on the ground impact.

The response by IPNI

The IPNI, a not-for-profit organization supported by the world's leading fertilizer producers, focuses on improving crop productivity and farm profitability through sustainable use of plant nutrients. IPNI has a rich history of supporting a global plant nutrition research and education programmes for over 80 years. Based out of Norcross, Georgia, IPNI programmes operate in more than 50 countries across the continents, contributing to plant nutrient management research and extension. IPNI's engagement is guided by the '4R Nutrient Stewardship Principles' of applying the right source of nutrients, at the right rate, at the right time and at the right place. This is at the core of IPNI's research and education programs. Defining and applying the 4Rs for appropriate crop-soil-climate context is expected to ensure optimum crop productivity and reasonable return on investment thereby reducing risk, and minimizing loss of nutrients from the rhizosphere to reduce environmental footprint. IPNI scientists join local researchers to define 4Rs for different crops and cropping systems that are grown under variable soils, tillage and crop establishment, water regimes and general crop management. IPNI programs operate in broad acreage as well as in smallholder production areas of the world. These two types of production areas have distinct differences in terms of number of people involved in farming, farm size, labour availability, farmer resource endowment, access to knowledge and use of modern agro-technologies. Locally relevant knowledge is communicated and disseminated through various mechanisms with the aim of reaching the end users for their on-farm implementation.

Figure 1. Supporting farmers to identify actionable interventions to apply fertilizer responsible is at the heart of IPNI's communication efforts.

Figure 2. Dr. Oberthür having a conversation on crop nutrition with cocoa farmers in a learning farm in Sulawesi, Indonesia.

> *IPNI uses multiple knowledge products and decision support tools*

Knowledge development partnerships

Asia and Africa boast the majority of smallholder farmers in the world. Fertilizer use by smallholder farmers is, in general, often imbalanced and inadequate. Under- or over-fertilization is common. Consequently, crop yields are low and soil fertility depletion is prevalent. While in some countries and crops, imbalanced and over-use of certain nutrients have escalated environmental risks. Large number of smallholder farmers managing majority of farmland in Asia and Africa are a vital part of the economic, social and environmental sustainability of the food systems. How well smallholder farmers manage plant nutrients is critical in these geographies. Evidences suggest that smallholders could double crop yield by adopting improved nutrient management. Despite some scattered success, transferring improved plant nutrition knowledge to smallholder farmers to simultaneously address crop production and environmental issues has been a major challenge. The need to reach a very large number of farmers for up-scaling relevant messages can be overwhelming even to organizations with sizable outreach capacity.

One of the most important part of IPNI's global research and education/extension strategy is to identify and collaborate with the most relevant stakeholders at the regional level – usually organizations that have vested interests in solving the problem at hand. Right from the problem identification and conceptualization of research, partner collaborations are a vital part of our research execution, analysis of results, and finally distilling and packaging the research information in to usable output formats. Besides the advantage of tapping in to a collective intellectual capacity for problem solving, the necessary buy-in at the local level to the research program and outputs immensely help in knowledge dissemination.

Research programmes

Majority of IPNI's research programmes are executed in farmers' fields. These inclusive and co-shared researches (also termed participatory), with contributions from farmers, local agencies, researchers, fertilizer industry agronomists and IPNI scientists, ensure that most relevant

local plant nutrition problems are addressed that incentivizes various stakeholders. The major groups that we work with in Asia and Africa include:

- Farmers/farmer groups/farmer cooperatives
- Government extension system
- National Agricultural Research System (NARS)
- Fertilizer industry
- Commodity value chain partners
- International research and development organizations

Knowledge communication pathways

These groups provide support to research, and development of various knowledge products for out-scaling improved practices to the farmers. Packaging of improved nutrient management information in usable formats varies with target groups. With support from partners

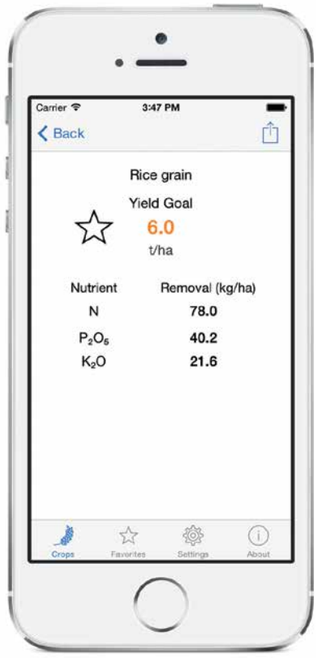


Figure 3: One of IPNI's Smart Phone Apps on calculating nutrient removals.

> *The unique challenge is reaching large numbers of farmers*

to facilitate knowledge transfer, IPNI deploys several pathways that communicate developed knowledge content effectively to farmers. The key pathways include:

- On-farm participatory research and demonstration
  - Examples are 4R learning sites that develop and demonstrate best nutrient management practices, or nutrient omission trials within farmer fields that assess and communicate the role of individual nutrients
- Advisory service support
  - Examples are crop nutrient deficiency photos, posters; radio and television, bulk SMS all of them give practicable and actionable advice to farmers
- Technical bulletins and industry journals
  - Examples are crop and nutrient specific brochures including those on nutrient deficiency identification and remediation; research with impact; 'Plant Nutrition Today', 'Better Crops Journal'
  - These communication outlets are designed to communicate tangible field evidence to partners of farmers (e.g. NGOs, service providers, and similar) so they systematically increase crop nutrition support to farmer clients
- Decision support tools and smartphone-based apps:
  - Examples are the nutrient expert fertilizer decision support tool; crop nutrient response tool, PlantCalc mobile app; nutrient expert mobile app
  - All of these are built so that they can be used either by farmers directly, or by their partners (e.g. extension agents, or fertilizer dealers)
  - We introduce further below the case of the nutrient expert fertilizer recommendation tool

IPNI has six programmes in Asia and Africa: China, Southeast Asia, South Asia, sub-Saharan Africa, West Africa and North Africa. All of the IPNI programmes are based on regional requirement and are partnered with organizations to produce knowledge products to aid in easy dissemination of improved nutrient management practices. IPNI scientists focus strongly on developing knowledge and respective communication products that engage farmers directly, but in parallel also provide the opportunities for farmer support institutions including regional public and private sector to effectively reach farmers (see table 1). Although the type of knowledge products produced have a strong regional influence, some of them do cut across regional boundaries, institutional actors and language barriers.

