Knowledge grows

Yara Fertilizer Industry Handbook

October 2018

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Yara Fertilizer Industry Handbook

This handbook describes the fertilizer industry and in particular the nitrogen part which is the most relevant for Yara.

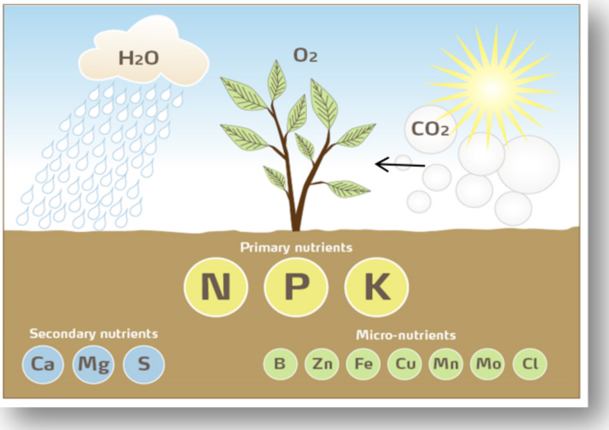
The document does not describe Yara or its strategies to a great extent. For more information on Yara-specific issues please see Yara's quarterly and Capital Markets Day presentations.

Fertilizers are essential plant nutrients that are applied to a crop to achieve optimal yield and quality. The following slides describe the value and characteristics of fertilizers in modern food production.

What is fertilizer?

Fertilizers are plant nutrients, required for crops to grow

- Crops need energy (light) CO_2, water and minerals to grow
- The carbon in crops originates from CO_2 absorbed through the leaves
- Crops absorb water and plant nutrients from the soil
- Plant nutrients are building blocks of crop material. Without nutrients the crops can not grow
- Mineral fertilizers provide plant nutrients for crops
- Three main nutrients: Nitrogen, Phosphorus and Potassium are primary nutrients



Three main nutrients: Nitrogen, Phosphorus and Potassium

- Nitrogen (N), the main constituent of proteins, is essential for growth and development in plants. Supply of nitrogen determines a plant's growth, vigour, colour and yield
- Phosphorus (P) is vital for adequate root development and helps the plant resist drought. Phosphorus is also important for plant growth and development, such as the ripening of seed and fruit
- Potassium (K) is central to the photosynthesis of crops. Potassium helps improve crop quality and crop resistance to lodging, disease and drought.

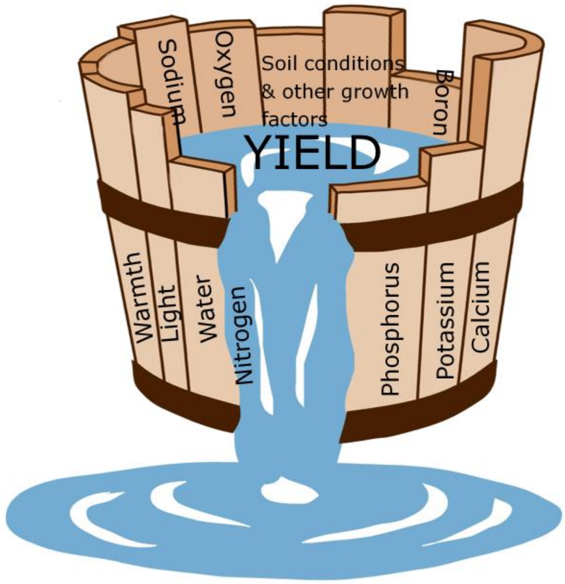
In addition, the secondary nutrients sulphur, magnesium and calcium are required for optimum crop growth.

- Sulphur is especially important in the initial growth stages, to produce essential amino acids, proteins, and oils
- Magnesium is needed for photosynthesis, converting light into chemical energy for nutritional purposes
- Calcium is particularly important for the yield, quality and shelf life of fruit and vegetables

Each plant nutrient has unique physiological functions which cannot be replaced by any other nutrient.

Principle of crop nutrition: crop growth is limited by the most deficient nutrient

- Law of the Minimum" (Liebig, 1843): "Crop yields are proportional to the amount of the most limiting nutrient."
- Plant nutrients have specific and essential functions in crop metabolisms
- They cannot replace each other, and lack of any one nutrient limits crop growth
- It is therefore essential to focus on a balanced nutrition of all plant nutrients



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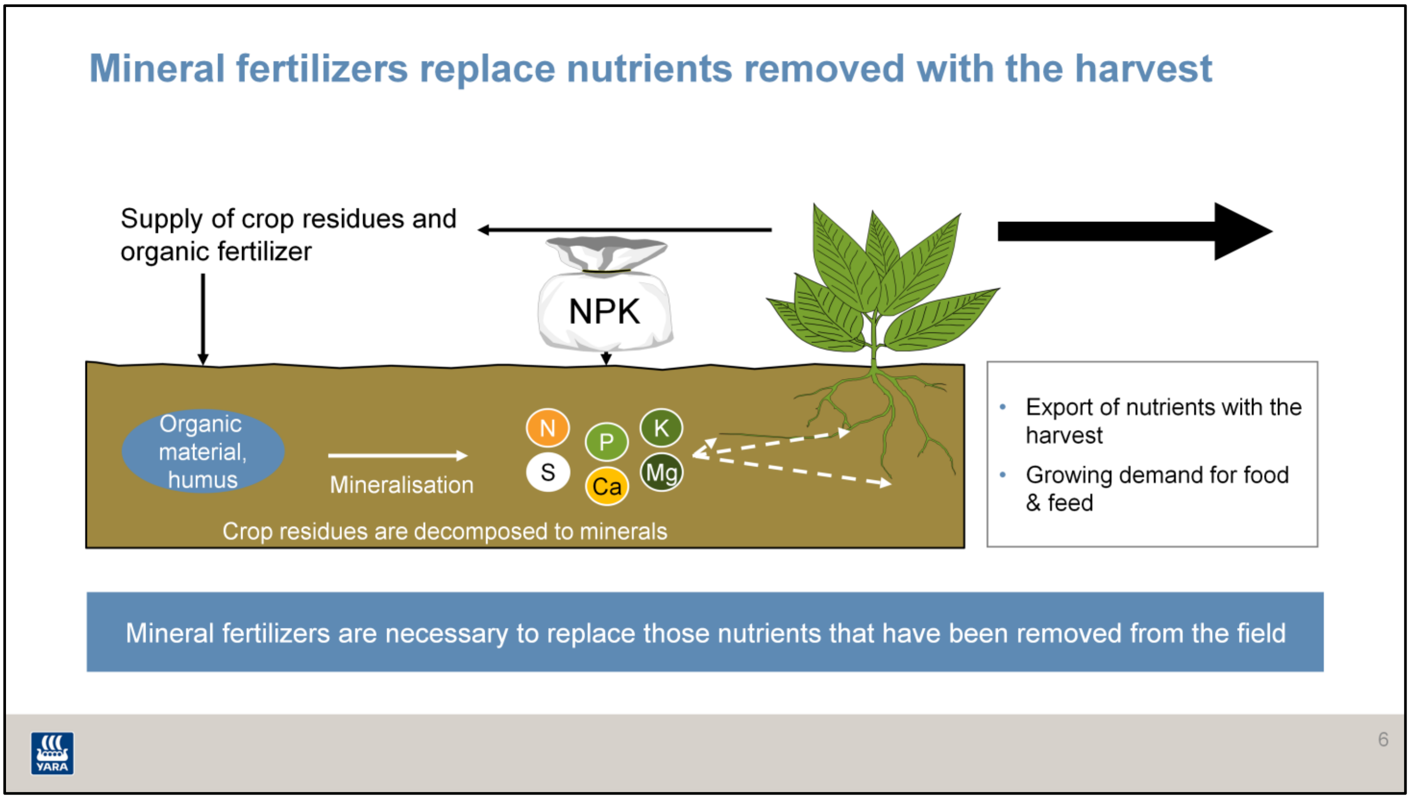
The law of minimum

The 'law of minimum' is often illustrated with a water barrel, with staves of different lengths. The barrel`s capacity to hold water is determined by the shortest stave. Similarly, crop yields are frequently limited by shortages of nutrients or water. Once the limiting factor (constraint) has been corrected, yield will increase until the next limiting factor is encountered.

Nutrients are classified into three sub-groups based on plant growth needs:
• Macro or primary nutrients: nitrogen (N), phosphorus (P), potassium (K)
• Major or secondary nutrients: calcium (Ca), magnesium (Mg) and sulphur (S)
• Micro nutrients or trace elements: Chlorine (Cl), Iron (Fe), Manganese (Mn), boron (B), selenium (Se), zinc (Zn), copper (Cu), molybdenum (Mo) etc.

Yield responses to nitrogen are frequently observed, as nitrogen is often the most limiting factor to crop production, but not the only factor. Balanced nutrition of all plant nutrients is required to obtain maximum yield and avoid shortages of nutrients.

Why mineral fertilizer?



Nutrients are depleted with the harvest

As crops take up nutrients from the soil, a substantial proportion of these nutrients are removed from the field when the crops are harvested. While some nutrients can be returned to the field through crop residues and other organic matter, this alone cannot provide optimum fertilization and crop yields over time.

Mineral fertilizers can provide an optimal nutrient balance, tailored to the demands of the specific crop, soil and climate conditions, maximising crop yield and quality whilst also minimizing environmental impacts.

Mineral fertilizer characteristics compared to organic fertilizer

Characteristics	Mineral fertilizer	Organic fertilizer
Nutrient source	Nitrogen from the air, Phosphate and Potassium from deposits / mines	Crop residues and animal manures
Nutrient concentration	High nutrient concentration Low logistical cost	Low nutrient concentration Large volumes to transport and store
Nutrient availability	Immediately available for the crop	Variable, organic material needs to be decomposed to release nutrients
Quality	Traceable and consistent	Often inconsistent Dependent on source

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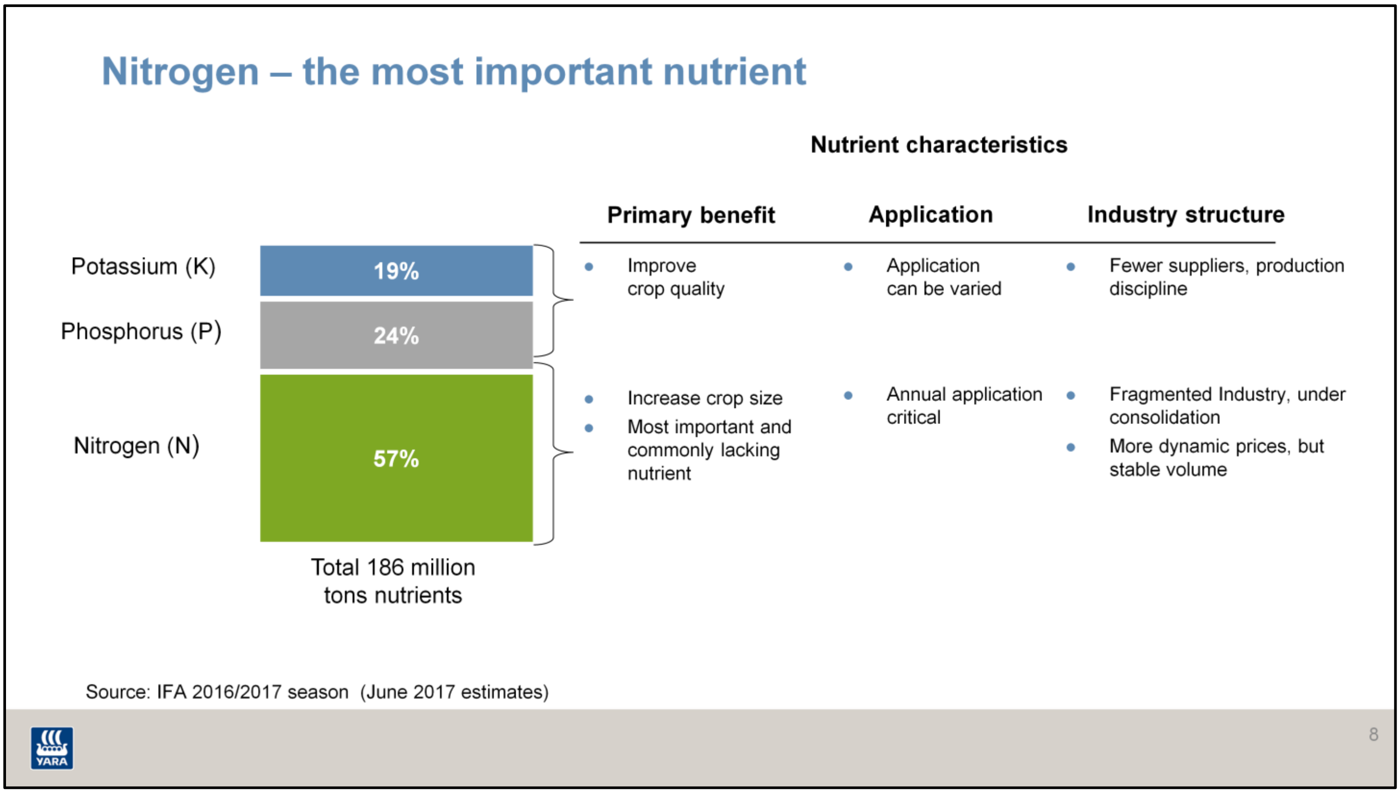
Organic fertilizer supply the same inorganic molecules to crops as mineral fertilizer

Crops can be fed with mineral or organic fertilizers (manure), and in both cases the crop will utilize the same inorganic molecules. A complete nutrient program must take into account soil reserves, use of manure or fertilizers, and an accurate supplement of mineral fertilizers.

Organic fertilizers contribute to build up the organic content of soil and at the same time support beneficial micro flora (e.g. bacteria) to grow on plant roots. The efficiency of organic fertilizer is dependent on the bacteria content in the soil. Bacteria decompose the organic content in manure and supply the minerals as nutrients for plant growth. But the quality and quantity of nutrient supplied to plants via this process is inconsistent and is very much dependent upon climatic factors. Plant productivity achieved by supplying only organic matter is low compared with mineral nutrients supplied in the form of fertilizers.

The separation of livestock and arable farming regions has led to nutrient distribution inefficiency, with a surplus in the animal farming regions. The low nutrient content and bulky nature of manure makes transportation inconvenient and costly.



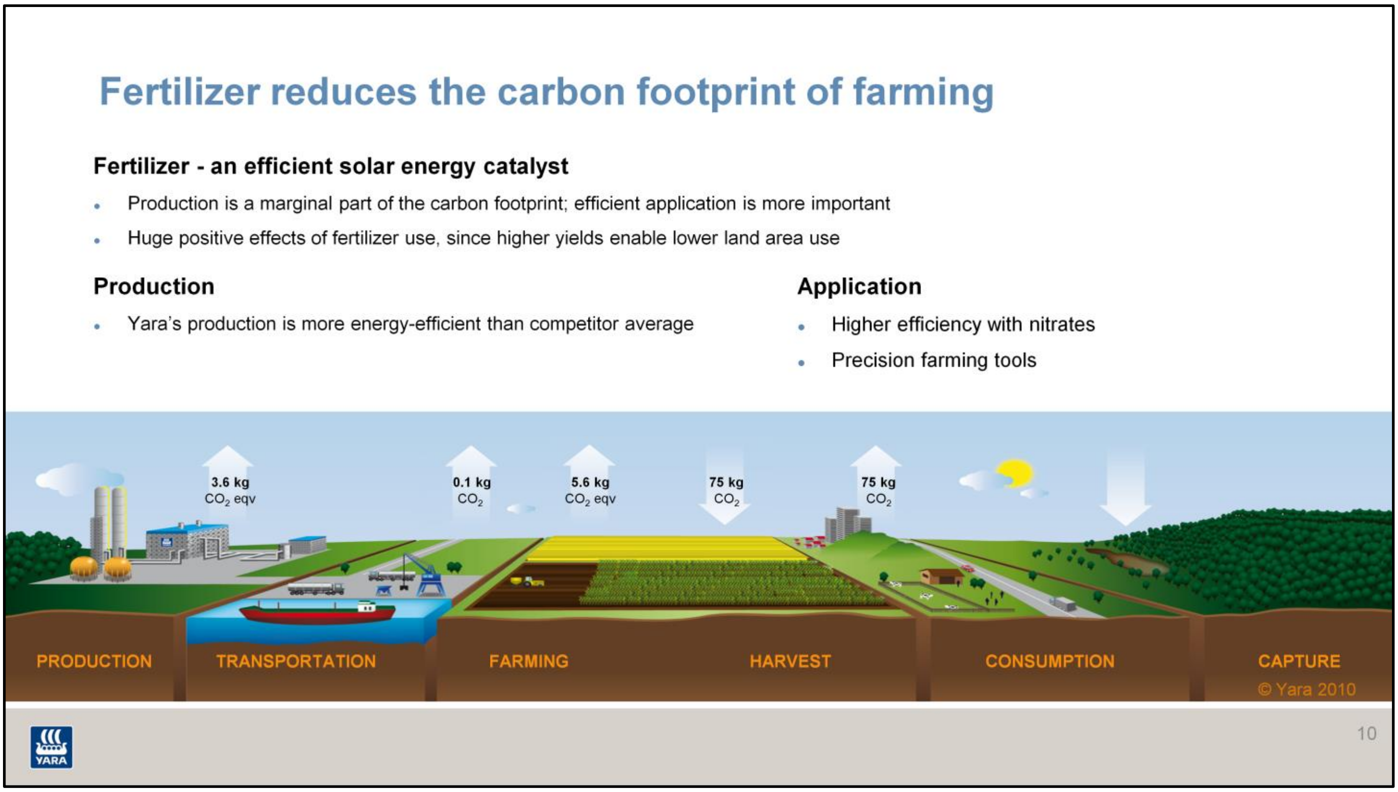
Among the plant nutrients, nitrogen is most important for higher crop yields

Nitrogen is the most important primary nutrient, accounting for 57% of total consumption, and Yara is the leading producer of this nutrient.

Phosphorus (phosphate) and potassium fertilizers are primarily applied to improve crop quality. Annual application is not always needed, as the soil absorbs and stores these two nutrients for a longer period compared with nitrogen. Nitrogen must be applied every year to maintain yield and biomass.

Phosphate and potash fertilizers are supplied by a small number of large industry players, as phosphate rock and potash mineral deposits are only available in certain regions of the world, while Nitrogen fertilizers are produced in many countries, reflecting the wide availability of key raw materials - natural gas and air, needed for its production on an industrial scale. The global nitrogen market is therefore less consolidated, but some regions such as Europe and the US have seen significant restructuring of their nitrogen industries in the last decade.

Environmental impact of fertilizer



A life-cycle perspective on fertilizer is important

Life-cycle analysis of fertilizers determines the greenhouse gas emissions and absorptions in fertilizer production, transportation and storage, as well as during application and crop growth.