Case example:
Nutrient Expert tool communicates fertilizer recommendations

The Nutrient Expert (NE) decision support tool, a 4R compliant tool that rapidly provides field-specific fertilizer recommendation, with or without a soil test, is a great example. Since its development in 2008 by the Southeast Asia Program, IPNI has so far developed the NE tools for 6 crops (maize, wheat, rice, soybean, cassava, potato), for 18 countries (China, Philippines, Vietnam, Indonesia, Bangladesh, Nepal, India, Ethiopia, Kenya, Tanzania, Zimbabwe, Nigeria, Ghana, Togo, Burkina Faso, Algeria, Tunisia and Morocco), that are available in 8 languages (English, Chinese, Hindi, Bengali, Tagalog, Indonesian, Vietnamese, French). These tools in web and smartphone platforms have been successfully used and scaled up by the stakeholders in Asia and Africa to increase the likelihood of improved crop production and profitability, and reduced environmental risk from plant nutrients.

Table 1. Regional stakeholders and plant nutrition communication pathways: more asterisks indicate increasing importance of a communication pathway for a stakeholder.

Stakeholders / Communication pathways	Farmer Groups/ Cooperatives	Local Extension	NARS	Fertilizer Industry	Value Chain Partners	NGO	International Development Agencies
On-farm Participatory Research & demonstration	***	***	***	***	**	*	***
Advisory Service Support		***		***	**	**	
Technical Bulletin		***	***	***			
Scientific Journal/ Articles			***	**	**	*	***
Decision Support Tools	**	***	***	***	**	**	***
Smartphone based	***	***		***		**	***
Online Services	**	**	***	***		*	**

Table 2 provides a break down of the number of farmers that IPNI reached directly with Nutrient Expert. These numbers obviously do not include those generated by spontaneous dissemination without direct engagement of IPNI, or the use by partners organizations of IPNI.

Figure 4: The successful Nutrient Expert software is available in various languages and for various crops in several countries.

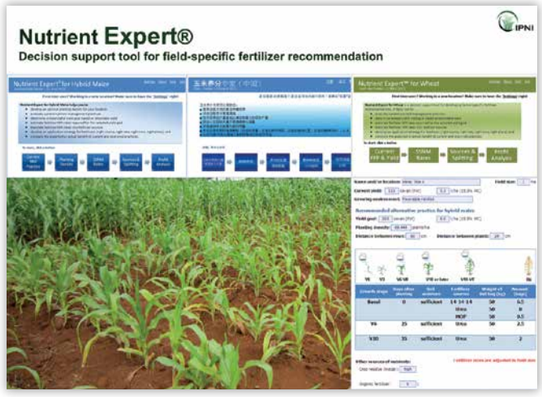


Table 2. On-farm impact of the Nutrient Expert fertilizer decision support tool in Asia and Africa

Country	Crops	Farmers reached directly
China	Maize, Wheat Rice, Soybean, Potato	2346
South Asia	Maize, Wheat Rice, Soybean	2452
Southeast Asia	Maize, Cassava, Sugarcane	4748
Northern Africa	Wheat	3964
Sub-Saharan Africa	Maize	12079
TOTAL		**25589**

Across all sites, compared with farmer's fertilizer practice, Nutrient Expert increased yield by 1.25, 0.84, and 0.78 t/ha and increased gross profit by 304, 214, and 234 USD/ha in maize, rice, and wheat, respectively. Average fertilizer P and K use with Nutrient Expert for all the three crops were mostly comparable with the farmer's rates, although rates varied from field to field and site to site. Nutrient Expert increased fertilizer K use consistently for maize and wheat; for rice, Nutrient Expert either increased or decreased the K application, depending on the country or region. NE balanced the application of nutrients depending on crop requirement and indigenous nutrient supply, resulting in increased nutrient use where farmers' rates were below the optimal and Nutrient Expert reduced the nutrient rates where farmers' rates were excessive.

IPNI uses multiple knowledge products and decision support tools, and leverages partner strengths to communicate plant nutrition science to farmers. Regions, where millions of smallholder farmers operate, it is impractical, if not impossible, for any single organization to reach the scale. Harmonizing our efforts with stakeholders, who have incentives to apply improved practices on-farm and using multiple strategies and tools provide the best possible chance of success on the ground. ■

Safe operation
of steam reformers

by **Mads Feddersen**, Product Line Director,
Charlotte Vinding Ovesen, Senior Principal Scientist and
Mette Stenseng, Senior Product Specialist, Haldor Topsoe A/S, Denmark

Ensuring a safe and reliable operation is one of the main challenges that an ammonia plant has to face on an everyday basis. The catalyst used in the steam reformer is paramount in this aspect, because it has a huge impact on the integrity and lifetime of the catalyst tubes. If excessive carbon formation occurs, operation of tubes beyond design temperatures will be the result. Long term operation in these conditions creates the risk of premature tube ruptures and uncontrolled plant shutdowns.

> *Top-fired reformers are more susceptible to carbon formation*

Causes of carbon formation in top-fired reformers

When looking at the reasons for unplanned shut-downs in ammonia plants, comparative surveys of ammonia plant operation taking place in the time period from 2002–2014 show that failure related to the primary reformer is one of the top three contributors to lost production days.

In top-fired furnaces, carbon formation in the catalyst tubes continues to be an operational challenge, and ways to prevent and/or monitor this phenomenon are high on most operators' agendas. Why then is carbon formation of special concern in top-fired reformers, and what exactly is carbon formation?

Carbon formation or carbon laydown is the result of higher hydrocarbons being thermally cracked inside the top part of the reformer tubes. Top-fired reformers are more susceptible to carbon formation due to the temperatures being higher in the top of the tubes compared to other reformer designs. At the design level, carbon formation will not occur, as the catalyst used in the top of the tubes will have sufficient activity to reform the higher hydrocarbons before the temperature in the tube reaches the critical level where carbon is formed. The majority of all plants with top-fired reformers use alkali-promoted catalysts which help suppress the carbon formation. Unfortunately, in the real world things are not ideal and carbon formation does occur for a variety of reasons listed below.

Sulphur poisoning

Low levels of sulphur (in the order of parts per billion) exiting the desulphurization section or entering with the steam will slowly be adsorbed by the nickel-based reforming catalyst, reducing the catalyst activity. Such a small and steady ingress is normally not a big ssue and high activity catalysts may operate for years under such conditions. Sudden breakthrough of sulphur from the desulphurization section or steam supply, however, will have a more dramatic effect, resulting in significant catalyst deactivation and ultimately leading to carbon formation.

As the catalyst activity decreases, the rate of conversion of higher hydrocarbons (as well as methane) is reduced, which allows the higher hydrocarbons to penetrate further down into the tubes. Furthermore, the temperature in the tubes also increases, as less heat is removed by the endothermic reaction (see figure 1). Combined, these conditions result in higher risk of carbon formation and the risk will continue increasing as the catalyst ages.

Other poisons, such as sodium and silica, which may originate from steam with too high levels of impurities, will also poison reforming catalysts. Nevertheless, sulphur is the most common poison observed creating problems in steam reformers.

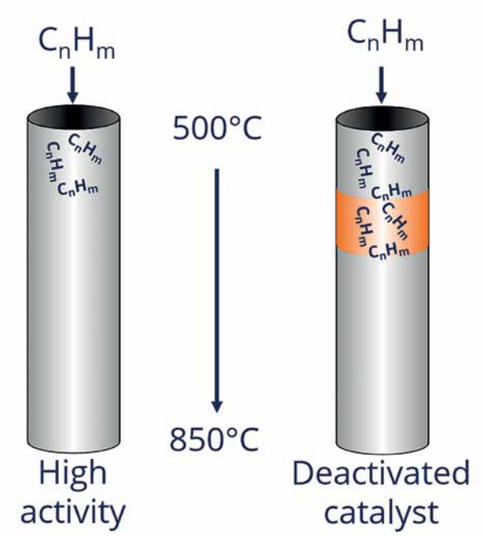
Uneven firing

Uneven firing can lead to significant temperature differences between the individual tubes, which can also be a contributing factor when it comes to carbon formation. Even a slightly higher tube wall temperature of single tubes can be the 'final straw', leading to the onset of carbon formation. Uneven firing is often part of the reason that neighbouring tubes do not always share the same fate, i.e. one tube experiences carbon formation while the neighbouring tubes may not.

Uneven catalyst loading

The loading of all types of tubular reformers is a critical operation that will have an impact on the operation of the reformer and on the lifetime of the catalyst charge. Differences in the achieved loading density will affect the pressure drop across the individual tubes, and any difference in the pressure drop will affect the flow through the individual tubes. If the firing is not adjusted, a tube receiving less flow will become hotter, thereby increasing the risk of carbon formation. As described in the section about uneven firing as well, this may also explain why carbon formation is sometimes only observed in some and not all tubes.

Figure 1. Conversion of higher hydrocarbons in the top of the reformer tubes.



> *Carbon formation may result in very serious consequences*

Fluctuating feedstock composition

As carbon formation in top-fired reformers is typically caused by thermal cracking of higher hydrocarbons, it comes as no surprise that the amount and types of higher hydrocarbons in feedstock will influence the risk of carbon formation.

At start-of-run for a reforming catalyst charge, there will be a certain safety margin allowing some feedstock fluctuations with no negative consequences. However, as the catalyst deactivates, higher hydrocarbons will penetrate further down the tube into increasingly high temperatures. For a given feed composition and catalyst temperature there exists a critical steam-to-higher hydrocarbon ratio (S/HHC) (see figure 2), and operation at a S/HHC ratio lower than the critical ratio can result in carbon formation.

Therefore, if the composition of the feedstock fluctuates, especially with regards to the content and/or types of higher hydrocarbons, an otherwise well-functioning reformer might suddenly experience problems with carbon formation.

Consequences of carbon formation and mitigation

Carbon formation may result in very serious operational, safety and economic consequences and the severity depends on the rate of carbon formation. If carbon formation occurs, the tube wall temperatures may rise above the design which leads to a decreased lifetime of the tubes or even tube rupture.

When the first signs of carbon formation occur, it might often be necessary to modify the operating

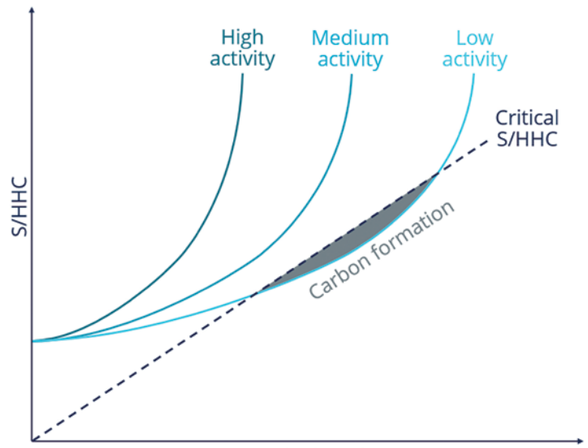
conditions (e.g. increase the steam-to-carbon ratio and/or reduce the outlet temperature) or decrease the plant load to slow down the carbon formation and protect the tubes from further damage. Most plants will also increase visual inspection frequency. In the worst case, it may even be necessary to shut down the plant to protect the tubes.

In less severe cases, a so-called 'regeneration' procedure (involving steaming and controlled oxidation/combustion of the carbon in the tubes) may help to remove the carbon deposits and any sulphur if sulphur poisoning has taken place. However, in some cases such a procedure will not be sufficient to fully restore the reformer performance to the level before the carbon formation occurred, and replacement of the catalyst may be necessary.

Before loading a new catalyst charge, the affected tubes should be inspected and thoroughly cleaned for any remaining carbon deposits. The cleaning itself may be time-consuming and increase the shut-down period and thereby lead to even more days of lost production.

Clearly, carbon formation can be costly and debilitating to the plant which is why avoiding it and ensuring an early detection should be emphasized. One of the main causes of carbon formation is the deactivation of the reforming catalyst by sulphur and therefore increased focus on the performance of the desulphurization section is often beneficial for the overall plant performance. Furthermore, ensuring proper burner management and thereby an even tube wall temperature distribution is of critical importance, and can be accomplished either by regular visual furnace inspections or by online digital monitoring tools. However, catalyst selection is also vitally important and significant developments have taken place in the recent years in alkali-promoted catalysts that reduce carbon formation.

Figure 2. Carbon formation as a function of S/HHC and catalyst activity.



> *Ensuring proper burner management is critical*

New generation of reforming catalysts

While the old generation of alkali-promoted reforming catalysts has been successfully used for many decades, the use of these traditional catalysts is not without problems. Over time, some alkali will slowly be stripped from these catalysts, resulting in lower carbon resistance and potentially causing alkali fouling of downstream equipment. However, in recent years, Topsoe has introduced a new generation of alkali-promoted catalysts, which minimizes these issues, promising more reliable and efficient protection from carbon formation.

The development of new catalysts is based on a detailed understanding of the mechanism of carbon formation and the role potassium has in mitigating it. Addition of alkali metal prevents carbon formation in the following two ways: it promotes gasification reactions, and by adsorption on step sites it inhibits nucleation of carbon islands, which leads to carbon formation. Given the fact that a poorly performing catalyst can seriously impact the overall performance of the plant, it seems imperative to choose a catalyst with a longer lifetime to prevent carbon formation as much as possible. ■

People & events

Van Iperen International is growing for the future

From the early beginning in 2010, Van Iperen International has continuously grown very fast. Serving clients in over 90 countries worldwide with a professional team spread over offices on all continents. To enable supporting our partners even better in the future, we decided to further strengthen our organization. Therefore, at the beginning of June, the management team was adjusted to prepare further growth.

Changes in the management team

Paul El Safty became Director of Sales, managing the team of International Sales Managers. Laurent Aubertin remains Director of Product Development and Agronomy, working closely together with our Agronomist and Product Developers. Philippe Artige, now permanently based in the US, is Director of Americas managing all business for both Latin and North America. Mehrdad Damavandi became Director of Operations, managing the Back Office, Document Management, Production and the new Sourcing department.