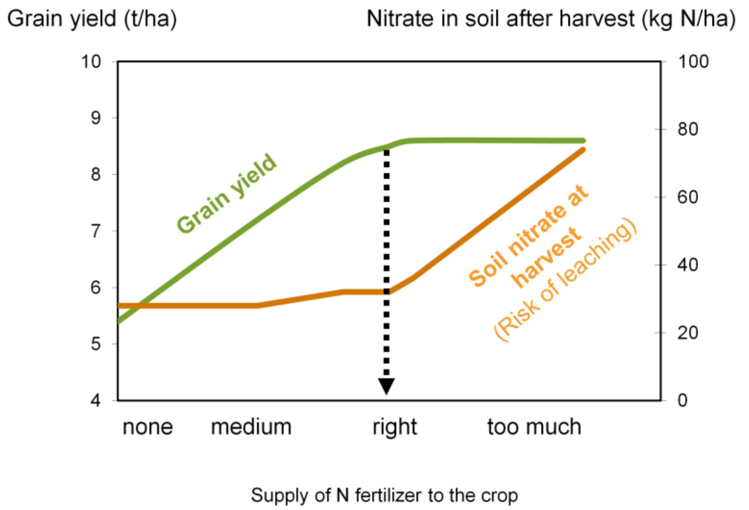
When new acreage is converted to cropland, above ground carbon is immediately removed, whereas carbon stored in the ground will leak out more gradually and is converted to CO_2.

With the ambition to minimize total carbon footprint from global biomass production, efficient use of land, based on modern agricultural practices, is of great importance. Intensive farming with high yields contributes to preserve forests, which are the real "carbon sinks". Organic farming with low yields tends to increase deforestation and emissions.

Different fertilizer types have different carbon footprints. Urea emits less CO_2 during production than nitrates, but upon spreading the situation is reversed since urea releases the CO_2 contained in its molecule. Urea also often releases more N_2O during farming. The life cycle carbon footprint is therefore higher for urea than for nitrates.

The right nitrogen fertilizer rate is key to avoid nitrate leaching

- Leaching of nitrate into groundwater affects water quality and contributes to eutrophication
- Oversupply of organic and mineral nitrogen fertilizer represents the main driver for nitrate leaching
- Nitrogen fertilizer application according to crop demand does not increase nitrate leaching



Soil nitrate content at harvest is a measure for the risk of nitrate leaching. This relationship has been confirmed in numerous trials and measurements.

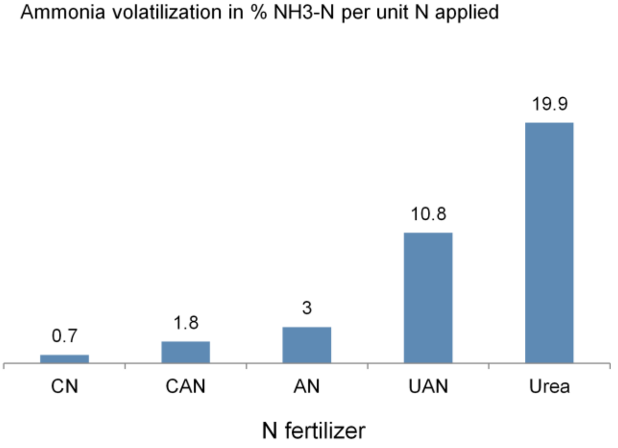
Elevated nitrate concentrations in ground and surface water are undesirable. Nitrate leaching occurs when the soil is saturated with water and nitrate is washed below the root zone by percolating rainfall or irrigation.

Nitrate leaching is independent from the source of nitrogen, it can be caused by mineral fertilizer, organic manure or even soil organic matter. Most loss of nitrate to water occurs during winter.

The overall objective is therefore to minimize soil nitrate concentrations at the end of the vegetation period. Nitrogen leaching can be effectively avoided through well managed fertilization practices, e.g. by using fertilizer with a quick, predictable nitrogen release, such as nitrates.

Choosing the right nitrogen fertilizer to avoid ammonia volatilization losses

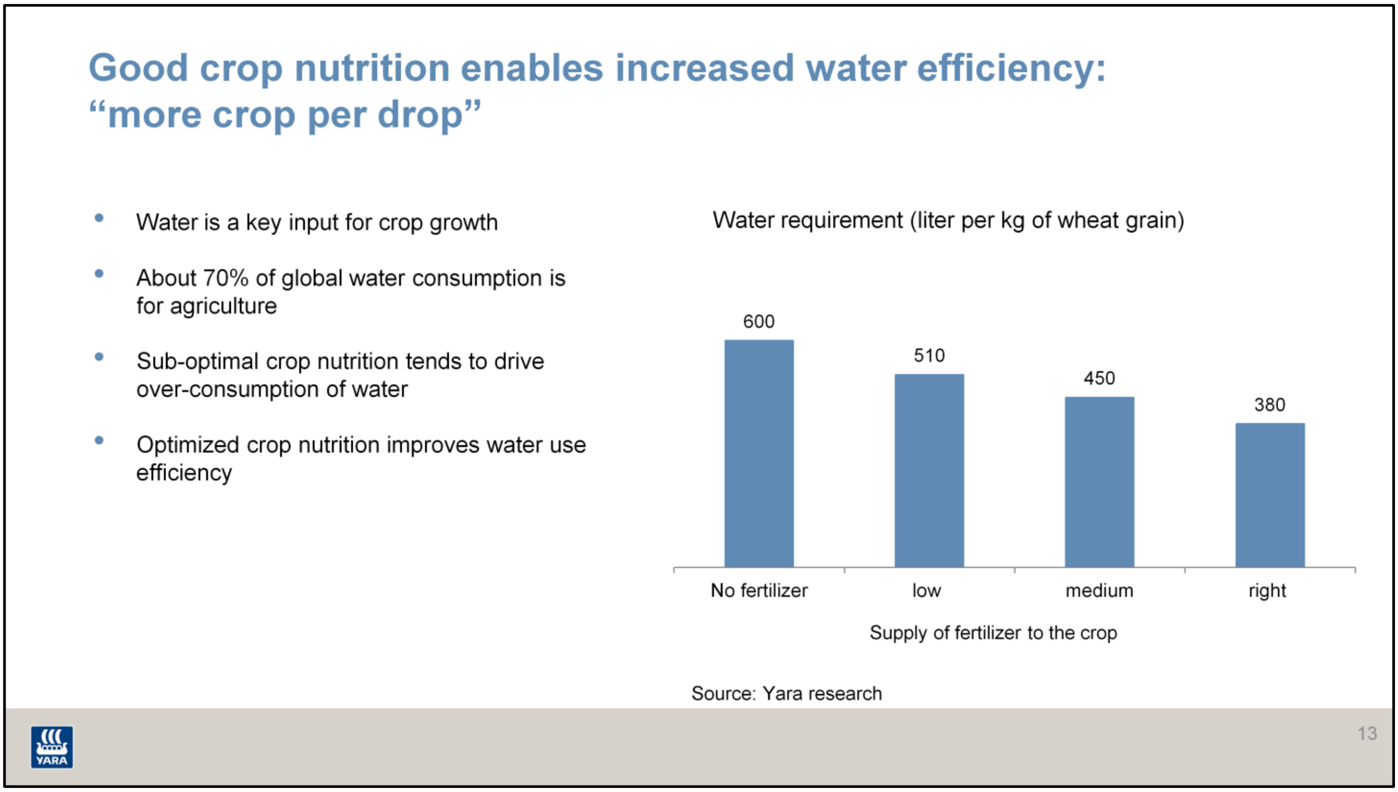
- Volatilization of ammonia gas contributes to pollution, affects air quality and induces soil acidification
- The use of organic or urea-based nitrogen fertilizer represents the main driver for ammonia losses
- Nitrate-based N fertilizer or immediate incorporation of urea into the soil avoids volatilization losses



Reference: EMEP/EEA emission inventory guidebook 2013

Ammonia can be lost upon spreading of fertilizers

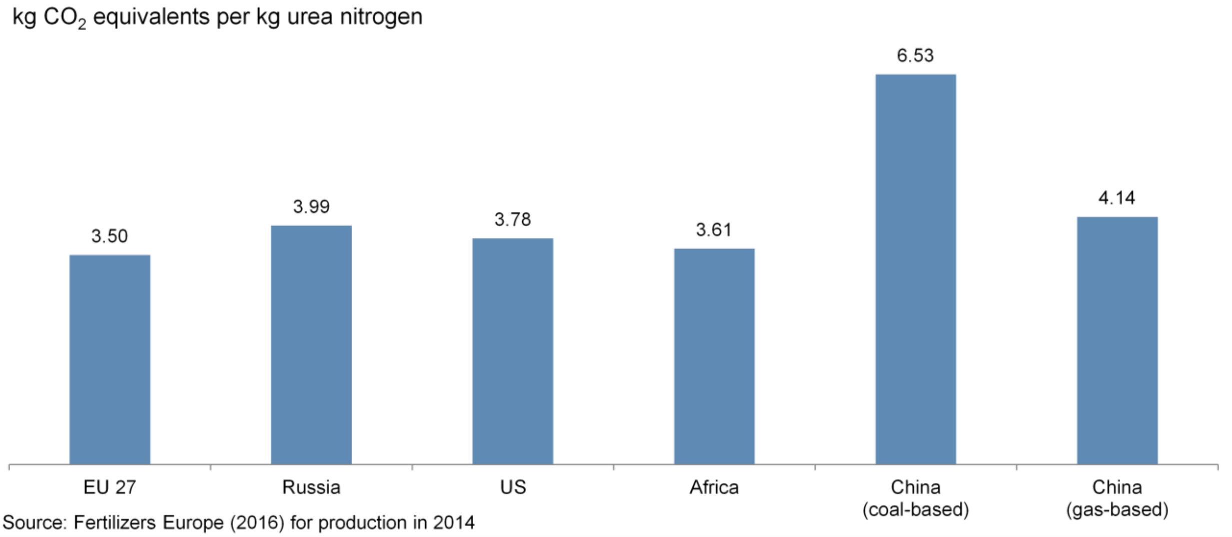
Ammonia volatilization occurs when ammonium is converted to ammonia and lost to the atmosphere. A high soil pH level increases conversion of ammonium to ammonia, and the losses are highest if conversion takes place at the soil surface. These two conditions are met when urea is spread and not immediately incorporated to the soil. Urea and UAN cause higher volatilization losses than nitrate-based fertilizer.



Increased water scarcity drives demand for new agricultural solutions

A steadily increasing population and food consumption continues to be the main driver for agricultural water use. Today most of the water globally used in agriculture does not reach the crop, as water is lost during transportation, through evaporation, runoff, drainage and transpiration.

Carbon footprint of urea production differs by region



Source: Fertilizers Europe (2016) for production in 2014

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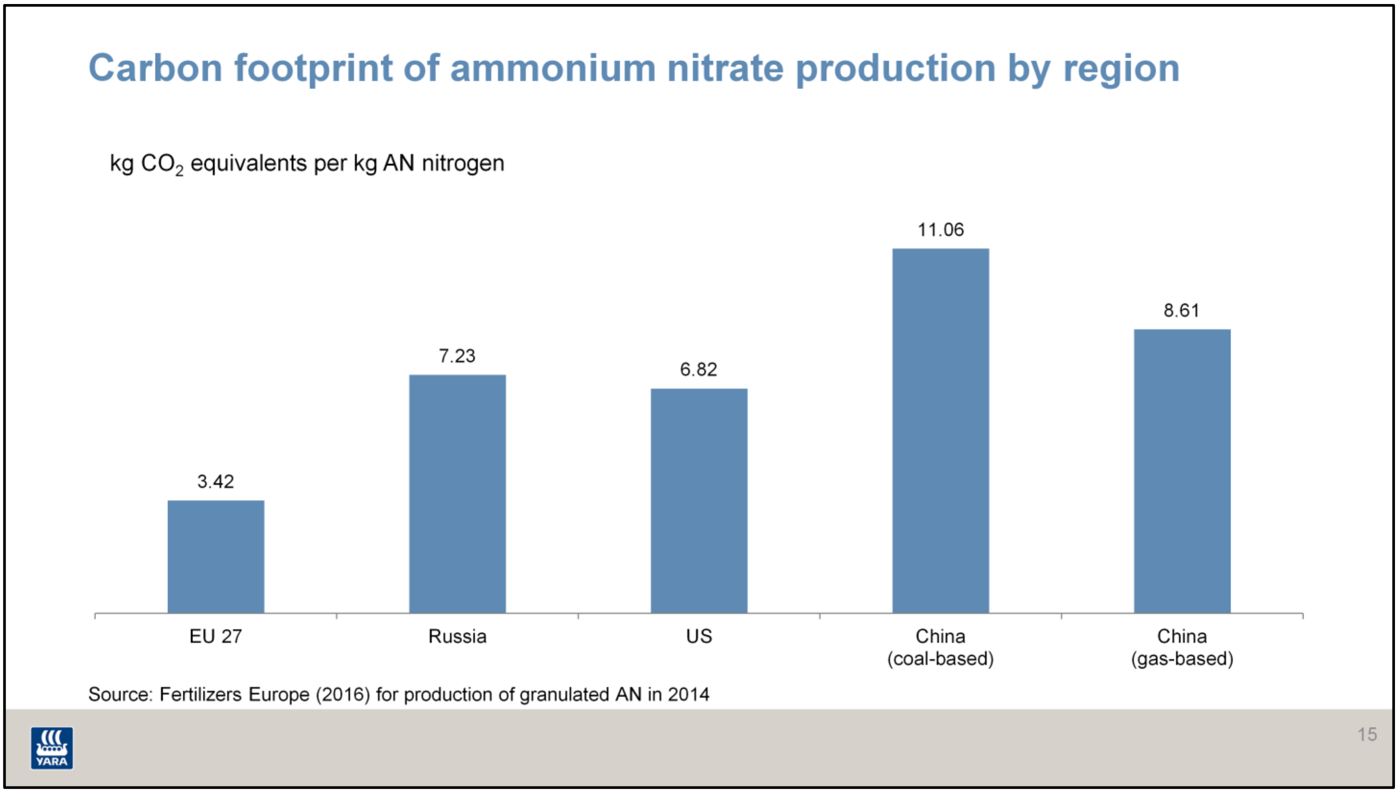
Nitrogen fertilizer production using coal-based ammonia almost doubles high greenhouse gas emissions per unit

The first and most energy-intensive step to produce urea is ammonia production. Ammonia producers in Western Europe have invested heavily in energy-efficient technology due to the historically high cost of energy in the region. According to Fertilizers Europe, several ammonia plants in Western Europe run on the lowest possible energy consumption levels given current technology, and have the lowest CO_2 emissions per ton of ammonia produced.

The Western European ammonia industry is on average more energy efficient than ammonia producers in other parts of the world. This is also driven by EU environmental regulations, which requires running plants at higher standards than elsewhere.

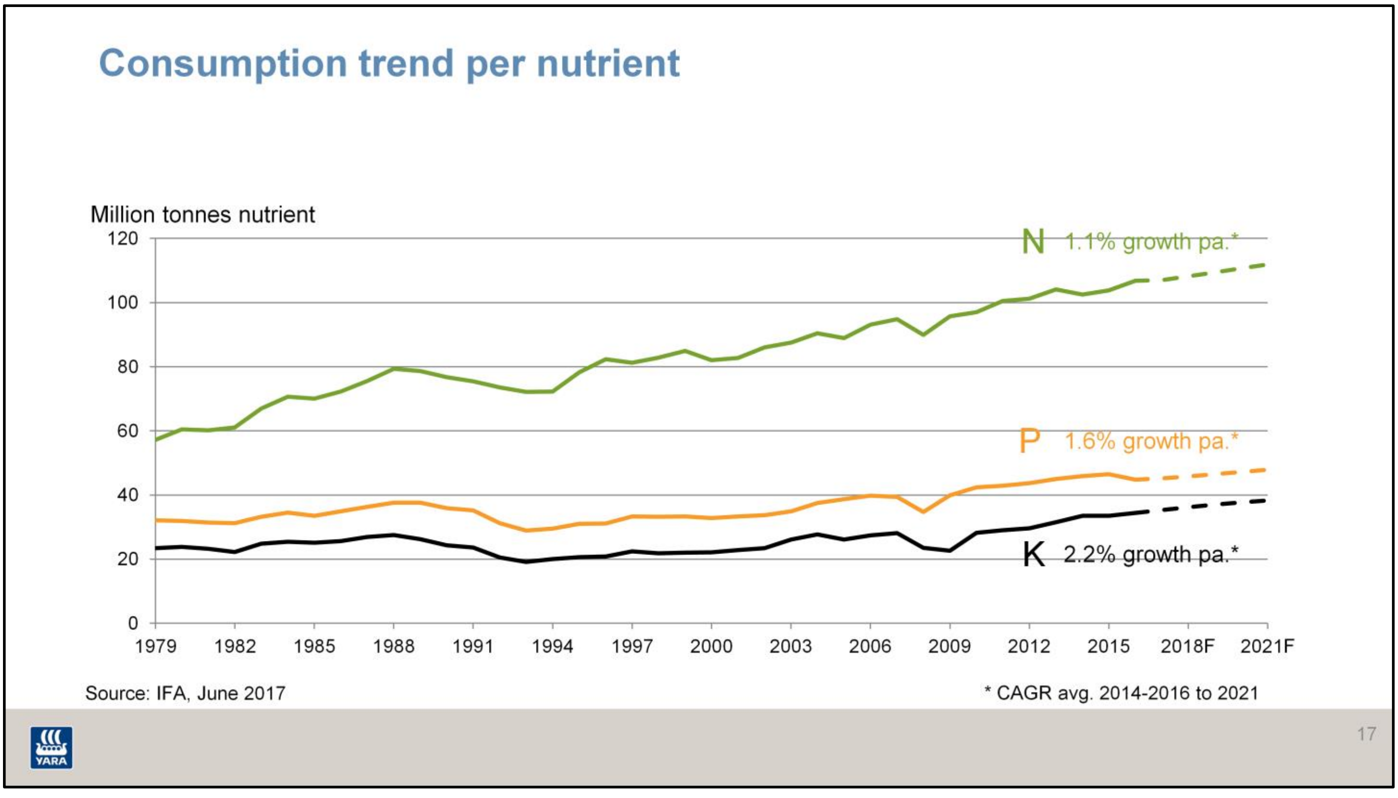


European nitrate production has the lowest greenhouse gas emissions globally

The carbon footprint of fertilizer is gaining increasing attention with the drive to reduce greenhouse gas emissions. In agricultural crop production nitrogen fertilizer use dominates the crop carbon footprint.

The European Fertilizer industry has upgraded its nitrate plants with catalysts that significantly reduce greenhouse gas emission (nitrox oxide = N_2O), enabling lower emissions than the best urea plants.