Paul El Safty
Director of Sales

Laurent Aubertin
Director of Product Development and Agronomy

Philippe Artige
Director of Americas

Mehrdad Damavandi
Director of Operations

At the Marketing department, Jan van de Voort joined the company in the new position of Director of Marketing. Jan has many years of experience in the agriculture business, especially at Bayer Crop Science. He will guide the marketing department with the marketing strategy for the coming years.

Jan van de Voort
Director of Marketing

Matteo Graiff
Product Manager Biostimulants

Marc Van Oers
Director of Innovations

New: Innovations department

In order to successfully grow for the future, innovation and R&D are essential. For this reason we created the new Department of Innovations with Marc van Oers taking the lead as Director of Innovations. Marc will work closely together with the R&D station Landlab in Italy and our Development Engineer at Euroliquids. We have some very promising innovations in the pipeline. The aim is to combine the best of traditional mineral fertilizers with the opportunities of biostimulants.

New: Product Manager Biostimulants

In line with this focus on combining nutrition with biostimulants, Matteo Graiff joined the marketing team in the new position of Product Manager Biostimulants. Matteo is Italian, has a background in agronomy and plant biostimulation, and will support the further development of our biostimulant range.

New appointment VP of R&D at BioConsortia

BioConsortia has announced the promotion of Dr. Hong Zhu to Senior Vice President of Research and Development. Dr. Hong Zhu will lead the next phase of expansion of BioConsortia's Advanced Microbial Selection (AMS) technology platform, including discovery pipelines, product development, and commercialization. In his new role, Dr. Zhu will oversee R&D operations, set R&D strategies, and direct scientists at the company's New Zealand research centre and US headquarters.

"Hong has been an exceptional contributor to every team at BioConsortia over the past two years. His decades of experience in the agricultural biologicals space, coupled with extensive technical expertise, has help grow the team both in numbers and in skill. I have no doubt that he will continue this success as he beings directing the whole R&D organization," says Marcus Meadows-Smith, CEO, who worked with Hong prior to their time at BioConsortia at biopesticide company AgraQuest and later at the biologics division of Bayer CropScience.

Dr. Zhu joined BioConsortia in 2016 from Bayer CropScience to lead the company's development programs. He has more than 20 years of industry experience in developing microbial based biopesticides, bioherbicides and biofetilizers. Since joining BioConsortia, Dr. Zhu has driven enhancements in the proprietary AMS process to speed time-to-value. He has honed in on industry needs, strengthened the R&D portfolio, and been instrumental in moving a number of leads into product development. Leading the R&D team as one group is a natural fit for him.

Meanwhile, Dr. Sue Turner, who has been Sr. VP of Research since 2014 and who championed the AMS process in the US as the company moved headquarters from New Zealand to Davis, California, will return to her home in Auckland where she will continue consulting with the company and will join the ranks of its Scientific Advisory Board.

"I'm excited to lead the team forward as we continue to expand our discovery platform and move products into the development phase. Dr. Sue Turner has built a fantastic research team over the past 4 years and we are delighted she will continue with us on a consulting basis" Says Dr. Zhu. "I am enthusiastic about exploiting this strong base and moving toward the launch of a portfolio of biological products with higher consistency and superior efficacy."

Marcus Meadows-Smith named Independent Director at Crop Enhancement

Crop Enhancement Inc., an innovator of sustainable agrochemical products for enhancing crop yields, has appointed Marcus Meadows-Smith to its board of directors. As a proven, successful, and recognized executive of the agrochemical industry, Mr. Meadows-Smith will assist the management team with the development of business models and go-to-market strategies that position Crop Enhancement for success as it reaches a key inflection point: commercialization of its technology.

Mr. Meadows-Smith is currently CEO of BioConsortia. Prior to that, he turned around the biopesticide business AgraQuest Inc. over a four-year timeframe, culminating in that company being acquired by Bayer CropScience for over USD400 mn. Following Bayer's acquisition of AgraQuest, he became head of biologics for Bayer CropScience. Previously, Mr. Meadows-Smith had a 14-year career at Chemtura Corporation, assuming multiple managerial roles and ultimately becoming EVP for a USD2 bn portfolio of businesses that included crop protection, consumer products, and plastics additives.

Trammo announces retirement of Brent Hart as CEO and names Edward G. Weiner as successor

Trammo has announced that Brent Hart will retire as Chief Executive Officer effective 31 December 2018 and that Edward G. Weiner will succeed him.

Mr. Hart has served Trammo for close to 25 years as a trader, as President of Trammo and since October 2016, as Chief Executive Officer. After his retirement, Mr. Hart will remain as a consultant to the Company.

Mr. Weiner, currently Executive Vice President, Chief Operating Officer and Chief Financial Officer of Trammo, will succeed Mr. Hart as CEO effective 1 January 2019. Mr. Weiner has been with the company since 1987 and became CFO in 1990.

Mr. Weiner said: "Brent Hart has been a role model of creativity, hard work and loyalty. I look forward to his continued counsel and guidance."

Founded in 1965, Trammo is a global commodities merchandising and distribution company with its corporate headquarters in New York City and offices around the world. Trammo owns and operates ammonia terminals in Meredosia and Niota, Illinois and a nitric acid production facility in North Bend, Ohio.

According to Mr. Weiner, "Trammo will continue to focus on growing the core businesses and activities in which it is a leading market participant, including anhydrous ammonia, sulphur, sulphuric acid, nitric acid and petroleum coke. We remain committed to providing to all of our business counterparties the high level of service that they have come to expect from Trammo."

Arianne Phosphate appoints new Director to Board

Arianne Phosphate has announced the appointment of Mr. Claude Lafleur to the company's Board of Directors.

Mr. Lafleur brings with him extensive experience in the agribusiness field, having served in senior management positions with several companies. For 16 years Mr. Lafleur was with Coop fédérée, including eight years as its Chief Executive Officer. With its affiliated co-ops, Coop fédérée is Quebec's largest agri-food organization with annual sales of over CAD9 bn. As well, Mr. Lafleur was CEO of IFFCO Canada, the Canadian subsidiary of IFFCO (Indian Farmers Fertilizer Cooperative Limited), India's largest fertilizer manufacturer with annual sales of USD3 bn. Currently, Mr. Lafleur is a member of Anges Quebec (Quebec Angels) Capital, a fund sponsored by Investissement Québec, Caisse de dépôt et placement du Québec and Fonds de solidarité FTQ and, continues to sit on several boards including Desjardins Groupe Assurance, a CAD4.5 bn enterprise.