The fertilizer industry

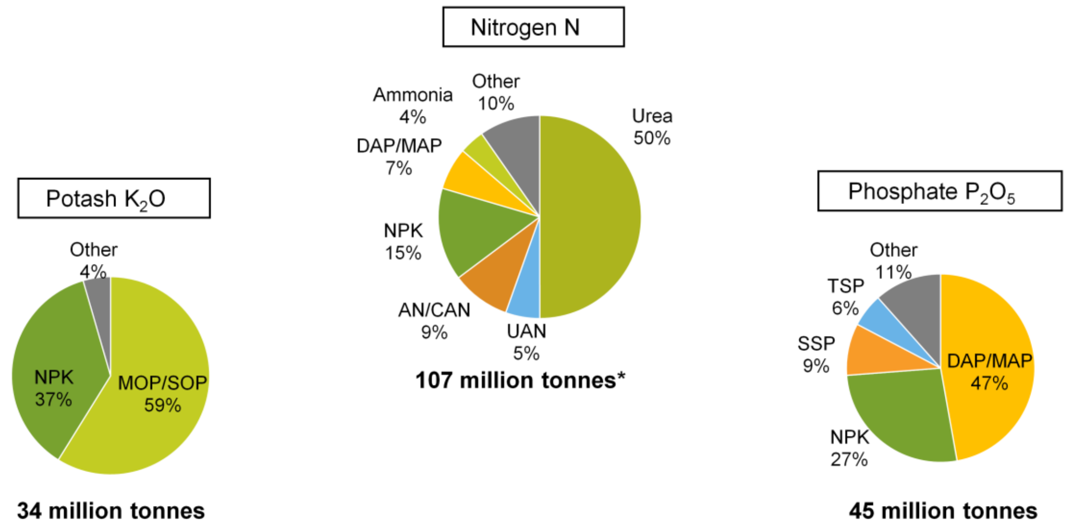


Nitrogen is the nutrient with highest consumption, with a projected annual growth rate of 1.1%

In 2016 nitrogen consumption increased by 2.4%, phosphate demand ended 4.5% higher, while potassium consumption increased by 2.5% compared to 2015. The average last 10-years' (2006-2016) consumption growth rates were 1.4% for nitrogen, 1.2% for phosphate and 2.3% for potassium.

Going forward, The International Fertilizer Association (IFA) forecasts nitrogen fertilizer demand growth at 1.1% per year through 2021. A growth rate of 1.6% a year is estimated for phosphate and 2.2% for potassium. A higher growth rate is forecasted for urea, since most new N-capacity additions are in the form of urea.

Key global fertilizer products



Source: IFA 2016 (nutrient totals) and 2015 (product split) * Does not include industrial nitrogen applications

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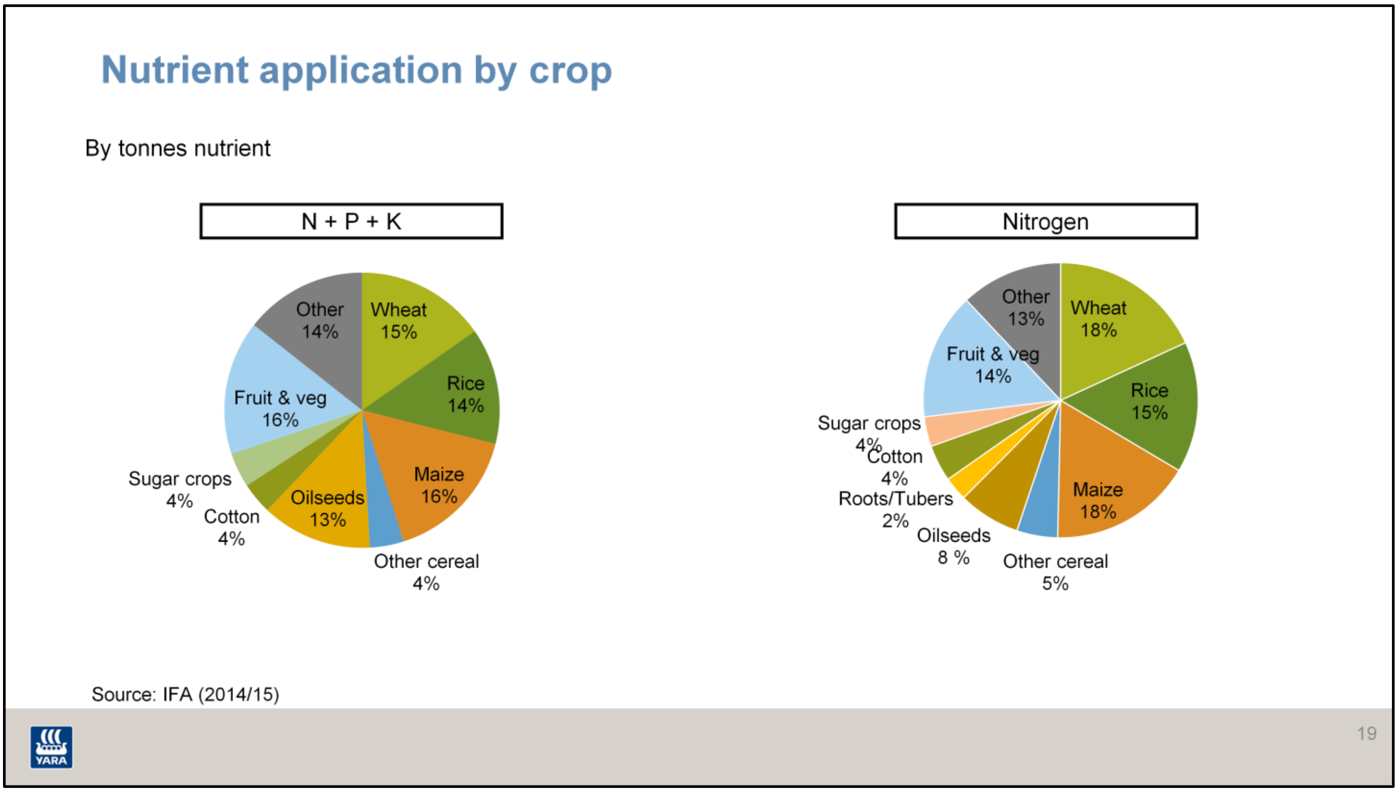
The key nitrogen, phosphate and potash products are urea, DAP and MOP respectively

Urea, DAP and MOP are the key products for respectively nitrogen, phosphorus and potassium fertilizer. They have a large market share and are widely traded around the world.

Urea contains 46% nitrogen, and its share of nitrogen consumption is increasing. The majority of new and pipeline nitrogen capacity in the world is in the form of urea.

Diammonium phosphate (DAP) contains 46% phosphate (measured in P_2O_5) and 18% nitrogen. Monammonium phosphate (MAP) contains 46% phosphate and 11% nitrogen.

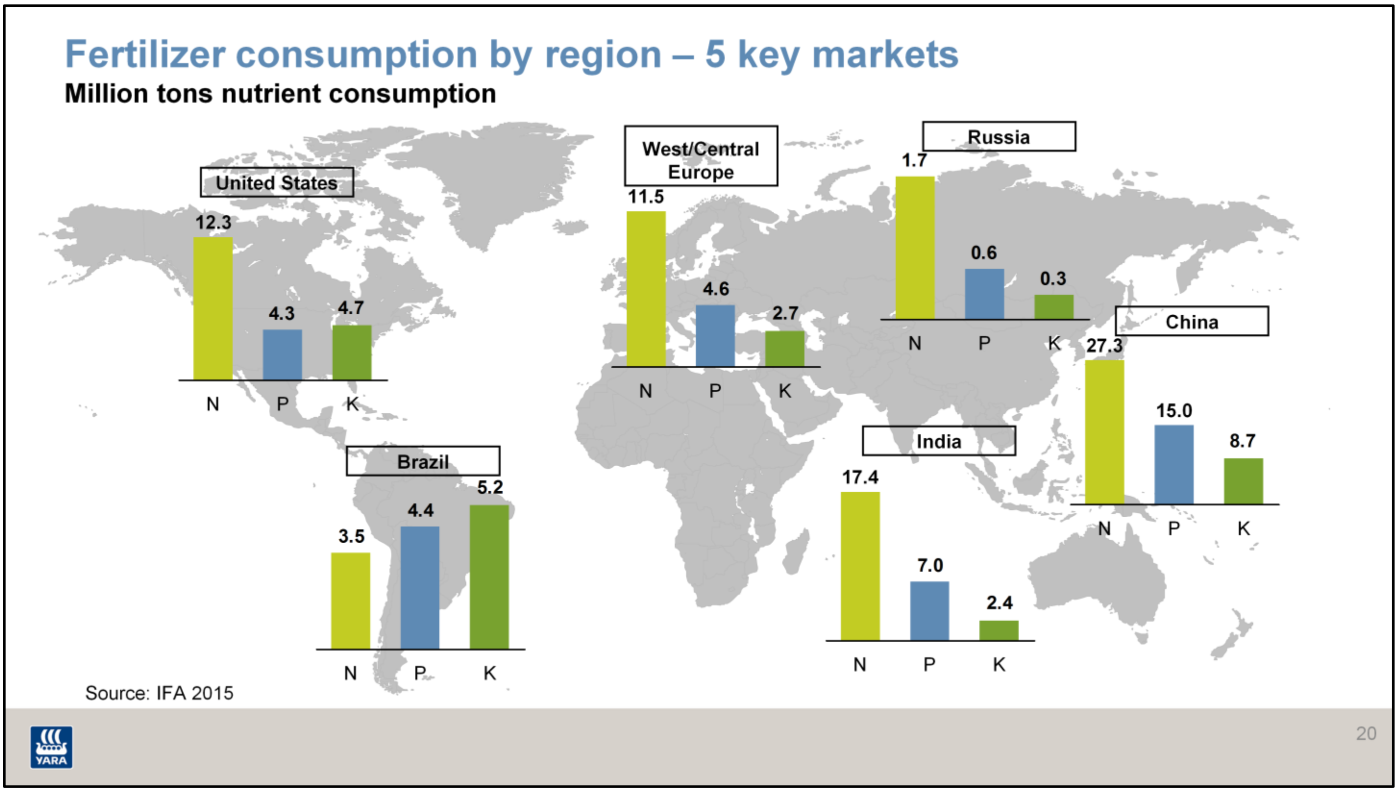
Potassium chloride (MOP) contains 60% potash, measured in K_2O.



The three main grain crops, wheat, rice and corn (maize), consume about half of all fertilizer globally

The fertilizer market is not only a significant market in terms of size, but also an essential industry serving global food production. Grain production is the largest agricultural activity, with global output estimated (USDA) at 2.61 billion tonnes for the 2017 harvest.

It would not be possible to achieve this scale of production without intensive agriculture and use of mineral fertilizers. Grains are the largest end-market for fertilizers followed by cash crops such as vegetables, fruit, flowers and vines. In order to gain a good understanding of the fertilizer market, it is necessary to analyse both the grain market and the market for cash crops.



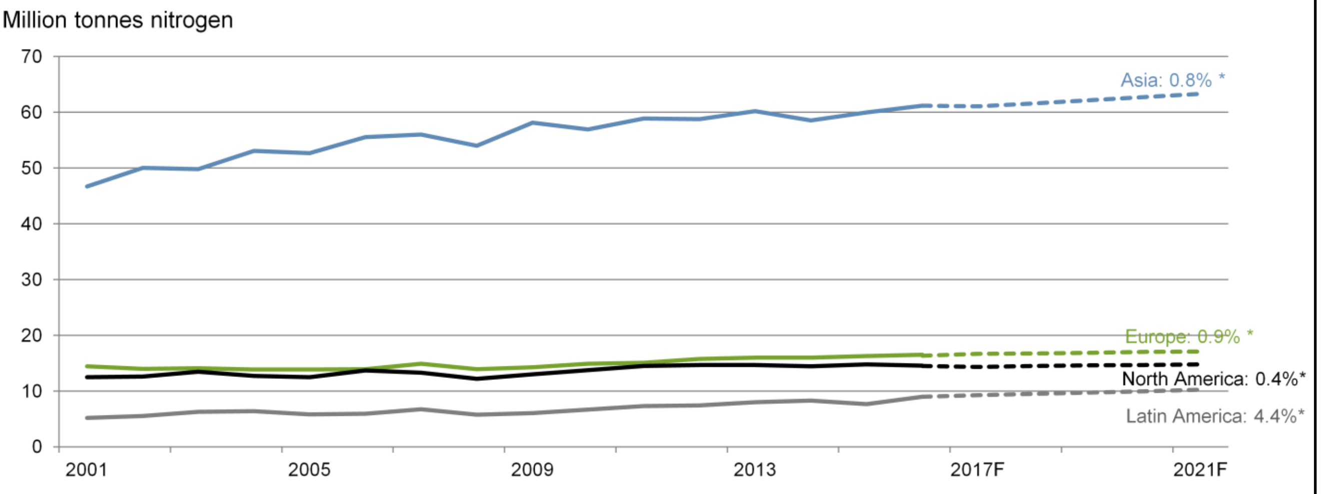
Geographical variances in fertilizer application

Fertilizer demand is influenced by the evolution of planted area and yields, the crop mix, crop prices and fertilizer-to-crop price ratios, fertilizer subsidy regimes, nutrient management regulations, nutrient recycling practices and innovation.

Nitrogen is by far the largest nutrient, accounting for almost 60% of total consumption.
Phosphorus (phosphate) and potassium fertilizers are primarily applied to improve crop quality. Annual application is not always needed, as the soil absorbs and stores these two nutrients for a longer period compared with nitrogen. Nitrogen must be applied every year to maintain yields and biomass.

Brazil consumes substantial amounts of phosphate and potash due to its significant soybean production.

Nitrogen consumption in key regions



Source: IFA, June 2017

* CAGR avg. 2014-2016 to 2021

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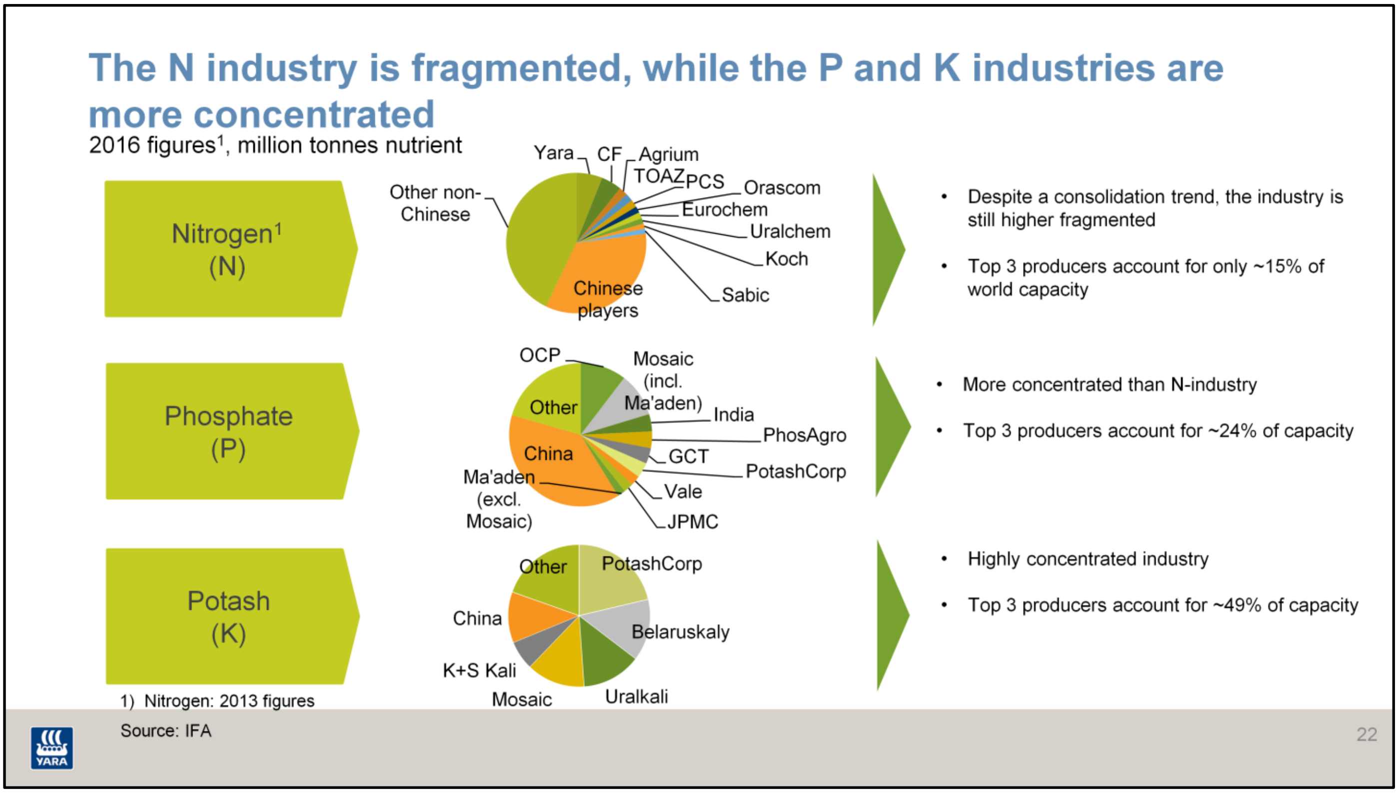
Asia is the largest fertilizer market, while Latin America has the highest growth rate

Asia’s share of global nitrogen consumption was 60% in 2016, with China representing approximately half of that share.

The highest growth rates going forward are expected to be seen in sub-regions with recovering agriculture such as Eastern Europe and Central Asia, and in regions with a large potential to increase agricultural production. Latin America falls into the latter category, and although it still accounts for a relatively small volume, the region is expected to keep its position as the region with the highest growth rate.

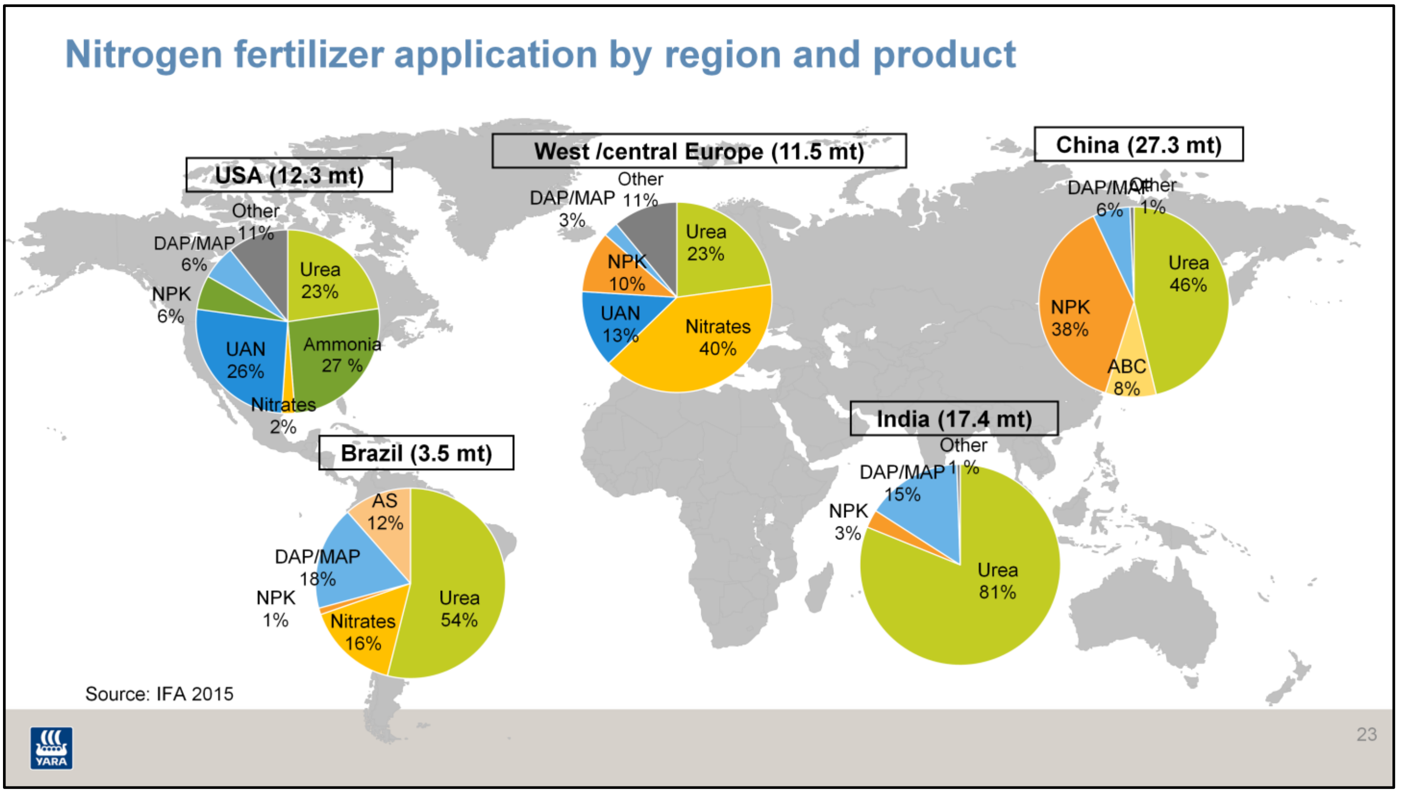
Consumption in mature markets like North America and West Europe is forecast to grow at a slower pace, while Chinese consumption is expected flat over the next years.