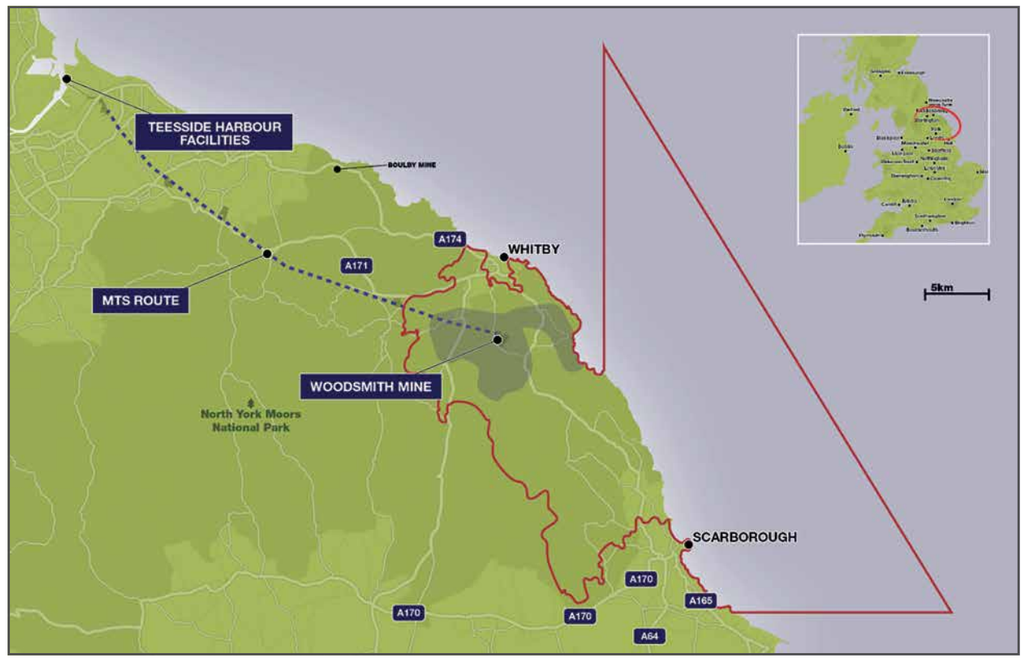
"Claude's resume speaks for itself," said Dominique Bouchard, Executive Chairman of the Board of Arianne Phosphate. "Having served with large domestic and international companies, Claude will be able to share his knowledge with the board and management of Arianne. As well, over the years, Claude has assembled a strong network of industry and government contacts that he will be able to draw on as he assists Arianne in formalizing the final pieces necessary to put the Company's Lac à Paul project into production. On behalf of the Arianne team, we want to welcome Claude and look forward to working closely with him." ■

Sirius Minerals

polyhalite project update

by **J.T. Starzecki**, Chief Marketing Officer and
Robert Meakin, Research and Development Director, Sirius Minerals, UK

The Sirius Minerals polyhalite project is a multi-billion dollar capital investment scheme to extract polyhalite, a natural mineral located deep beneath the North York Moors in north eastern England, and to sell it as a bulk multi-nutrient fertilizer to customers around the world. The low environmental impact mine will create over 4,000 jobs (directly and in the supply chain) and at full production will generate GBP2.5 billion in annual exports, delivering a huge boost to the UK economy and trade after Brexit. Following on from last year's article on polyhalite (September/October 2017 edition), the company updates Fertilizer Focus on project progress and plans for the future.

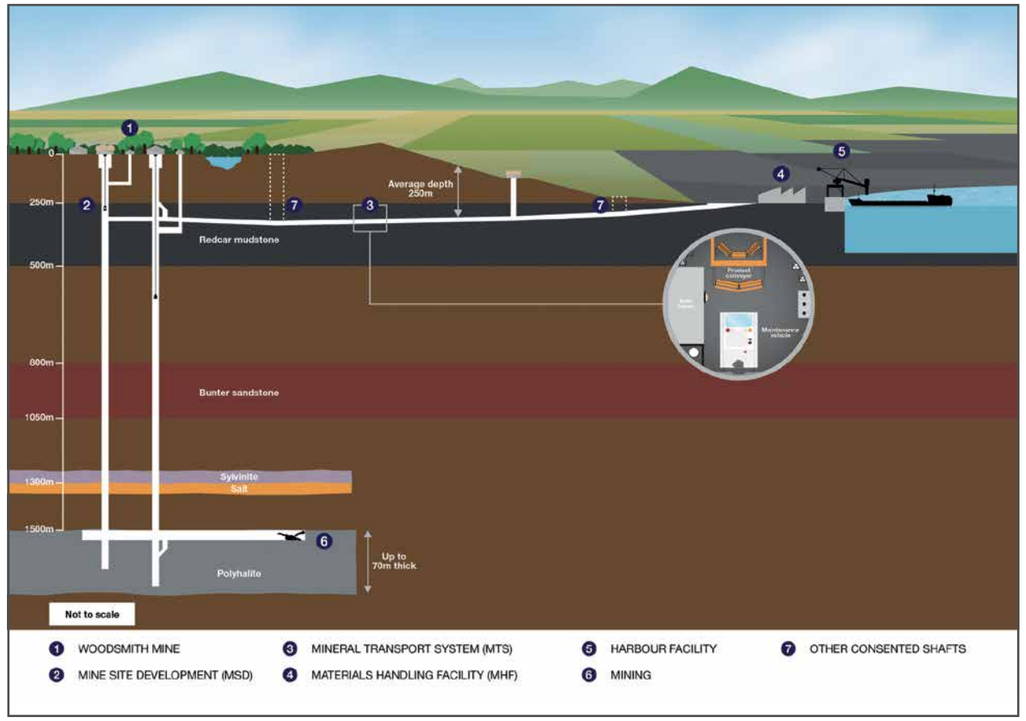


Project overview

Situated just outside Whitby in North Yorkshire, Sirius Mineral's Woodsmith Mine is currently under construction. The Project's total area of interest is some 750km^2 onshore and offshore. First polyhalite is expected in 2021, and the project's first phase will deliver 10 mn t per annum (Mtpa) of its multi-nutrient, low-chloride fertilizer product POLY4.

POLY4 is derived from the naturally-occurring mineral, polyhalite ($K_2SO_4.MgSO_4.2CaSO_4.2H_2O$). Polyhalite is a relatively common mineral which occurs in marine evaporite systems and is usually found in accumulations several centimetres thick. In Yorkshire, Sirius has intersected high-grade seams of polyhalite (mean grade of 88.4%) up to 70 metres thick, and an average thickness of 25 metres, around 1,550 metres below sea level. The company's resource amounts to some 2.66 bn t from 7% of its area of interest.

To access its world-class mineral resource, Sirius has designed its mine infrastructure to not only be sympathetic to its sensitive location under a national park, but to also allow the company to efficiently mine and transport bulk volumes of polyhalite from the Woodsmith Mine to the materials handling facility (MHF) on Teesside causing minimal surface impact. The low-impact infrastructure ensures no mineral will come to surface until after it arrives at the harbour for export.



> *117 long-term partnerships have been developed*

The engineering

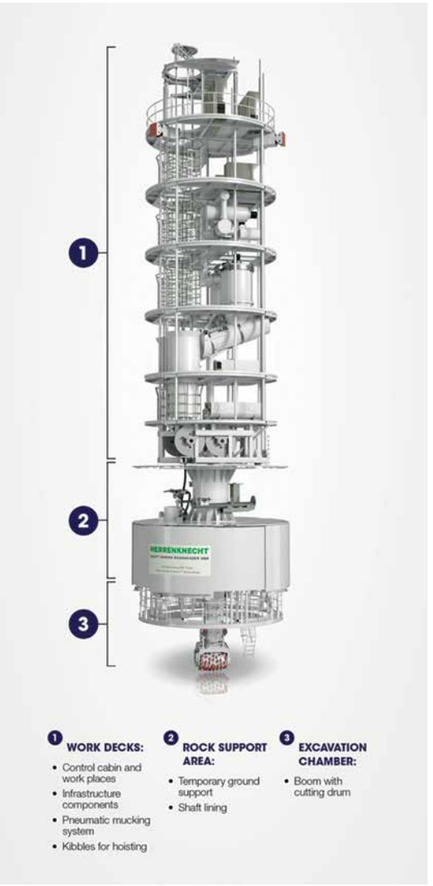
Tried and tested construction techniques are being used to develop the Woodsmith Mine and its associated infrastructure. The low impact design coupled with a mineral transport system (MTS) – a tunnel containing a conveyor belt linking the 37 kilometres between mine and port – is setting a new standard for sustainable mine development.

Shafts

At the Woodsmith Mine site, two deep shafts are being constructed to access the polyhalite in the centre of the mineral reserve: the production shaft reaching a depth of 1,594 metres and the service shaft reaching a depth of 1,565 metres.

Construction on the foreshafts commenced towards the end of 2017 and is nearing completion. This has been done using a technique called diaphragm walling – the construction of a 60-metre-deep circular concrete wall in the ground, which is then hollowed out to create a chamber. This chamber will house the winding equipment, thus shielding the workings of the mine from public view and maintaining its low visual impact.

Once the chambers are excavated, Sirius's shaft sinking contractor, DMC Mining Services Ltd (DMC), will use the Herrenknecht Shaft Boring Roadheader (SBR) to construct the main shafts. The SBR is an adaptation of tunnel boring technology, enabling high sinking rates and maximum safety for personnel working in the



(above) View of the Woodsmith Mine site, July 2018; *(left)* Diagram of an SBR which will be used to excavate the main shafts

excavation chamber compared to conventional shaft sinking methodologies. The SBR is equipped with a roadheader boom and a rotating cutting drum. As the SBR descends on winches, permanent lining is inserted in sections from an upper working deck. The SBR has recently completed excavation of two deep shafts in Saskatchewan, Canada, for BHP Billiton.

Mineral transport system

The MTS will carry mined polyhalite ore 37 kilometres underground from the Woodsmith Mine to a materials handling facility at the Wilton site on Teesside. A high- capacity conveyor will transport mined ore within a 4.3 metre diameter, concrete-lined tunnel. The MTS incorporates industry standard equipment, providing a transport system that is reliable, low-maintenance and low-cost.

The MTS will be constructed using three tunnel boring machines (TBMs). These will be launched from the Woodsmith Mine, the MHF end at Teesside, and from an intermediate site along the route of the tunnel. The MTS is being constructed within Redcar Mudstone, a consistent geological formation which can be excavated efficiently but has the structural integrity to accommodate a tunnel.

Initial preparation work for the tunnel began at the Wilton site on Teesside in June, with the building of a ramp and portal for the TBM by contractor, Strabag. The initial stages of the tunnel will be excavated later this year, before the TBM arrives on site in early 2019.

Materials handling facility and port

Located at Teesside on the Wilton International site, the MHF will consist of the plant and equipment necessary for a simple and cost-effective granulation process to produce bulk volumes of POLY4. The polyhalite ore will undergo a simple process of crushing, grinding, granulation, screening and drying to produce the finished POLY4 granular product. This is then put onto a conveyor belt to a quay 3.5 kilometres away, where ship loaders will transfer finished product into a ship's hold at 5,000 t per hour.

POLY4

POLY4 has the ability to reshape the fertilizer market. POLY4 is unique in that it provides a natural combination of four of the six key macro nutrients plants require to grow: potassium (K), sulphur (S), magnesium (Mg) and calcium (Ca).

In addition to its multi-nutrient content, POLY4 is certified for organic use and has a number of other positive characteristics which make it suitable for widespread commercial use, including:

- Low chloride and pH neutral
- Improved fertilizer use efficiency through greater nutrient uptake
- Desirable nutrient release profile which matches crop demand
- Ability to reduce agricultural impact on the environment by improving soil strength, structure and nutrient legacy

Three TBMs will be used to construct the MTS tunnel

POLY4 nutrient composition and formula.

$K_2SO_4MgSO_42CaSO_42H_2O$

K_2O	S	MgO	CaO
14	19	6	17

- Availability for use as a direct application fertilizer or as a component of blend formulations with excellent compatibility with other fertilizer products.

Because of these unique characteristics, and the huge size of the deposit, POLY4 is being marketed as the world's first bulk speciality fertilizer: a freely available potassium fertilizer that can be used to improve yield and quality on both broad-acre as well as high-value crops.

The company believes that the product will be uniquely disruptive in the market, as farmers substitute some of their potassium input for POLY4 in order to achieve better yields and find cost savings through applying four nutrients in one product. In addition, because of its organic certification, low CO_2 footprint and soil-enhancing properties, POLY4 will be instrumental

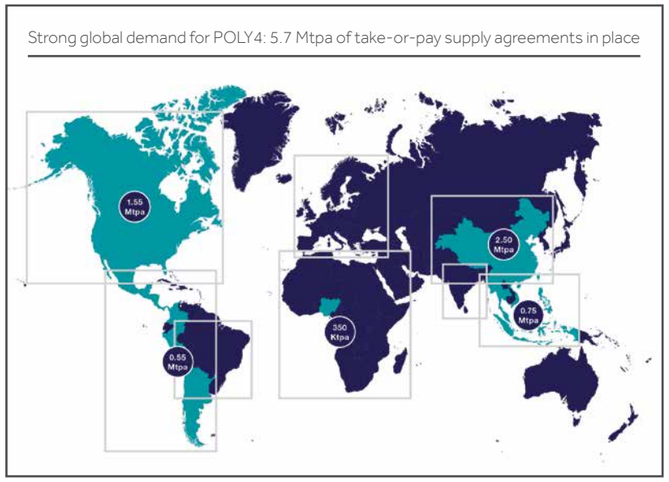
Images from the POLY4 trials: ryegrass (England), rice (Tanzania), tomato (England), cotton (Brazil), tea (China), potato (Scotland).

in developing the market for more environmentally-friendly fertilizers and sustainable soil management practices.