Nitrogen market is more fragmented than potash and phosphate markets

Nitrogen fertilizers are produced in many countries, reflecting the wide availability of key raw materials (natural gas and air) needed for production. The global nitrogen market is therefore less consolidated, but some regions such as Europe and the US have seen significant restructuring and consolidation in the last decade.

There are fewer large suppliers of phosphate and potash fertilizers, as phosphate rock and potash mineral deposits are only available in certain regions of the world. The potash industry is the most consolidated fertilizer industry.

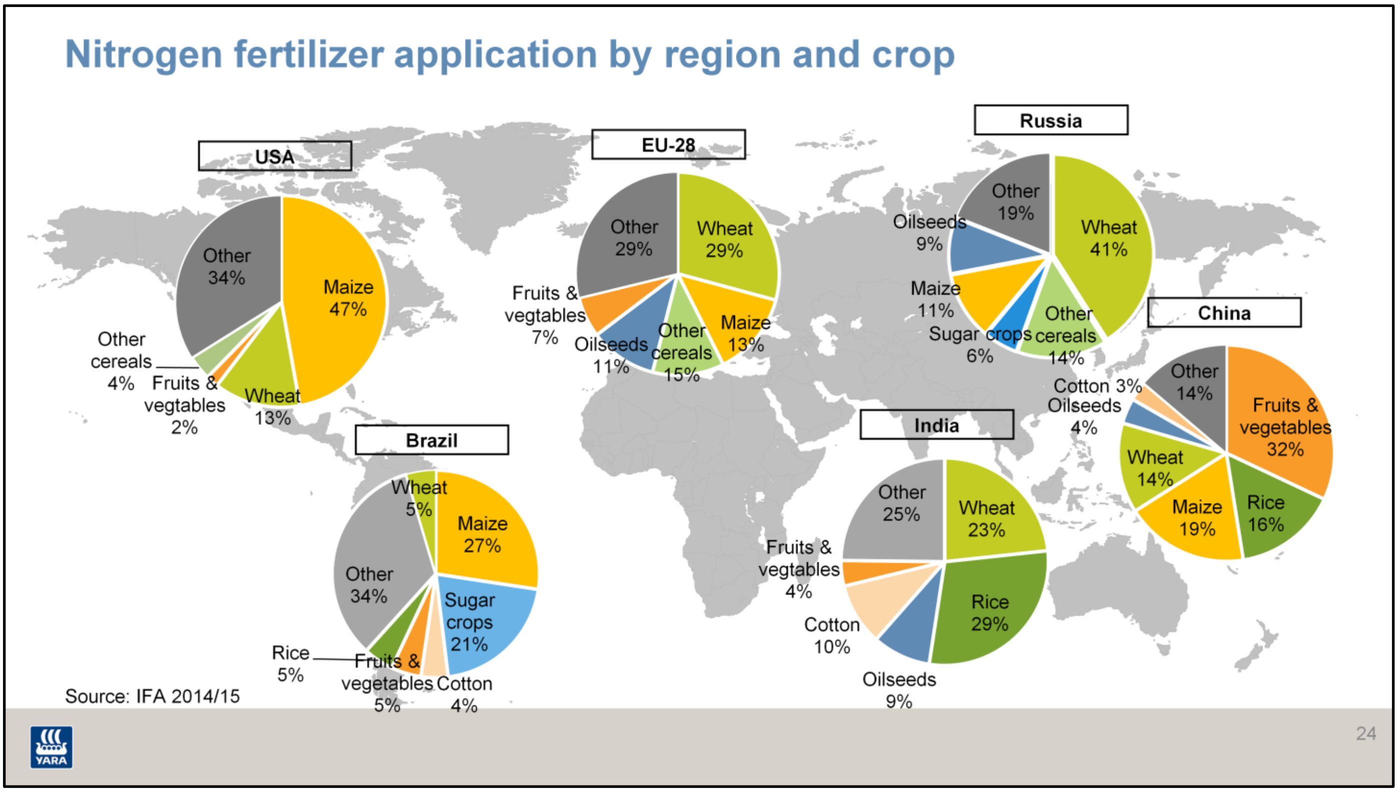


Geographical variances in nitrogen fertilizer product application

There are large variations in nitrogen fertilizer use in different regions and countries. Urea, the fastest growing nitrogen product, is popular in warmer climates. UAN is mainly used in North America, while nitrates are mainly used in Europe. In the US, ammonia is also used as a source of nitrogen in agriculture, especially for fall application.

In China, urea is dominant. China is also the only country that uses ammonium bicarbonate (ABC). Although this product is gradually being phased out, it still has approximately 8% market share in China.

Brazil consumes relatively more phosphate and potash compared with nitrogen, due to a large soybean production.



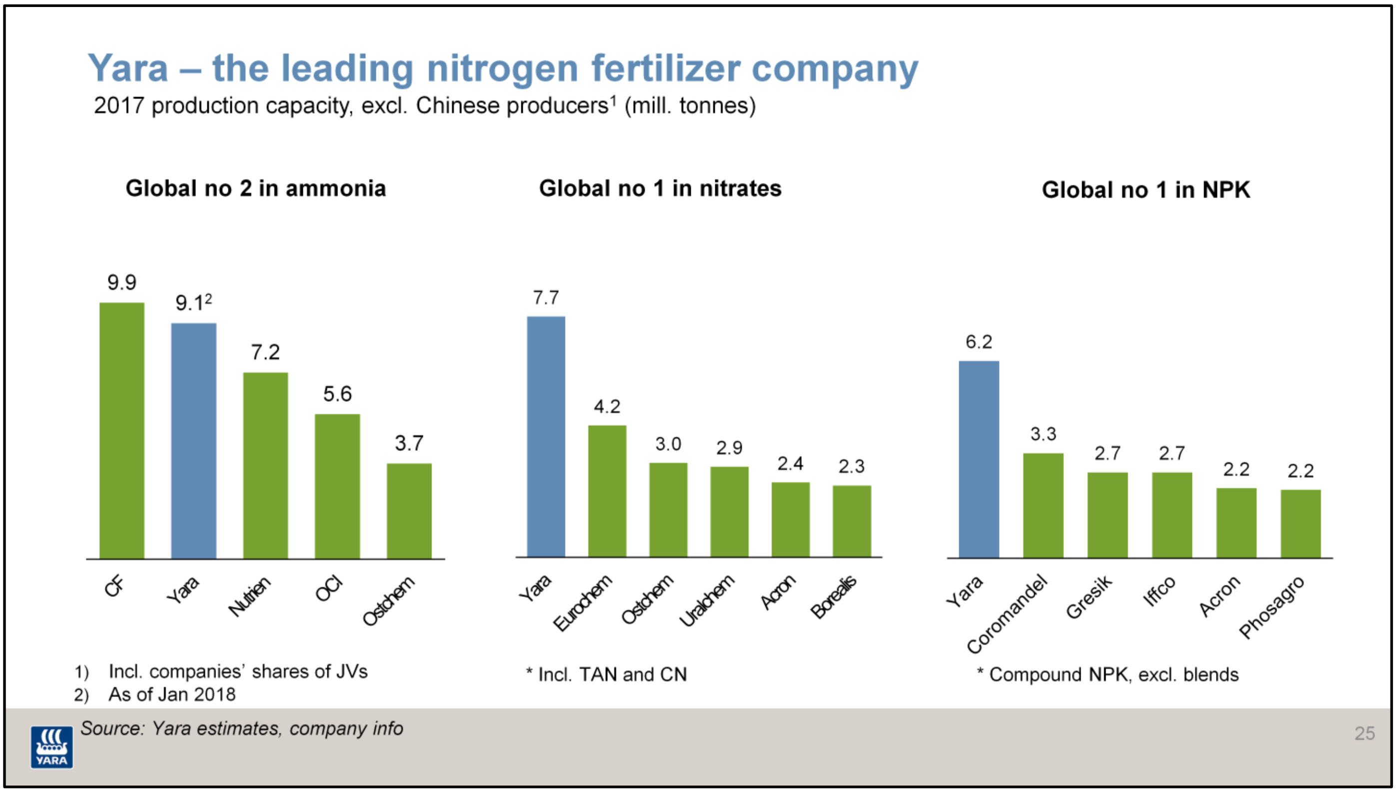
Geographical variances in nitrogen fertilizer crop application

There are large regional differences also in terms of crop demand for nitrogen fertilizer.

Due to strong growth in bioethanol production in the US in the last decade, corn has become by far the biggest nitrogen-consuming crop in the US. Wheat and other cereals like barley dominate in Europe and Russia, while inn Asia rice is a big nitrogen-consuming crop in addition to the fruits & vegetables segment in China.

These regional differences impact regional demand patterns as soft commodity prices develop differently and hence impact farmer economics and farmer incentives to apply fertilizer differently.

Yara's strong European presence means that wheat is a key crop exposure for its fertilizer sales.

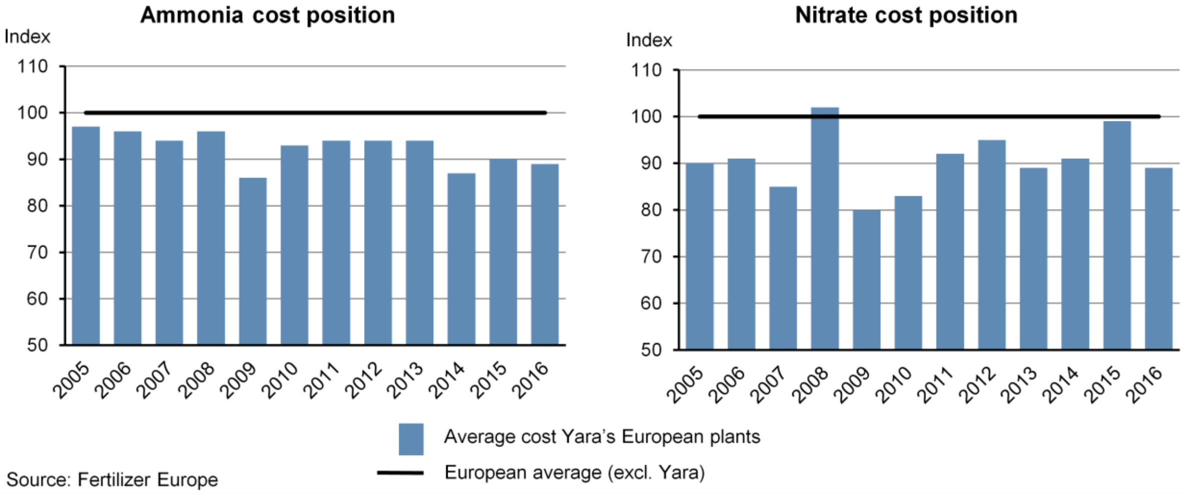


Yara is the global no. 1 producer of nitrates and NPK, and global no. 2 producer of ammonia

Yara's position gives it unique opportunities to leverage economies of scale and drive best practice across a large network of plants. Scale and global reach are key drivers for Yara's competitive edge.

Yara – the European cost leader

Production cost index: 100 = European industry average excl. Yara



Source: Fertilizer Europe

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Yara benefits from a favourable cost position in its European home market for nitrates and NPKs

Yara's strong cost position reflects both its long-term investments in energy efficiency, scale and competitive raw material contracts, including its move away from traditional oil-linked natural gas contracts to hub / spot gas exposure.

Yara's higher nitrate cost position in 2008 explained due to a legacy gas contract in Tertre (acquired in 2007 as part of Kemira GrowHow) which was revised during that year.

Yara is also the low-cost leader on NPK with production cost approximately 20% below its European competitors.

Ammonia

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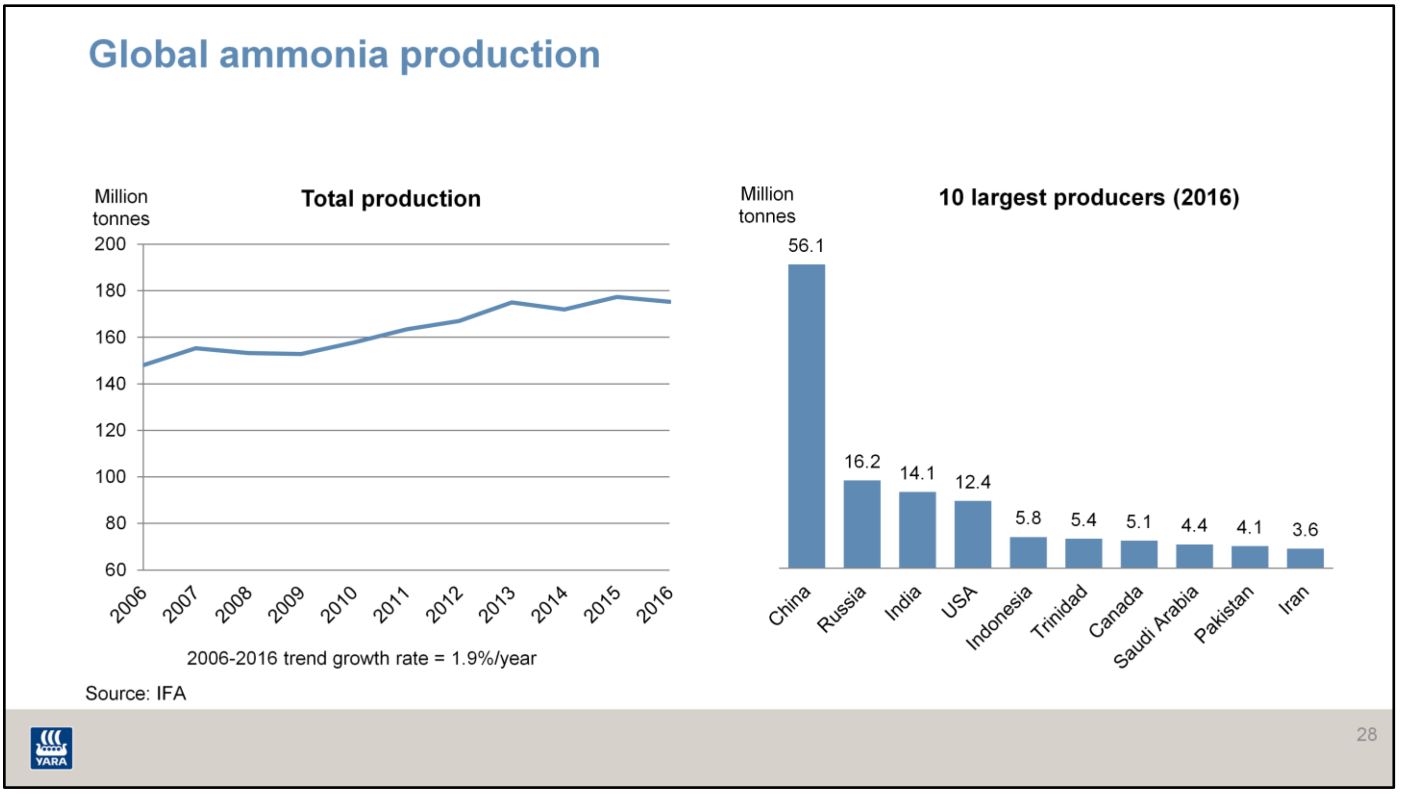


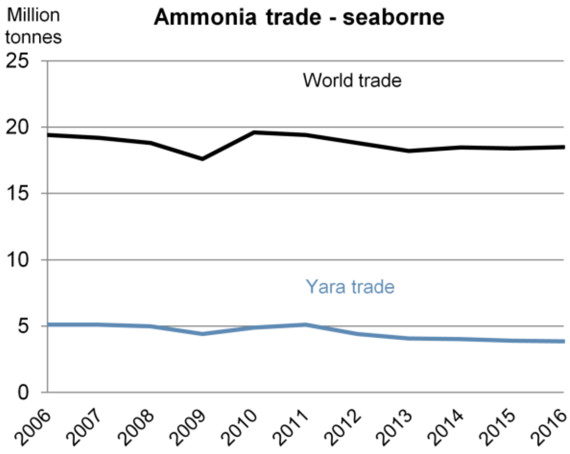
China is the largest ammonia producer

Ammonia is the key intermediate for all nitrogen fertilizer products and large nitrogen-consuming countries are also large producers of ammonia.

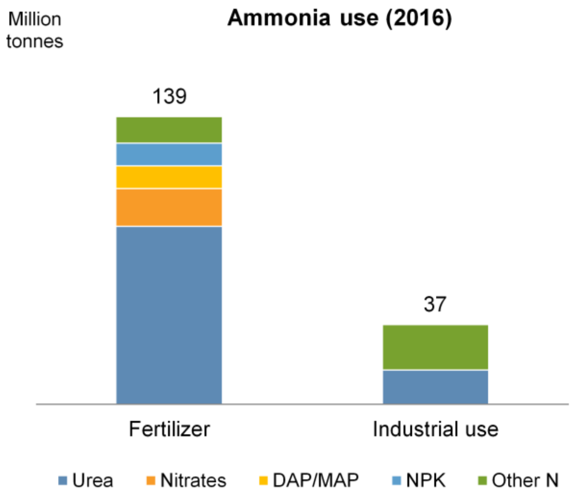
Ammonia is predominantly upgraded to other nitrogen products at its production site. Only 18.5 million tons or 11% of the ammonia produced globally in 2016 was traded.

Ammonia production reached 175 million tons, a decrease of 1.2% compared to 2015. The trend from 2006 to 2016 shows a growth rate of 1.9% per year.