The low-chloride nature of the product is also particularly important. Currently 32% of global potassium is used on chloride-sensitive crops. However, only 9% of this supply is chloride-free, mainly due to the high cost and restricted supply of low chloride products like SOP. By supplying a bulk, low-chloride option, Sirius is confident that it can access pent up demand in the market that has hitherto been stifled.

The company has embarked on a robust marketing approach, combined with a thorough agronomic programme to prove this model and POLY4's efficacy. Long-term partnerships have been developed with over 117 leading agricultural universities, research institutions and commercial associates across five continents such as Virginia Tech and the University of Florida, the University of São Paulo and Fundação MT, the University of Warwick and Wageningen University & Research, the Agricultural Research Institute – Uyole, Tanzania, the Sichuan Academy of Agricultural Science and the Nanjing Institute of Soil Science.

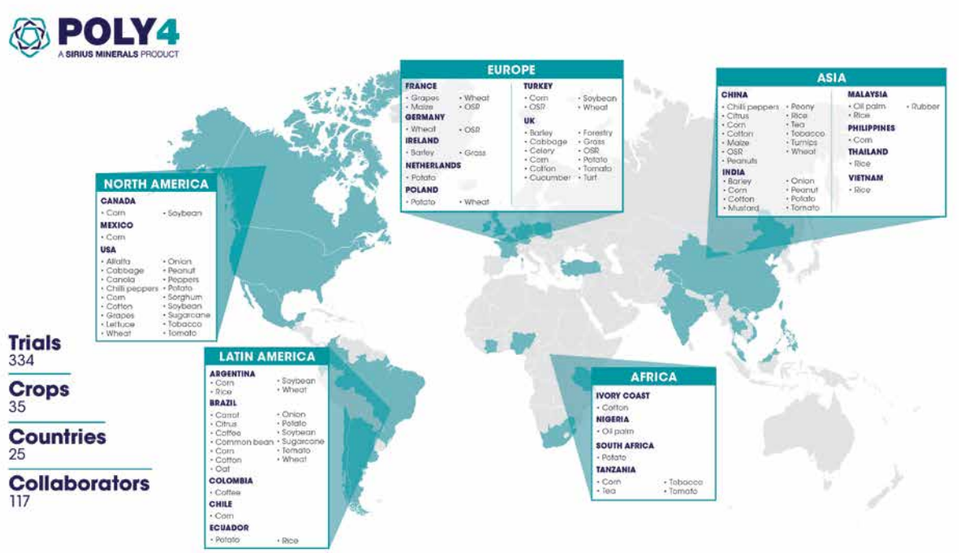
Strong global demand for POLY4: 5.7 Mtpa of take-or-pay supply agreements in place



These partnerships, combined with a targeted regional sales strategy, have enabled Sirius to enter into a number of binding, large-volume, long-term supply agreements under which customers have agreed to buy a minimum amount of POLY4, once production begins, and pay a given price. To date, these agreements total 5.7 Mtpa at their respective full volumes, with the majority of pricing mechanisms linked to the underlying nutrient value and competing product benchmark pricing.

Sirius Minerals customers have recognised the value that POLY4 can deliver, as well as the strong results achieved by the global agronomy programme, which demonstrate the benefits of multi-nutrient fertilizers. Products that bring a better balance of nutrients will help boost agricultural productivity and assist with building food security across the globe. The company's offtake agreements are in Southeast Asia, China, Africa, North America and Latin America, and include significant businesses within the agricultural, fertilizer and animal feed markets.

Sirius Minerals research and development programme (as of August 2018)



> *"Products that bring a better balance of nutrients will boost agricultural productivity*

The agreements with customers typically include agronomic support and partnerships to accelerate the development of POLY4 and educate farmers in its effective use. The company believes this approach will continue to showcase the efficient, effective, flexible and sustainable qualities of POLY4 across a wide range of crops and different geographies and climates. Already over 334 trials on 35 crops in 25 different countries have been established since 2012, all demonstrating that POLY4 works, blends well, releases its nutrients efficiently, can be easily spread and transported, and improves yields and soil conditions.

The future

The company is already 18 months into construction and expects to strike the first polyhalite in 2021, and then ramp up to an initial production level of 10 Mtpa by 2024. In the short term, Sirius intends to complete its stage 2 financing to finalise construction.

So while several challenges lie ahead for the company before it fully realises its vision of becoming a disruptive force in the fertilizer industry, it is well on track. With 5.7 Mtpa of take-or-pay supply agreements in the bag before an ounce has even been extracted, construction work is proceeding at pace. The global agricultural production is estimated to increase by 60% between 2010 and 2050 to meet population growth, and Sirius Minerals is confident that the company will play a key role in supporting a more sustainable agri-food system globally. ■

Finding harmony

within the chemistry-biology dichotomy

by **Holly Meadows-Smith**, Manager, Business Development, BioConsortia Inc., USA

As biologicals have garnered well deserved research, financial, and public attention in recent years. The expanding global population requires an increased food supply, produced on limited arable land at the lowest possible expense to the environment. A number of successful natural products have made strides onto wide-spread commercial acreage, thanks in part to support from traditional industry giants who have incorporated these new products into their own conventional treatment packages. BioConsortia, and many others in the biologics space, recognize the need to work with the chemical industry to develop compatible, synergistic solutions. This is not about replacing chemistry, rather making chemistry and biology work together to provide superior solutions for growers and consumers.

Chemical Industry

The agrochemical industry is on track to breach a valuation of USD250 bn by 2020. Despite a decline in global usage of over 8% last year, the agchem market remains the most vital input into agriculture. Continued growth is being driven in large part by developing areas, more recently incorporating technologies into their farm practices. Acquisitions and mergers between the top six players that dominate the space make for an uncertain future for the industry landscape. The USD130 bn Dow-DuPont merger is close to close, although recently delayed by DuPont's announcement that it will sell part of its crop protection business to FMC in hopes of appeasing the European Commission's concerns around the size of the union with Dow. The Syngenta-ChemChina deal is also awaiting regulatory approval and the potential Monsanto-Bayer team received positive indications from President Trump about their own consolidation.

> *"There is concern from growers around impending price increases*

There is reported concern from certain growers around impending price increases and fewer options as a result of these mega-mergers.

While the companies are promising bigger research spends and enhanced innovation, farmers fear reduced competition and profit-hungry deal-making. From another perspective, consumers have their own apprehensions toward the industry and have led the focus-shift toward sustainability and environmental consciousness that has been transforming agriculture for many years. Spurred by the Bayer CropScience acquisition of biopesticide company AgraQuest in 2008, the 'big-six' have now each made moves to support the incorporation of natural, sustainable products into commercial, mostly synthetic chemical, agricultural practice, either through their own research spend or by procuring smaller biological companies.

A more direct impediment to the traditional chemical industry comes from resistance issues, which have plagued both growers and suppliers for decades. Pests that have grown resistant to conventional pesticides have historically been combated with higher pesticide rates, alternative chemistries and genetic modification. More recently however, regulations are increasing, and development timeframes limit the speed of new chemical products to market. Resistance should ideally be managed before becoming an issue, through need-based pesticide application, chemistry rotation, and non-chemical alternatives. At the beginning of the year the EPA released an update of neonicitinoid use in the US. It estimated that 45-65% of US corn is treated with clothianidin annually and 26-45% is treated with thiamethoxan. Already the tens of thousands of US acreage treated with neonics was under scrutiny due to declines in the bee population but such high rates of wide-spread pesticide application could also be contributing to new pest-resistance.

BioConsortia CEO, Marcus Meadows-Smith, working with research team in laboratory, Davis, California

Over the years, the EPA has tried to respond to and guide these industry shifts by tightening regulations when necessary and creating space for innovative developments. Methyl bromide has been phased out and neonics are under current risk assessment. Non-chemical and non-GM alternatives benefit from less regulatory restriction and faster speed-to-market. Effective natural solutions, especially the microbial products, provide quick and crucial solutions to some of these resistance issues. Thereby, actually giving longer life on market and better efficacy to some of these threatened chemistries.

Biological Industry

The biologicals market has been increasingly growing for a number of years now. Estimated at over USD3 bn value in 2016, projections claim that by 2022 the biopesticide market will have reached USD8.8 bn. Biostimulants are also growing in acceptance, with a CAGR of over 10% through the same timeframe. Within the agricultural bioscience investment arena, biologics are prioritized over new chemicals, genetics, and seeds. Inside the industry itself, almost all major ag companies have a hand in the biologics game.

The major acquisitions and partnerships for biological companies of the past decade include Bayer-AgraQuest, Monsanto-Novozymes, BASF-Becker Underwood, DuPont-Taxon, Syngenta-Pasteuria, FMC-Chr Hansen, and Koch-Mendel-Pathway. These alliances alone make for over USD2 bn worth of direct investment into biological research programs, which were once considered largely 'snake-oil' by the industry giants. That said, the biocontrol market has persisted for many decades with certain technologies, such as Bt, coming to the top as commercial successes. Current successful SME players include AgBiome, Koppert, Marrone Bioinnovations, and hundreds more. The biostimulant space (with solutions that range from plant growth promotion to improved fertilizer use efficiency to abiotic stress tolerance) is less saturated, although growing in size, and is made up of companies such as Agrinos, BioConsortia, Indigo, Verdesian, and Valagro. It should be noted that many of these companies work in both areas.

New technologies

Technological advancement is one contributor to the growing success of biologicals, enhancing both the breadth and scope of research programs through lowered cost and superior methodologies. Techniques like microbiome analysis have become common-place in many research programs, as genome sequencing costs dropped dramatically, and the resolution of results became clearer. Big data and machine learning have become buzzwords throughout many industries but specifically within the biological space, companies like BioConsortia using microbiome data to help identify teams of microbes in superior performing plants or Trace Genomics who are able to precisely diagnose mutations and discover organisms based on genetic data that supports the development of yield-relevant solutions. Much of the technical progress can be attributed to industrial and pharmaceutical biotechnology – companies like DSM, Novozymes, and Chr Hansen were all focused in those areas originally. Some of these transferable advancements include characterization of microbial and natural product chemistry libraries, efficient metabolite screening, and physical assets for scaling-up and producing large volumes of fermentation-based solutions.

CRISPR-Cas9, a new gene-editing tool has recently stepped into the agricultural limelight. CRISPR allows for gene activation, as well as natural gene addition/deletion, through precise mutation of existing DNA. This year, Monsanto announced their license of the CRISPR-Cpf1 system, which offers even more flexibility to use the methodology across different crops and genes. The editing tool has already been incorporated into agricultural research. Although not technically a product of CRISPR, Cibus has released a non-transgenic, altered canola hybrid that is being sold to growers. SU Canola, as it is marketed, was developed by their Rapid Trait Development System and is bred for herbicide tolerance. The GM debate continues, and European growers remain barred from planting GM crops. As we have seen within the chemicals industry, biologicals and other natural solutions work as effective alternatives in these disputes.

> *"The industry needs to educate growers and reset expectations*

Coexistence

The biologics industry still faces many challenges that inhibit actual competition with the well-established and dominant ag-chemical world. Firstly, many biological products have different modes of action than their synthetic synonyms. For instance, pest control with a chemical oftentimes results in direct mortality of the bug. A microbial seed treatment for the same solution, on the other hand, may have no effect on the pest but could induce a response in the plant that allows it to protect itself against the attack. The industry needs to educate growers and reset their expectations or markers of success to help acceptance of biologics. Serious interest from the big players has placated some of this apprehension. More field data and additional effective products on the market will continue the task. Another challenge for natural solutions is consistency when compared to chemistries. Historically, microbial solutions have been considered efficacious if they show yield effects 50% of the time. This is improving, of course, and will continue to do so with advancements in R&D tools that allow researchers to better understand the mechanisms of biological effects. Additionally, continued investment into discovery and development will lead to high-quality, innovative new products. Certain organisms, while effective at improving plant stress resistance and yield, have a hard time surviving in volatile conditions. Formulation developments specific to microbial treatments will ensure that biological products are delivered to the seed or plant in an optimized form.

The best strategy for biologicals is to work side-by-side with synthetic solutions. A natural treatment that can provide growth benefits under a reduced chemical fertilizer program or a biological that brings benefit on top of a GM trait are both viable routes to market and potentially more acceptable from a grower's perspective. On a practical level, a biological treatment is not likely to be applied commercially to a bare seed. Chemical seed treatments are so widely used that compatibility with harsh treatments should be considered at the initiation of biological research programs. BioConsortia uses chemically treated seed throughout the discovery process in order to select for microbes that can survive in these conditions. Poncho/VOTiVO combines natural and chemical solutions and the BioAg Alliance's new Acceleron B-300 SAT does the same. Biologicals have great potential to improve crop survival, growth, and yield while limiting negative impacts on the environment. By working within the current system and together with current solutions, biologicals will deliver the most success to the industry. ■

BioConsortia
BioConsortia Inc. is developing effective microbial solutions that enhance plant phenotypes and increase crop yields. We are pioneering the use of directed selection in identifying teams of microbes - working like plant breeders and selecting plants based on targeted characteristics, then isolating the associated microbial community. Our proprietary Advanced Microbial Selection® (AMS) process enriches the crop microbiome, allowing us to identify organisms that influence the expression of beneficial traits in plants. We are currently focused on products for fertilizer use efficiency, growth improvement and both abiotic tolerance and biotic resistance, as commercial seed treatments, liquid in-furrow products and granule products for a range of crops.

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