Most of global ammonia production is upgraded to urea and other finished fertilizer



Source: Yara, IFA



Source: Fertecon

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Only 11% of ammonia production is traded

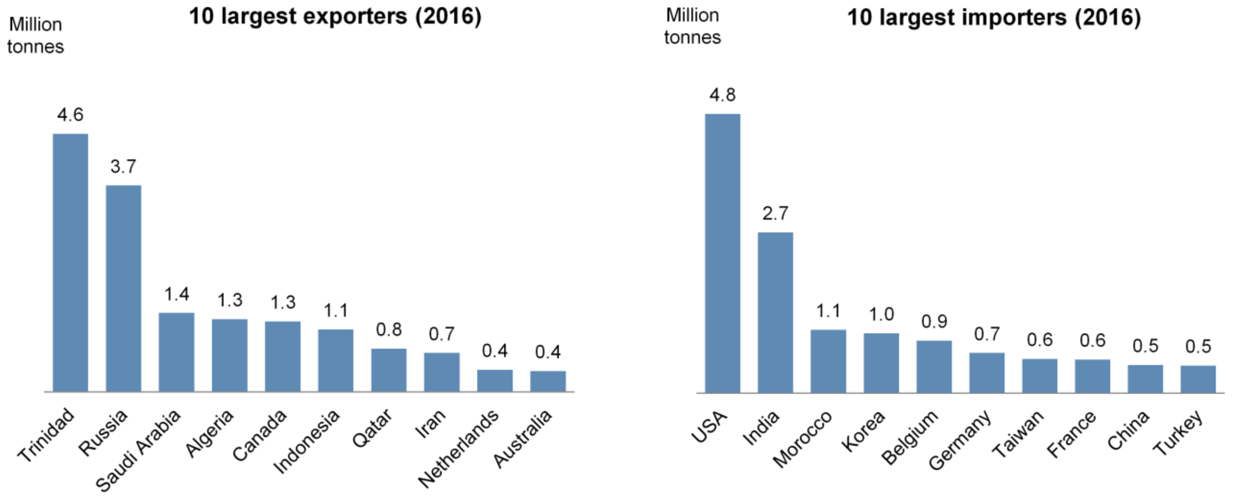
In 2016, world ammonia trade increased by 0.6% to 18.5 million tonnes, representing only 11% of world ammonia production. Urea production consumes 53% of all ammonia production. This ammonia needs to be upgraded on site as urea production requires CO_2 which is a by-product of ammonia production.

For traded ammonia, there are four main categories of customers:

1. There is a substantial industrial market for ammonia
2. Producers of the main phosphate fertilizers (DAP, MAP and some types of NPK) import ammonia, as the regions with phosphate reserves often lack nitrogen capacity
3. Some nitrate production capacity is also based on purchased ammonia.
4. Direct application on the field (only common in US)

Yara has a market share of around 20% of global ammonia trade. This leading position gives the company a good overview of the global supply / demand balance of ammonia and enables a better optimization of its global product flows.

Global ammonia trade



Source: IFA

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Trinidad is the world's largest ammonia exporter

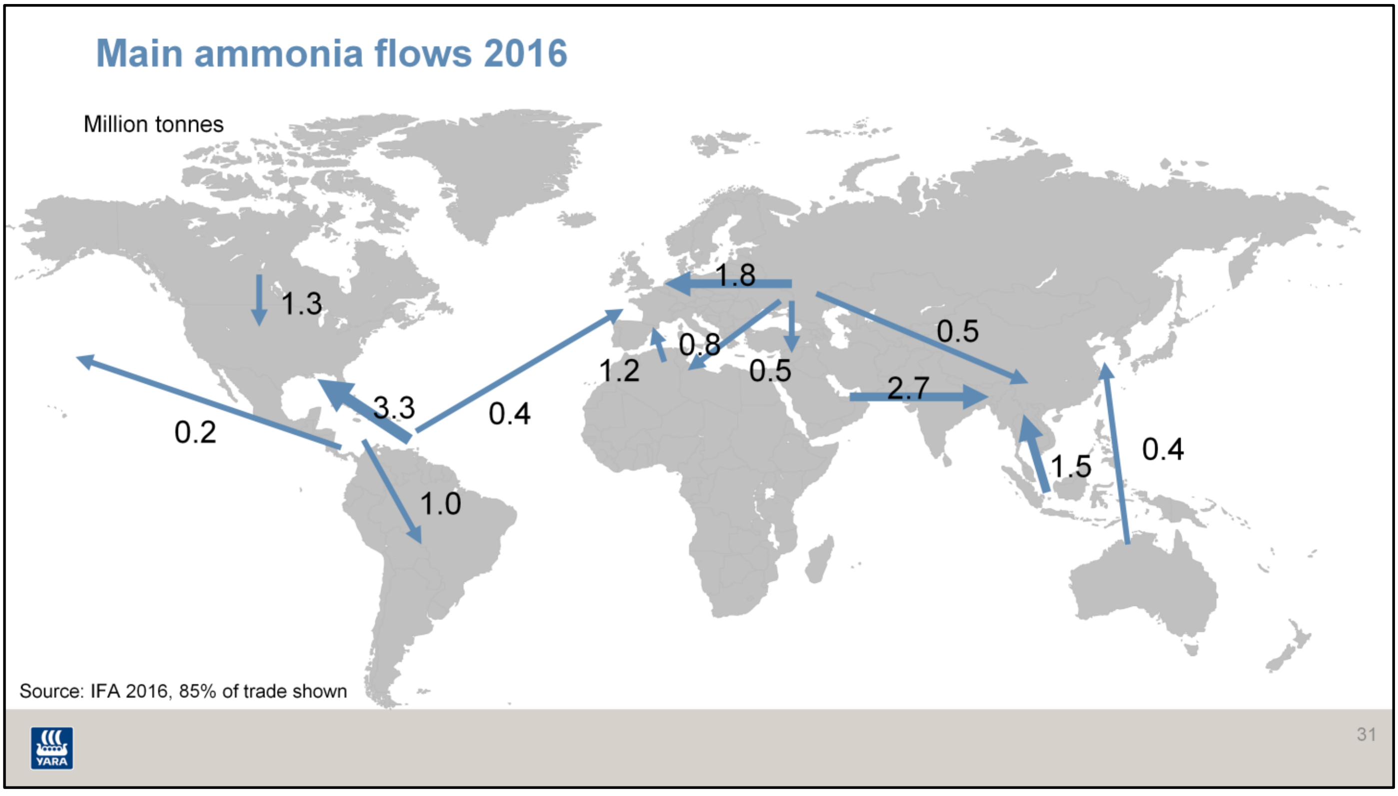
The large ammonia exporters in the world have access to competitively priced natural gas, the key raw material for its production.

Trinidad has large natural gas reserves and also lies in close proximity to the world's largest importer of ammonia, the US. Trinidad has large stand-alone ammonia plants and excellent maritime facilities that cater for export markets. Yara owns two large ammonia production facilities in Trinidad.

The Middle East also has some of the world's largest reserves of natural gas. The Qafco fertilizer complex in Qatar produces significant amounts of ammonia, but most of the ammonia produced in Qafco is upgraded to urea. Therefore, Qafco is a major exporter of urea and there is a relatively small surplus of ammonia left for exports.

In the US, imported ammonia is used for DAP/MAP production, for various industrial applications and directly as a nitrogen fertilizer.

India uses its imported ammonia mostly to produce DAP.

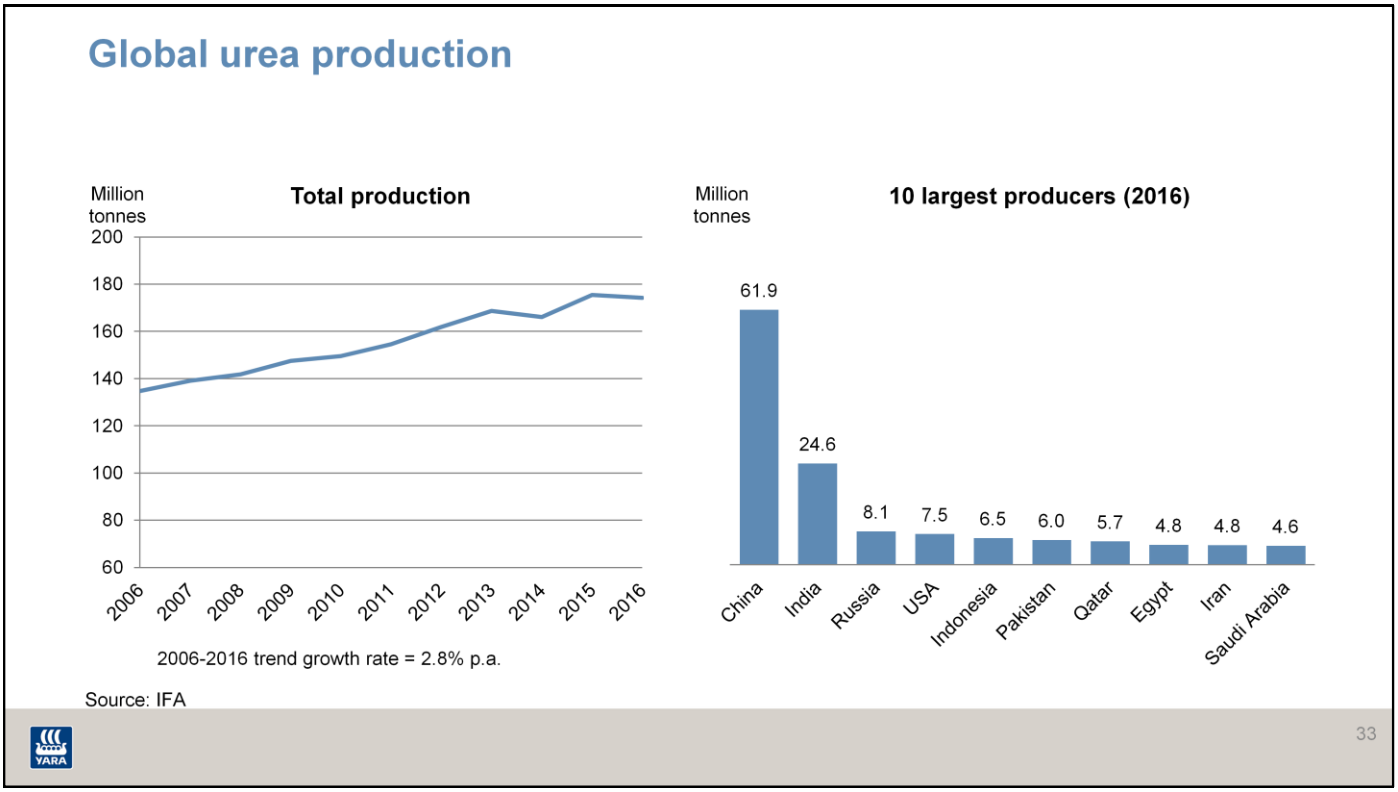


The majority of ammonia trade follows the routes shown in the map, mainly from countries with lower-cost gas

The main center for ammonia trade is Yuzhnyy in the Black Sea, the most liquid trade hub, and where most spot trades take place. Russian and Ukrainian ammonia typically sold wherever netbacks are the highest, and relative pricing to the US, Europe and other markets West of Suez is typically consistent with prevailing freight rates.

Asia is almost in a balanced supply situation for ammonia. If there is a deficit, fob prices in Asia increase to attract imports from the Black Sea. If there is a surplus, Asian exporters will compete West of Suez, and Asian fob prices typically reduce.

Urea

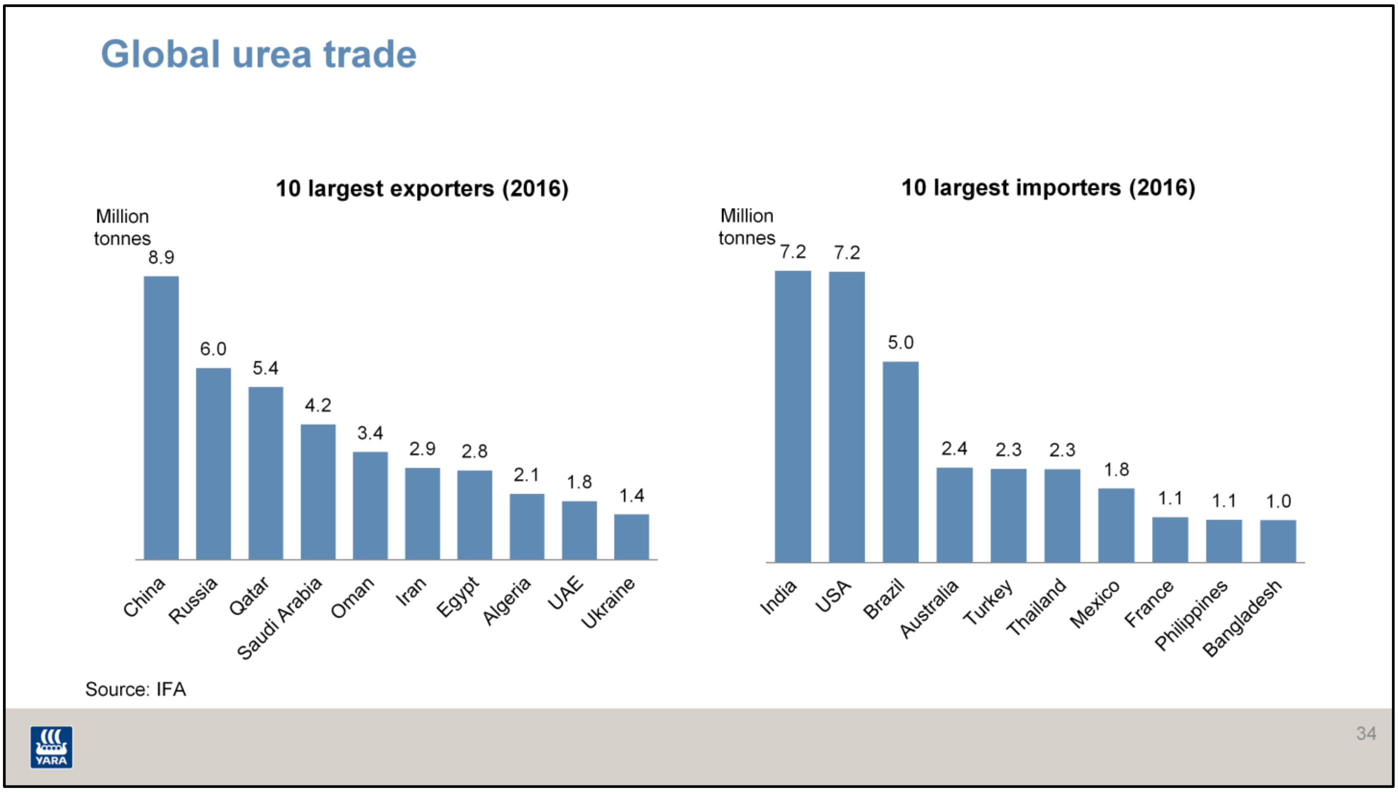


Urea is the main nitrogen fertilizer product

Urea production increased to 174.3 million tonnes in 2016, down 0.6% from 2015. During the years 2006-2016, urea production had a trend growth at 2.8% per year. The largest producers are also the largest consumers, namely China and India. China is self-sufficient on nitrogen fertilizer but India's imports requirement is substantial.

Most of the new nitrogen capacity in the world is urea, so it is natural that production/consumption growth rates are higher for urea than for ammonia/total nitrogen. Lately, the difference has been quite large, since urea has taken market share.

As urea has a high nitrogen content (46%), transport is relatively inexpensive compared with other products.



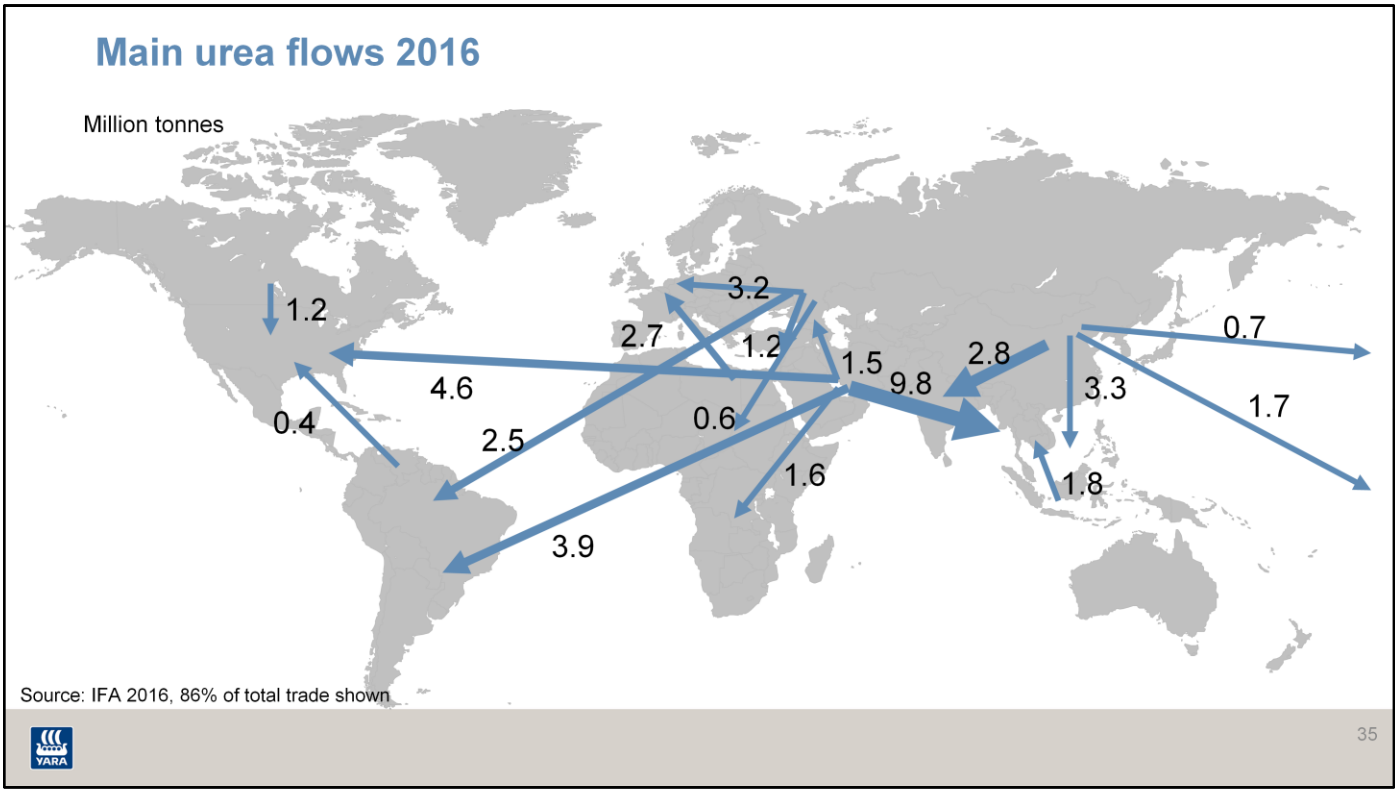
Natural gas-rich regions generally tend to be big exporters of urea

Urea is a global fertilizer and is more traded than ammonia. Exports from China ended at 8.9 million tonnes in 2016, down from 13.7 million tonnes in 2015. Global trade of urea increased by 1.3% in 2016, to 50.4 million tonnes.

The main urea exporters are gas-rich countries/regions with small domestic markets. However, there are some exceptions.

China has huge domestic capacity. Although the main purpose is to supply the domestic market, there has in recent years been excess capacity resulting in exports. However, Chinese exports fell significantly in 2017 and 2018.

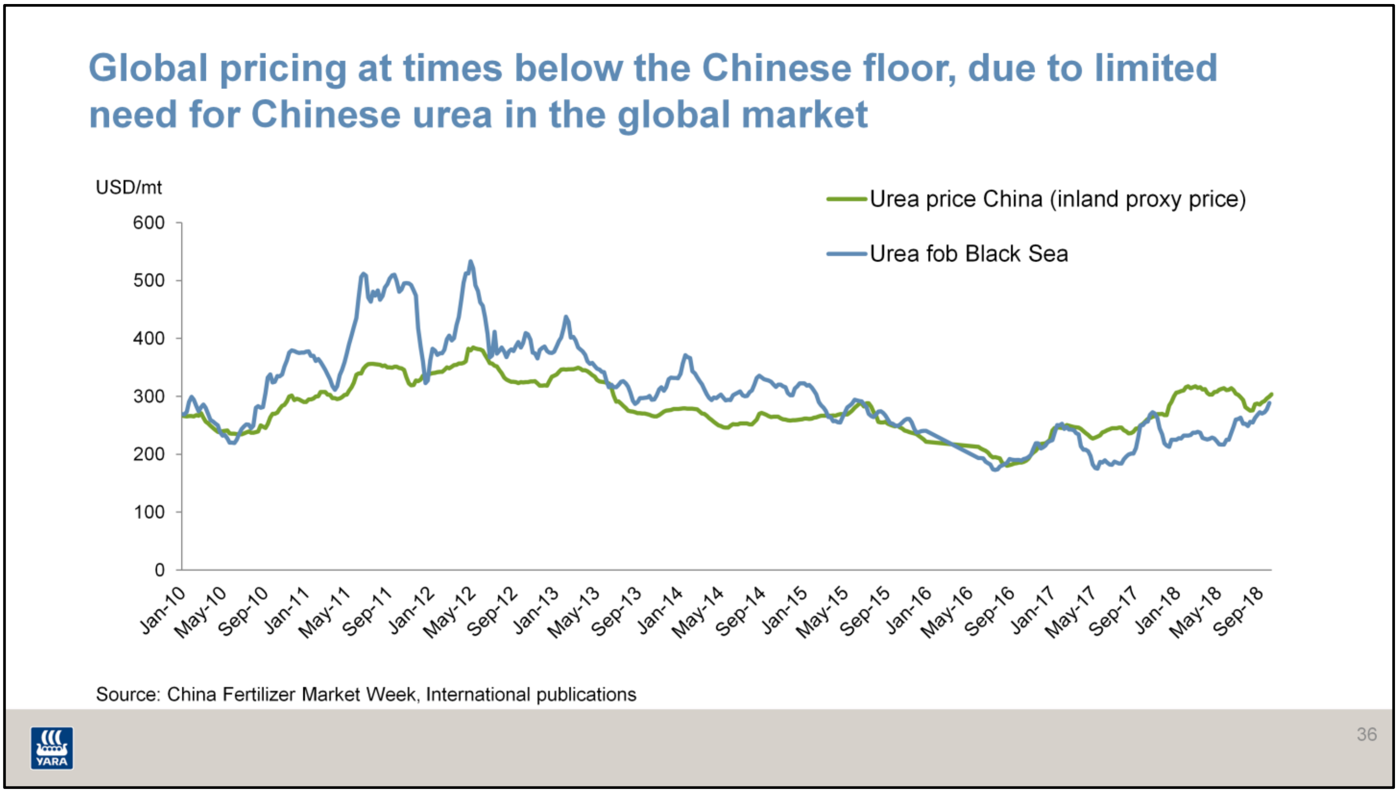
North America, Latin America and South and East Asia are main importing regions.



Russia, China, North Africa and Arab Gulf are main urea export hubs

Russian exports supply Europe and Latin America, while Arab Gulf exports supply North America and Asia/Oceania. All the other flows, of more regional nature, like Venezuela to USA, Indonesia to other Asian countries etc, are only interesting to the extent they affect the need for Black Sea/Arab Gulf material. As an example, if China reduces its export, the Arab Gulf is not able to supply Asia on its own. Black Sea urea will flow to Asia, and an upward price movement will tend to take place.

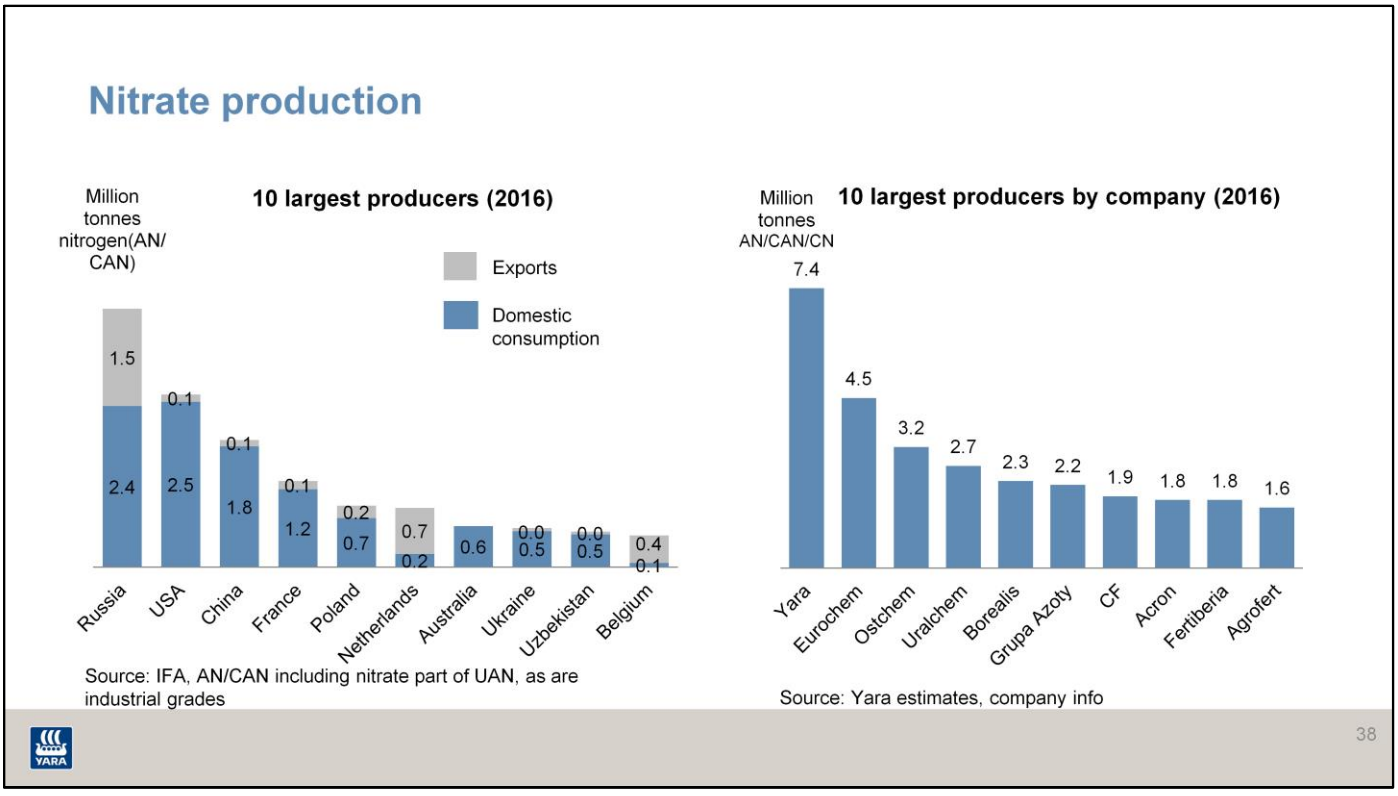
The relative pricing between Black Sea, Egypt and Arab Gulf depends on where the competition on the marginal volumes takes place. If the main demand pull is from Latin America/Europe/Africa, Black Sea/North Africa will lead pricing. If it is Asia/North America, Arab Gulf will lead.



Domestic price and currency set the floor price from China

Selling domestically is the alternative to exporting for a Chinese producer. The domestic price level and currency sets the floor price for Chinese exports. But due to the reduced need for Chinese urea in the global market, due to capacity expansions elsewhere, there are periods where global pricing disconnects from the Chinese export price.

Nitrates



Ammonium nitrate (AN, 33.5% nitrogen) and Calcium ammonium nitrate (CAN, 27% nitrogen) are the main nitrate fertilizer products

Nitrate production increased to 20.4 million tonnes N in 2016, up 0.9% from 2015. Production of AN increased by 1.4%, while production of CAN/MAN dropped by 1%. During the years 2006-2016, nitrates production grew on average at 2.0% per year.

Russia is the largest producer of nitrates, followed by the USA and China. AN solution for UAN production is included in the US figures.

Nitrates (AN/CAN) is biases towards Europe, and contains only 27-34% nitrogen making it less attractive to transport than urea.

Calcium Nitrate (CN) provides soluble and strength-building calcium and nitrate-N (15.5%). Calcium Nitrate is mainly applied to cash crops, such as fruit and vegetables as calcium is good for rooting, stress-free growth, strong cell walls, improved fruit quality and better storage.

Nitrates are products with a nitrate content of 50 % or more

N fertilizer	N content	Nitrate (% of total N)	Other nutrients
CAN (calcium ammonium nitrate)	27%	50%	4% MgO
AN (ammonium nitrate)	33.5%	50%	
NPK	various	about 50%	P & K
CN (calcium nitrate)	15.5%	93%	19% Ca
Urea	46%	0%	
UAN (liquid urea ammonium nitrate)	28%	25%	
ASN (ammonium sulfate nitrate)	26%	25%	13% S
AS (ammonium sulfate)	21%	0%	24% S

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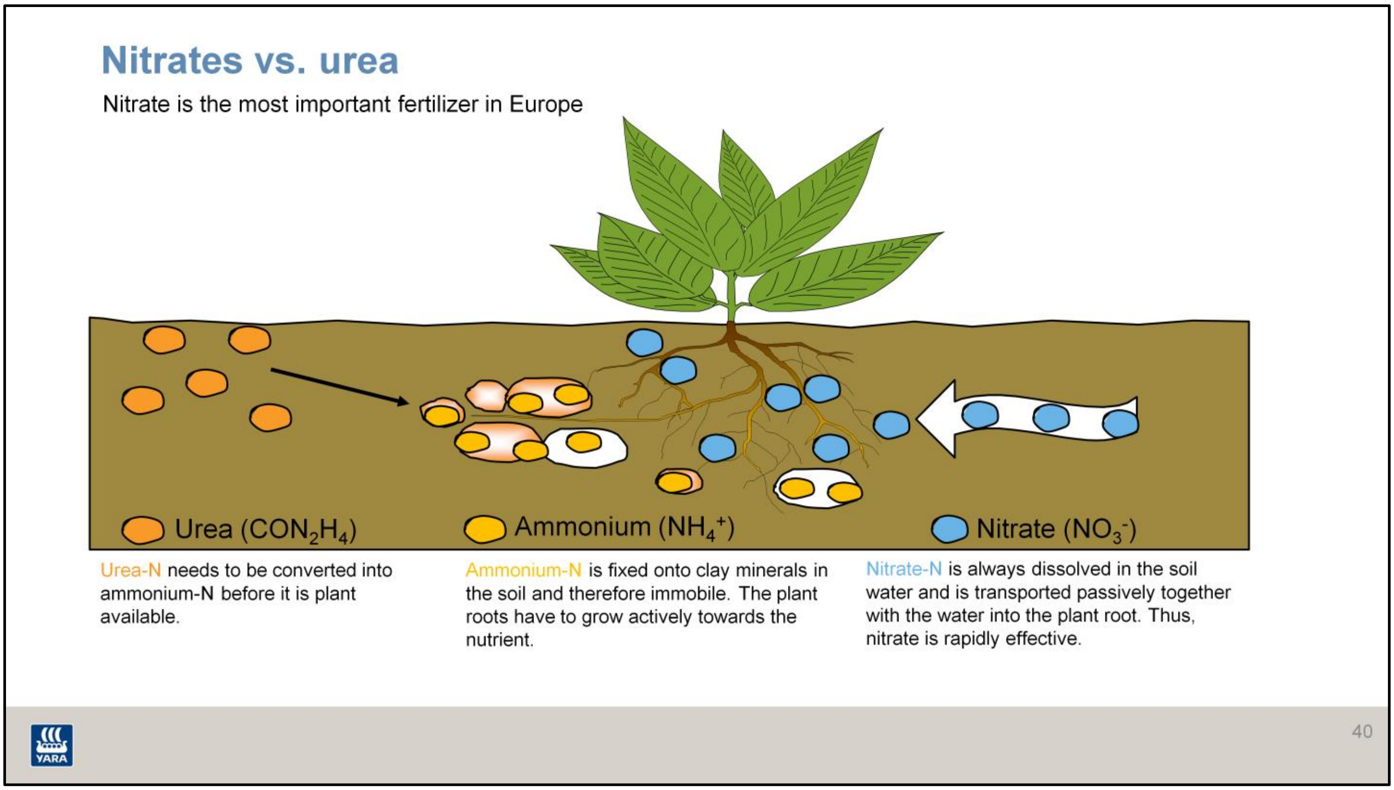
There are several types of nitrogen fertilizers, from urea to straight nitrate fertilizers

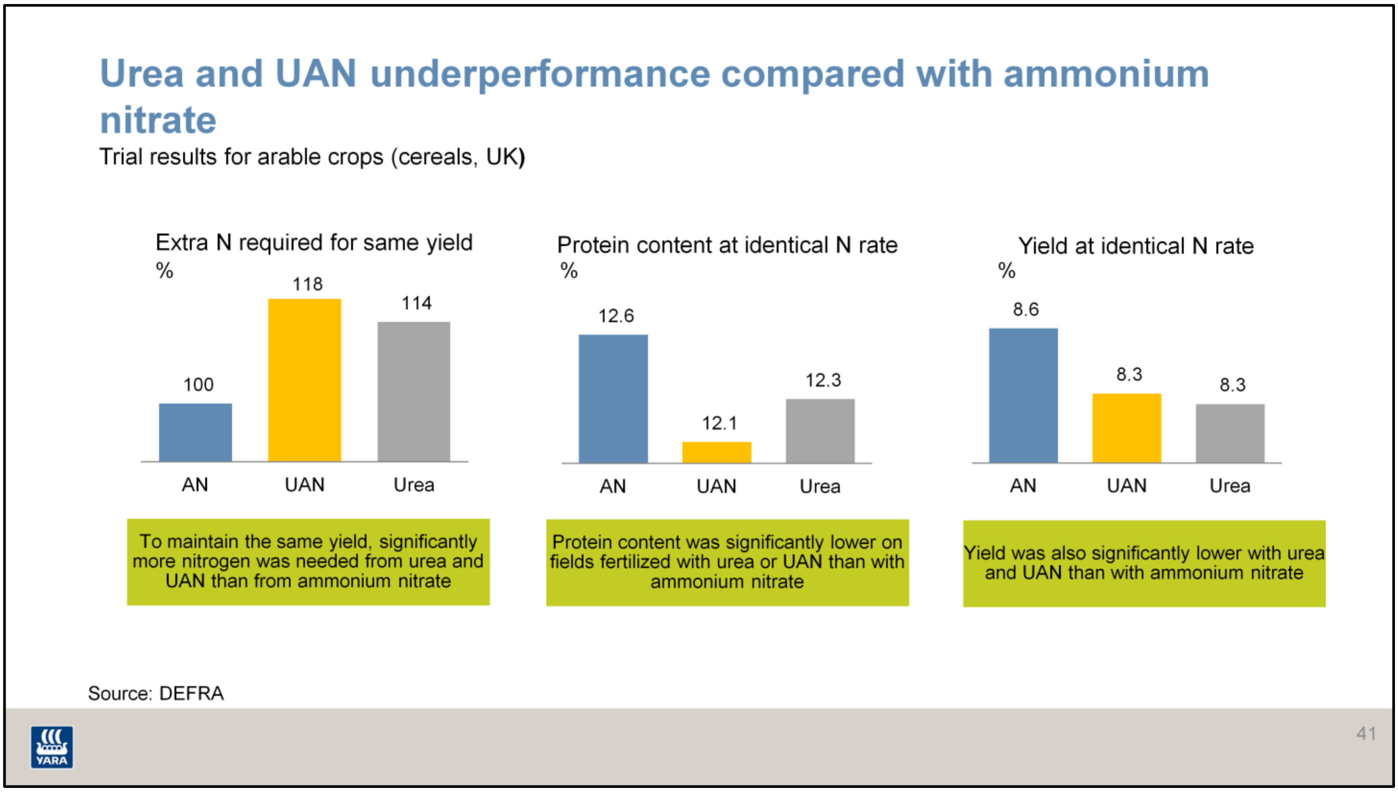
Nitrates are defined as products containing 50% of the nitrogen in the form of nitrate. Nitrate-based fertilizers are the most efficient and most reliable nitrogen source available. In addition, these products have a significant lower environmental impact than urea-based products through better control of leaching, lower volatilization and a lower life cycle carbon footprint.



Nitrate is immediately and easily taken up by plants

Ammonia (NH_3) is the basis for all nitrogen fertilizers and it contains the highest amount of nitrogen (82%). Ammonia can be applied directly to the soil, but for several reasons, including environmental, it is common to further process ammonia into, e.g., urea or nitrates before application. If ammonia is applied directly to the soil, it must be converted to ammonium (NH_4) and nitrate before plants can use it as a source of nitrogen.
While ammonium and nitrate are readily available to plants, urea first needs to be transformed to ammonium and then to nitrate.

The transformation process is dependent upon many environmental and biological factors. E.g., under low temperatures and low pH (as seen in Europe), urea transformation is slow and difficult to predict with resulting nitrogen and efficiency losses. Nitrates, in comparison, are readily absorbed by the plants with minimum losses. Therefore, nitrates are widely regarded as a quality nitrogen fertilizer for European agricultural conditions. This is reflected in their large market share.



The more nitrate in fertilizer, the higher the yield

There are numerous examples that support the superior performance of nitrates in arable, fruit and vegetable crop production, both with regard to yield and quality.

For arable crops, nitrogen fertilizer containing 50% nitrate and 50% ammonium such as CAN or AN are likely to be the financially optimal choice, due to the relatively low crop value.

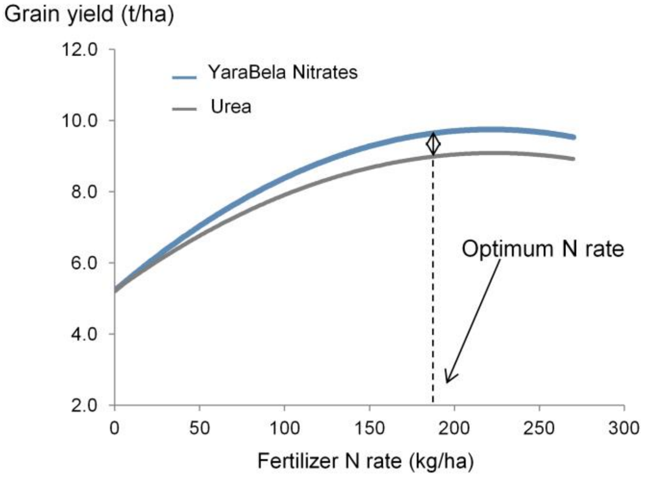
For higher-value cash crops such as fruit and vegetables, fertilizer products containing a high proportion of nitrate nitrogen are likely to be the optimum choice, especially for rapidly growing vegetables which need nitrogen readily available.

The most extensive study comparing different forms of nitrogen fertilizers was performed on behalf of the UK government between 2003 and 2005 (Department for Environment, Food and Rural Affaires - DEFRA). Besides quantitative differences, the study highlighted the variability of results observed with urea and UAN. The required nitrogen application rates can therefore not be predicted with the same reliability as with ammonium nitrate.

Yield advantage of nitrates in tropical climate

Brazil, main season corn

- Research shows that the benefits of nitrates are even more pronounced in the tropics than in colder climates
- YaraBela nitrate provides direct and efficient uptake of nitrate-N
- Consistently lower NH_3 volatilization losses
- Reduced acidification in the root zone, supporting root growth and nutrient uptake

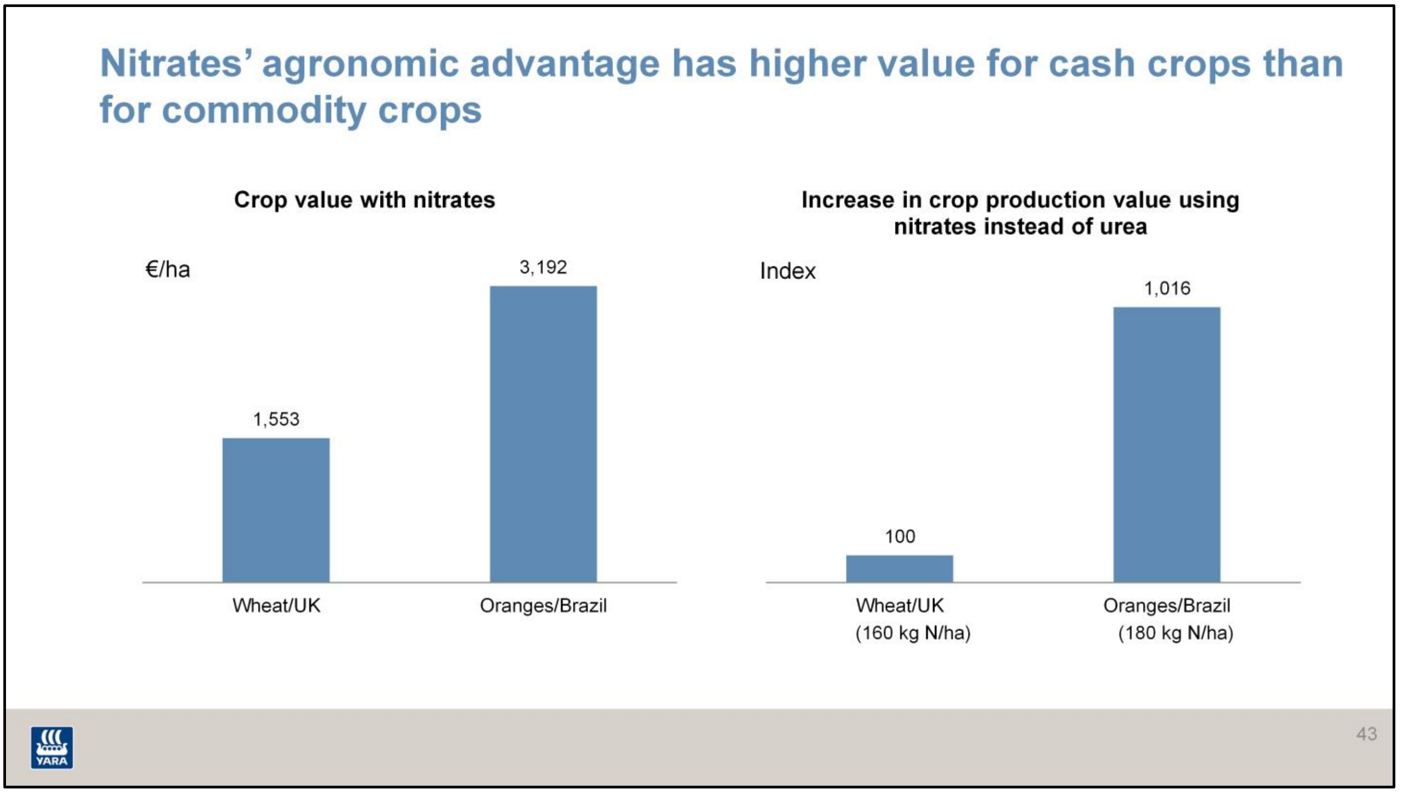


Source: Fundation Bahia (2013)

Benefits of nitrates are high in tropical climates

The trial was carried out in the Cerrado region of Bahia by/at “Research and Technology Centre of Western Bahia (CPTO) – Fundacao Bahia, Brazil. The trial was done with a 1st season maize (season 2012/2013, previous crop was soybean (2011/2012) under conventional tillage system. Site location: Luis Eduardo Magalhaes (LEM).

Grain diff (CAN-urea) at ~ YaraBela N_{opt} = +6.8 %



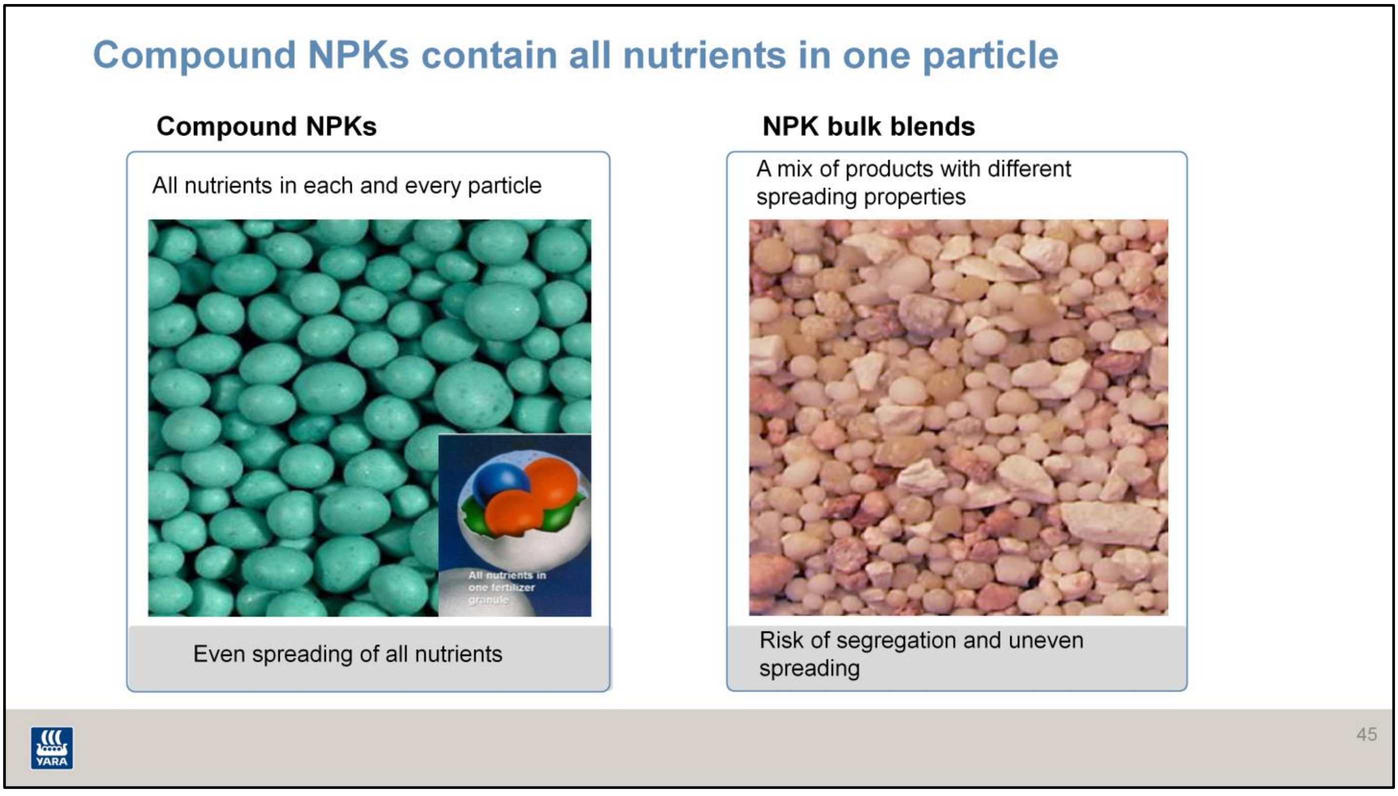
Field trials confirm the advantages of applying nitrates instead of a commodity nitrogen fertilizer

For wheat in UK trials concluded that yields improved by 3%, while for orange production in Brazil the yield improvement was a massive 17% using nitrates instead of urea.

<u>Winter wheat, UK</u>
- Average of 15 field trials between 1994 and 1998, both N forms tested at 160 kg N/ha
- Levington Research
- Yield with urea = 8.38 t/ha, CAN = 8.63 t/ha
- Grain price = 180 €/t (price at farm in NW-Germany, Nov 2011)

<u>Citrus, Brazil</u>
- Based on 1 field trial with oranges in Brazil, both N forms tested at 180 kg N/ha
- Cantarella, 2003
- Yield with urea = 37.1 t/ha = 909 boxes, AN = 43.3 t/ha = 1061 boxes
- Price per box = 4 \$ = 3.01 € (industry price excluding harvest service, Nov 2011)

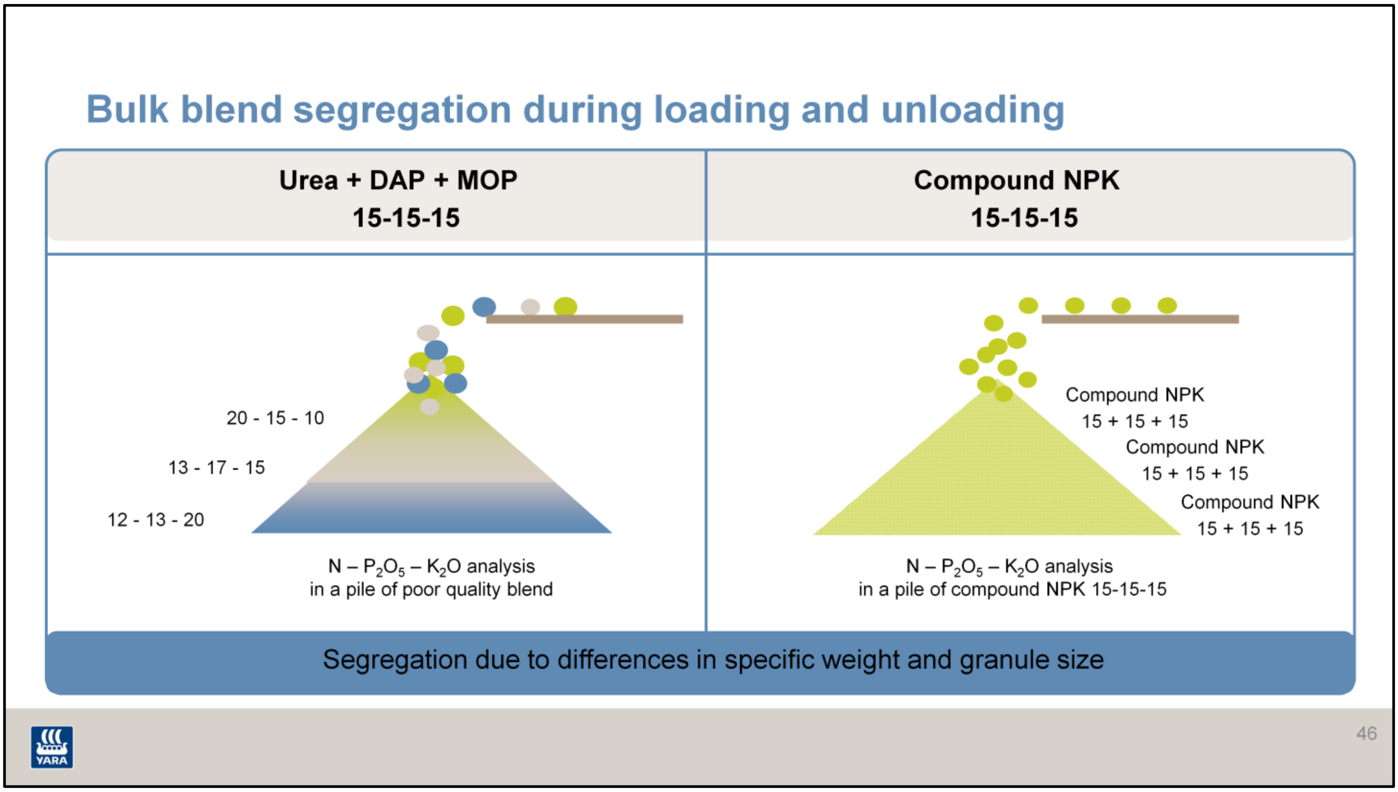
NPKs



Different quality between blended and compound NPK

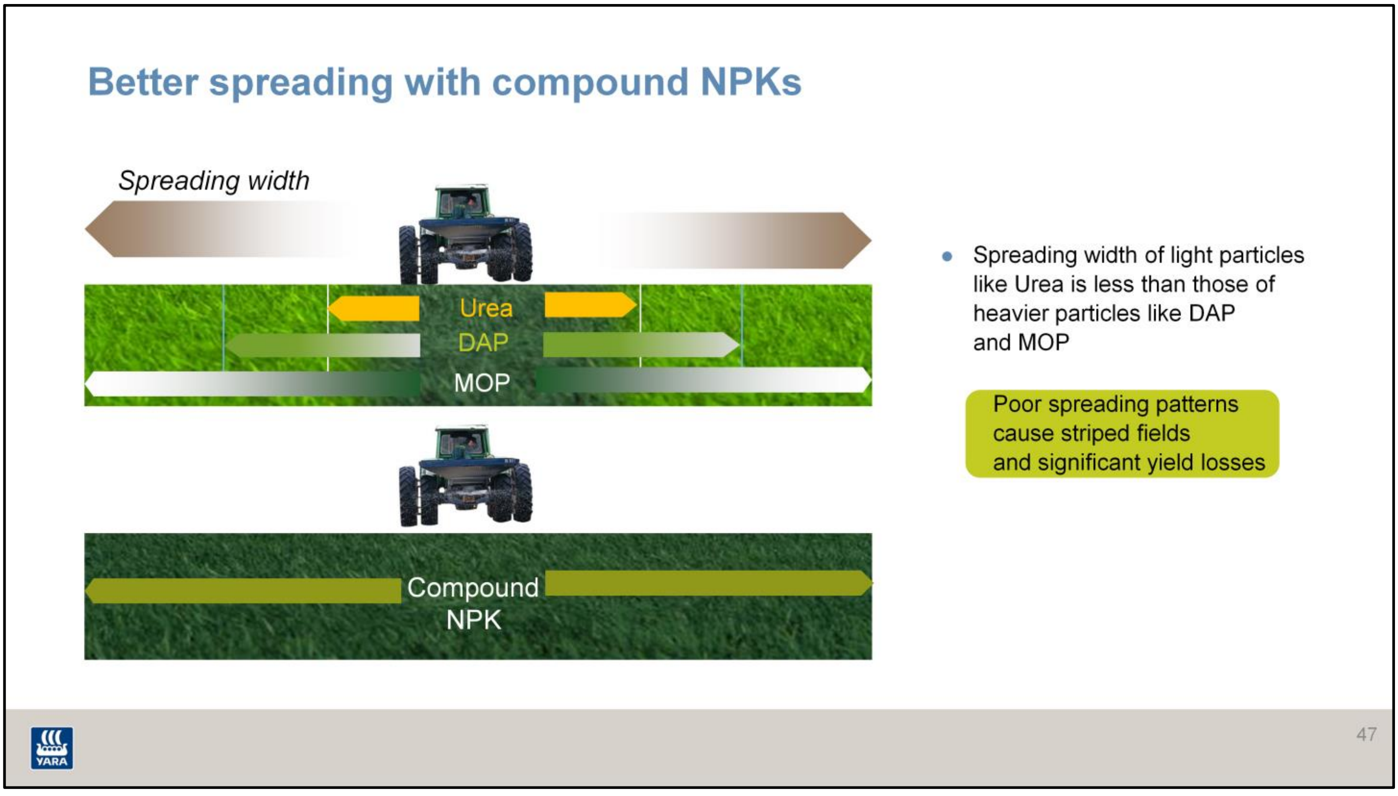
In compound NPKs, the same mix of all the N, P and K nutrients is present in every particle of product, while in a blended NPK, separate particles of straight fertilizer like urea, nitrates, DAP, TSP, MOP, SOP etc, are mixed, or blended together.

The photo on the right shows a typical low quality blended product with a wide variation of particle sizes, shapes and nutrient contents. Larger, denser particles will spread further, and smaller lighter particles will spread the least distance. Where different sized particles have different nutrient content, this leads to segregation of nutrients upon spreading. In turn this will create uneven crop growth, and typical striping on crops such as cereals or rice. Compare this to the picture on the left of compound NPKs. The particle sizes are different, as this helps achieve uniform spread pattern, but all the nutrients are in every particle so that no segregation of individual nutrients takes place. All together this ensures accurate feeding of crops.



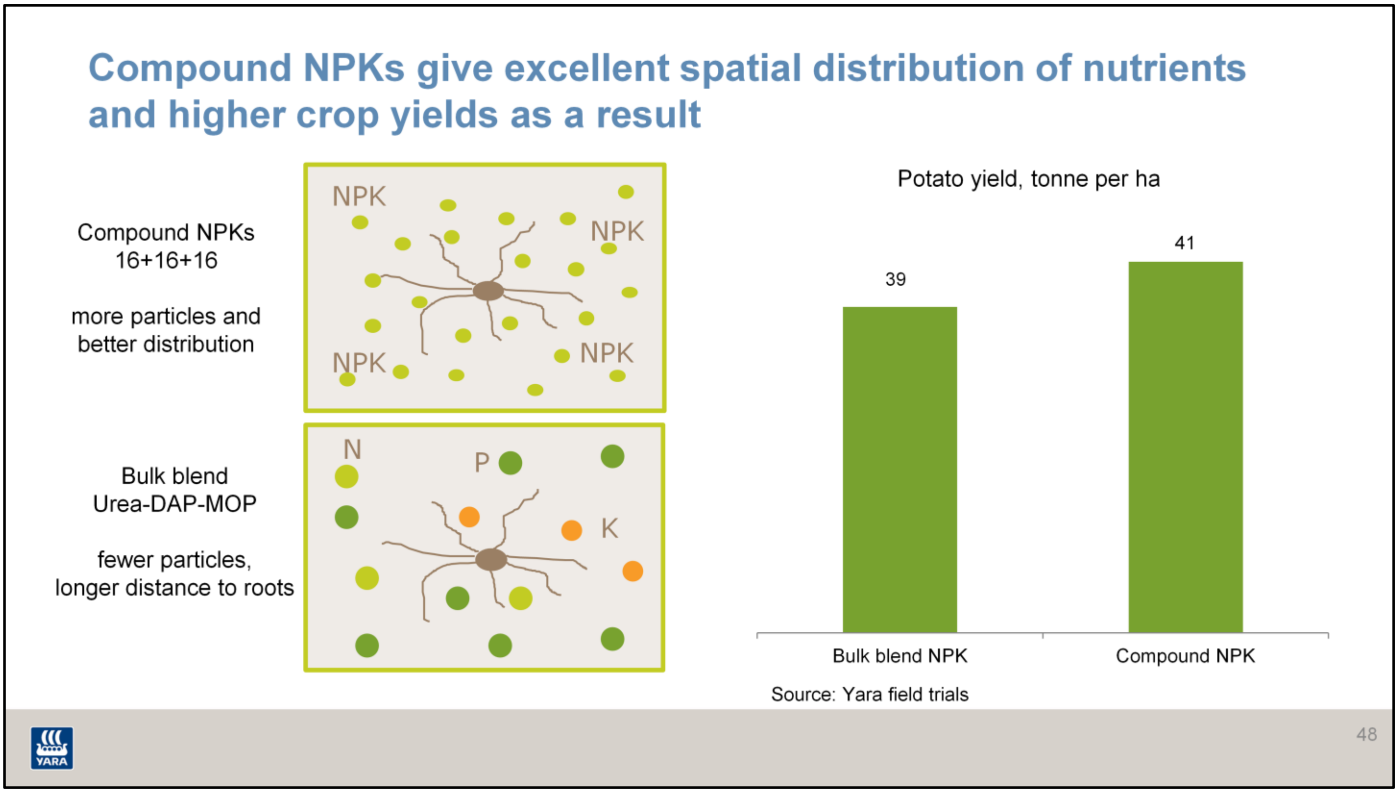
Careful handling of blended NPKs important to avoid segregation

Segregation of fertilizer blends can occur on loading into ships or bulk heaps, as larger particles will round to the edge of the heap. Careful handling of blended products is required to prevent segregation. With compound products, segregation of individual nutrients is not possible. However, it is also important to handle these products carefully, as separation of smaller as larger particles will alter the particle size distribution and spreading pattern.



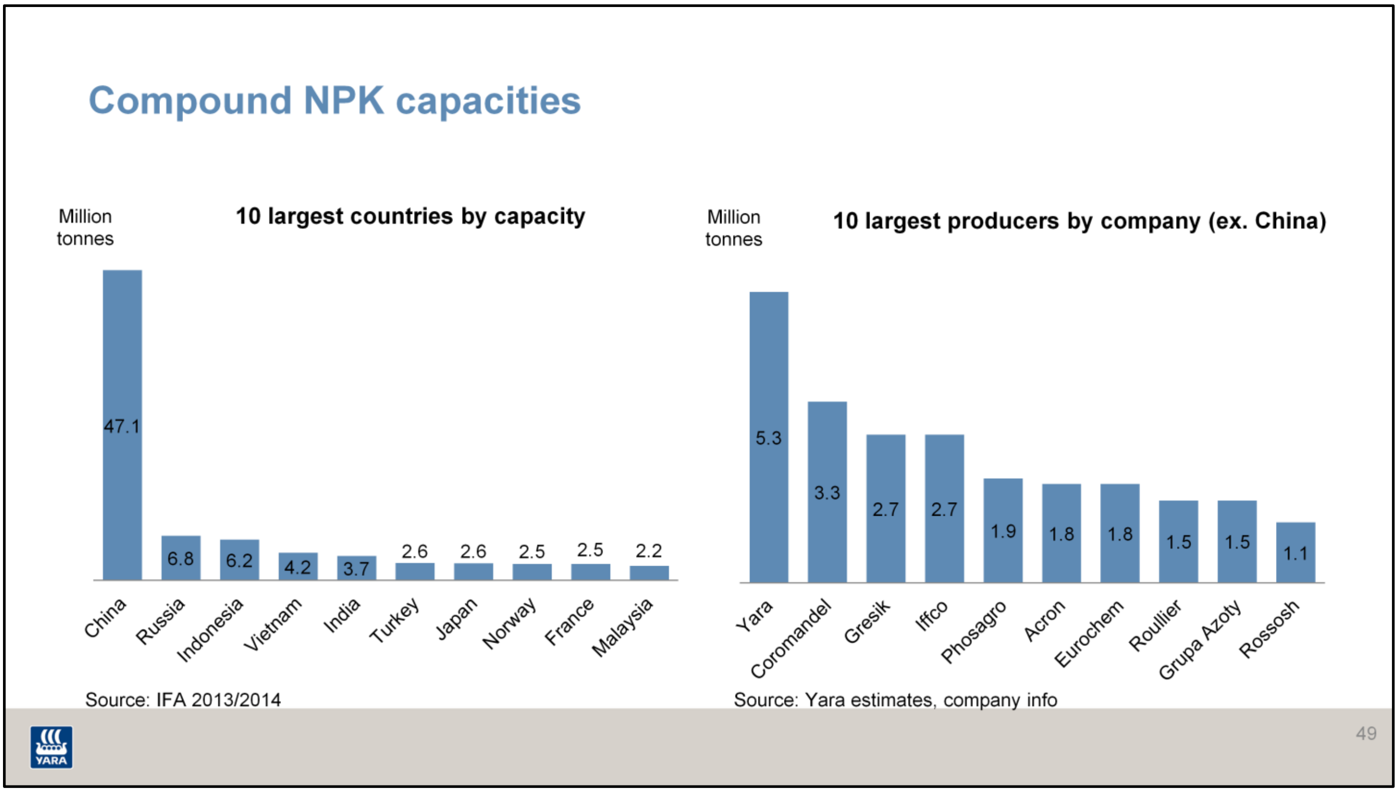
Striping reflects poor distribution of nutrients

Spreading tests have shown the deviation in actual nutrient application rate compared to target nutrient rate can be considerable. Deviation in nutrient rates will cause a major impact on the quality and yield of grains/fresh fruit and vegetables.



Compound NPKs provide better distribution of nutrients

Deviation in nutrient rates will cause a major impact on the quality and yield of the crops. Compound NPKs includes all N, P and K nutrients in one fertilizer particle and therefore better distribution of nutrients to the crop.



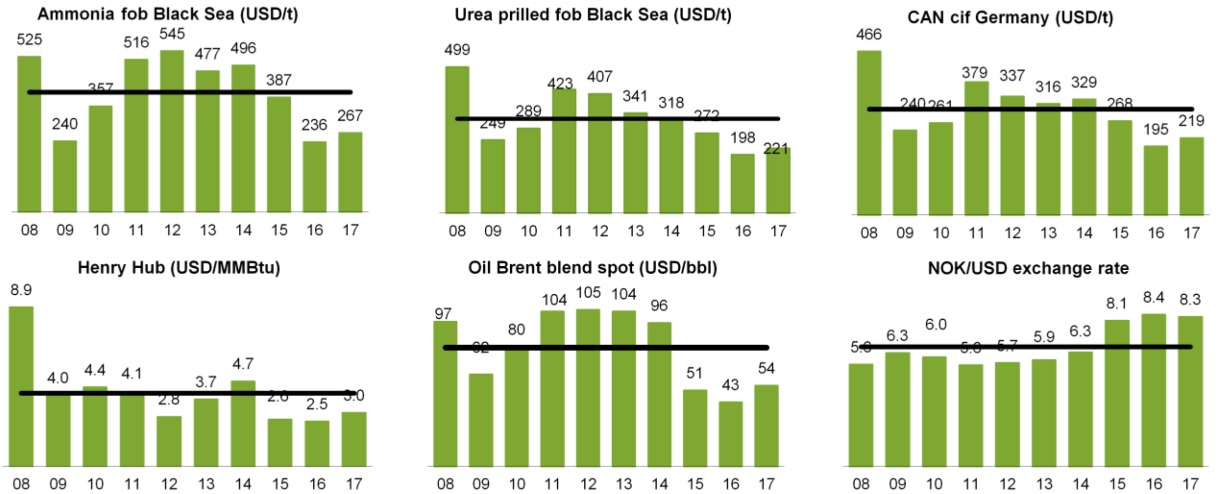
China is the world’s largest producers of NPK fertilizer

Since all fertilizers containing potassium are exposed to export taxes, little or no compound NPK is exported out of China. For 2018 export tax on NPKs in China is set at 100 RMB/t (~15 USD/t), down from the flat 20% export tax seen in 2017. Of the 10 largest producers of compound NPKs, Russia and Norway are the main exporters.

Excluding Chinese companies, Yara is the largest compound NPK producer globally.

Industry value drivers

Key value drivers



Source: Fertilizer market publications, World Bank, Norges Bank — Average 2008 – 2017

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Fertilizer prices are cyclical

Fertilizer prices are cyclical like any other commodity. The cyclicality is primarily caused by the “lumpiness” in supply additions resulting in periods of overcapacity and undercapacity.

Nitrogen fertilizer value drivers

	Drivers		Effect on
Revenue drivers	Chinese coal prices	→	Supply-driven price for urea
	Grain inventories/prices	→	Urea demand
	New urea capacity vs. closures	→	Urea supply
	Global urea demand vs. supply	→	Urea price (above floor)
	Urea price	→	Most other nitrogen fertilizer prices
	Cash crop prices	→	Value-added fertilizer premiums
Cost drivers	Oil product prices and LNG capacity expansion	→	Gas cost in Europe
	Manning and maintenance	→	Fixed cost
	Productivity and economies of scale	→	Unit cost

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Drivers of supply and demand

In general, when demand is low, there tends to be a ”supply-driven” fertilizer market in which the established “price floor” indirectly determines fertilizer prices. This price floor is set by the producing region with the highest natural gas prices. Historically the highest gas prices were in the US and in Western Europe but since 2009 the Ukrainian and other Eastern European producers have had the highest production costs together with coal-based producers in China.

When fertilizer demand is high, there is typically a ”demand-driven” market with fertilizer prices above floor prices for swing (highest cost) regions. The fertilizer market balance and capacity utilization are other key factors that impact prices for urea and other N-fertilizers.

Yara’s gas consumption in its fully-owned plants was 227 million MMBtu in 2016 (of which 157 was in Europe). Adding Yara’s share of joint venture companies, the total consumption of natural gas is approximately 290 million MMBtu.

Drivers of demand

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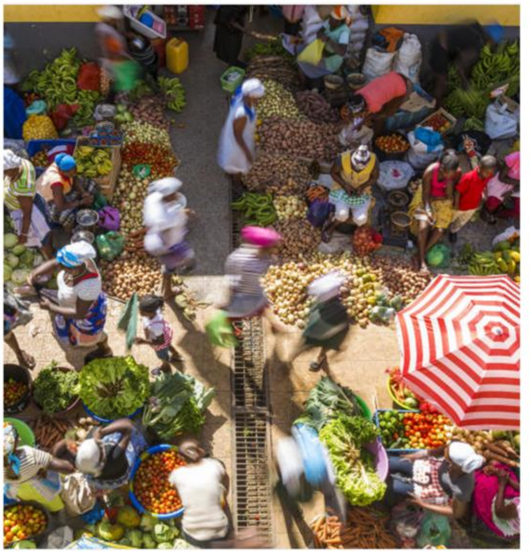
Drivers of fertilizer consumption growth

- Food demand drives fertilizer consumption
  - Population growth of about 80 million each year
  - Economic growth change diets
    - Higher meat consumption in developing countries
    - More protein-rich diets
    - More fruit and vegetables
    - Reduce hunger
  - Biofuels
- Industrial consumption
  - Economic growth
  - Environmental limits (e.g. reduction of NOx emissions)



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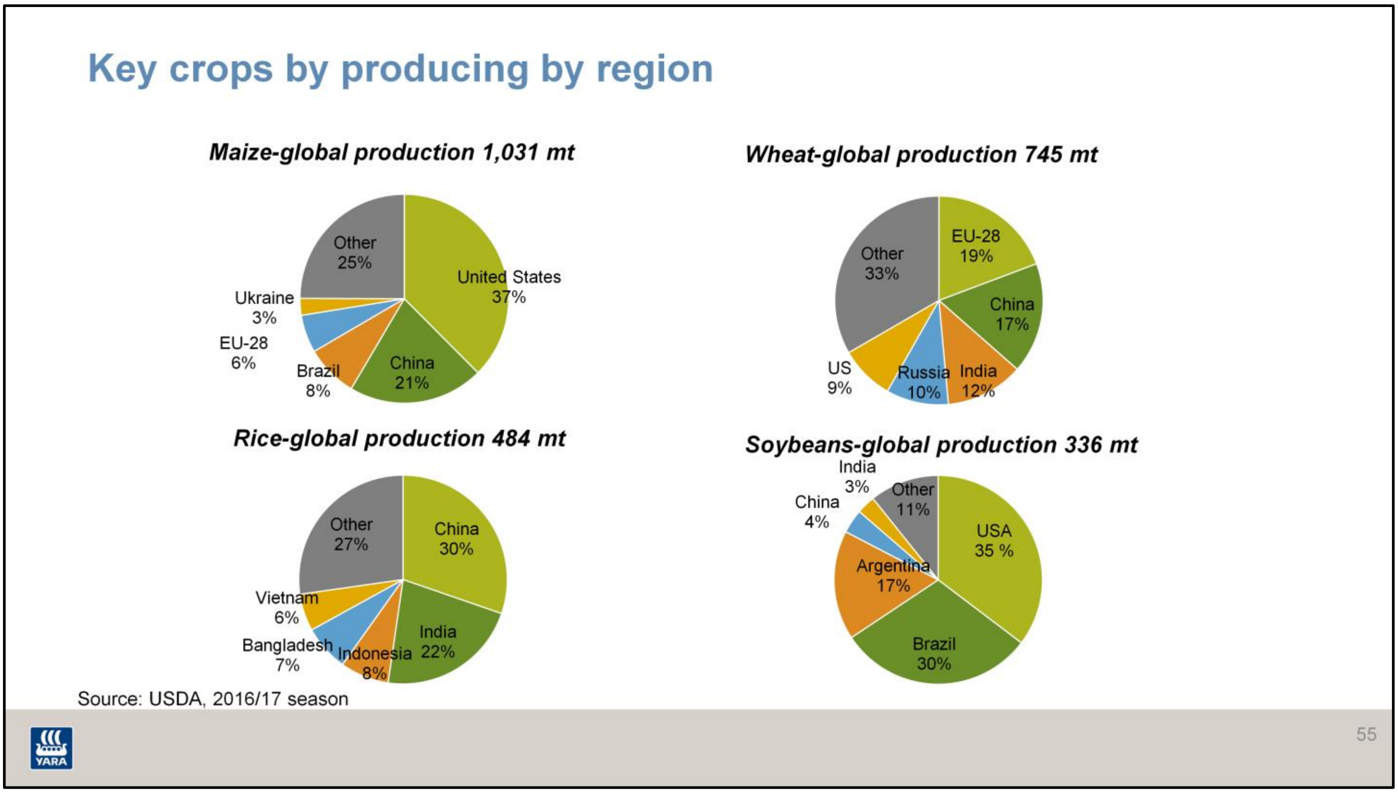
Nitrogen consumption growth exceeds global population growth

Population growth and economic growth are the main drivers for increased fertilizer consumption. Industrial consumption of nitrogen is mainly driven by economic growth and environmental legislation.

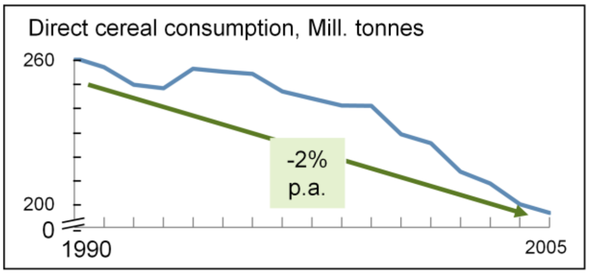


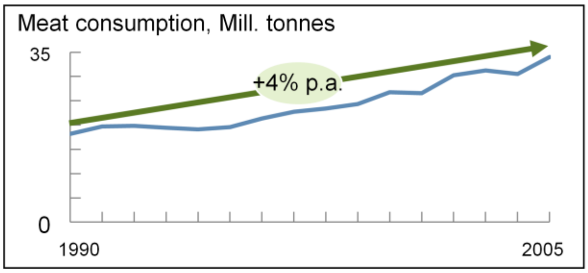
Crop producing countries

The United States and China are large producers of agricultural products. While the US is the biggest producer of maize and soybeans, China is the biggest producer of rice.

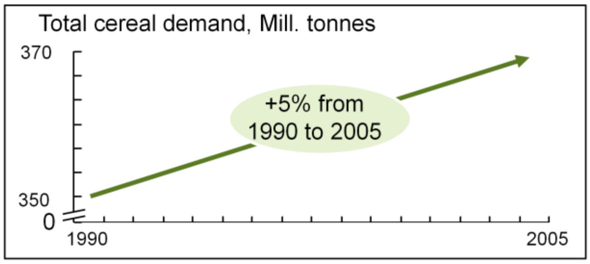
Growing meat consumption increases demand for cereals

China example





- The example of China illustrates that changing diets towards higher meat consumption increases overall demand for cereals
- Higher meat consumption requires more feed grain



Source: McKinsey

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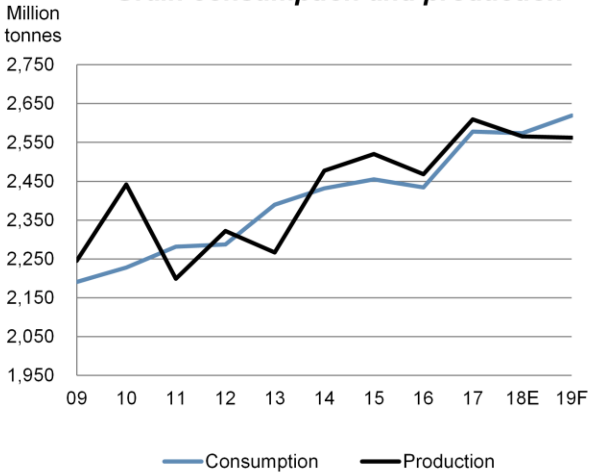
Global per capita consumption of meat is increasing

Pork and poultry are gaining popularity on a global basis, and meat consumption requires feed. To produce 1 tonne of poultry meat, feed corresponding to 2 tonnes of grain is needed. The multipliers are 4 for pork and 7 for beef.

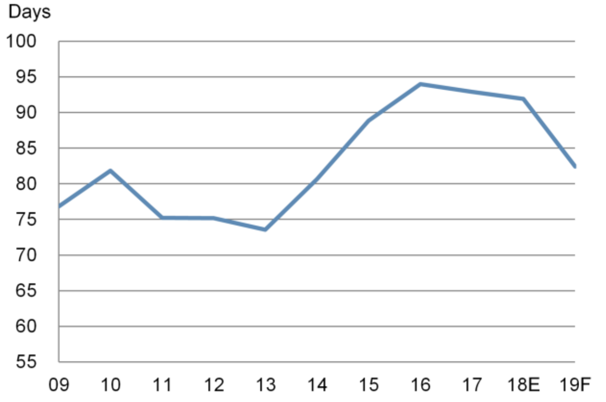
Nitrogen required for meat production is estimated at 20-30% of total nitrogen fertilizer consumption

Steady growth in grain consumption, while production growth is more volatile due to weather variations

Grain consumption and production



Days of consumption in stocks



Source: USDA October 2018

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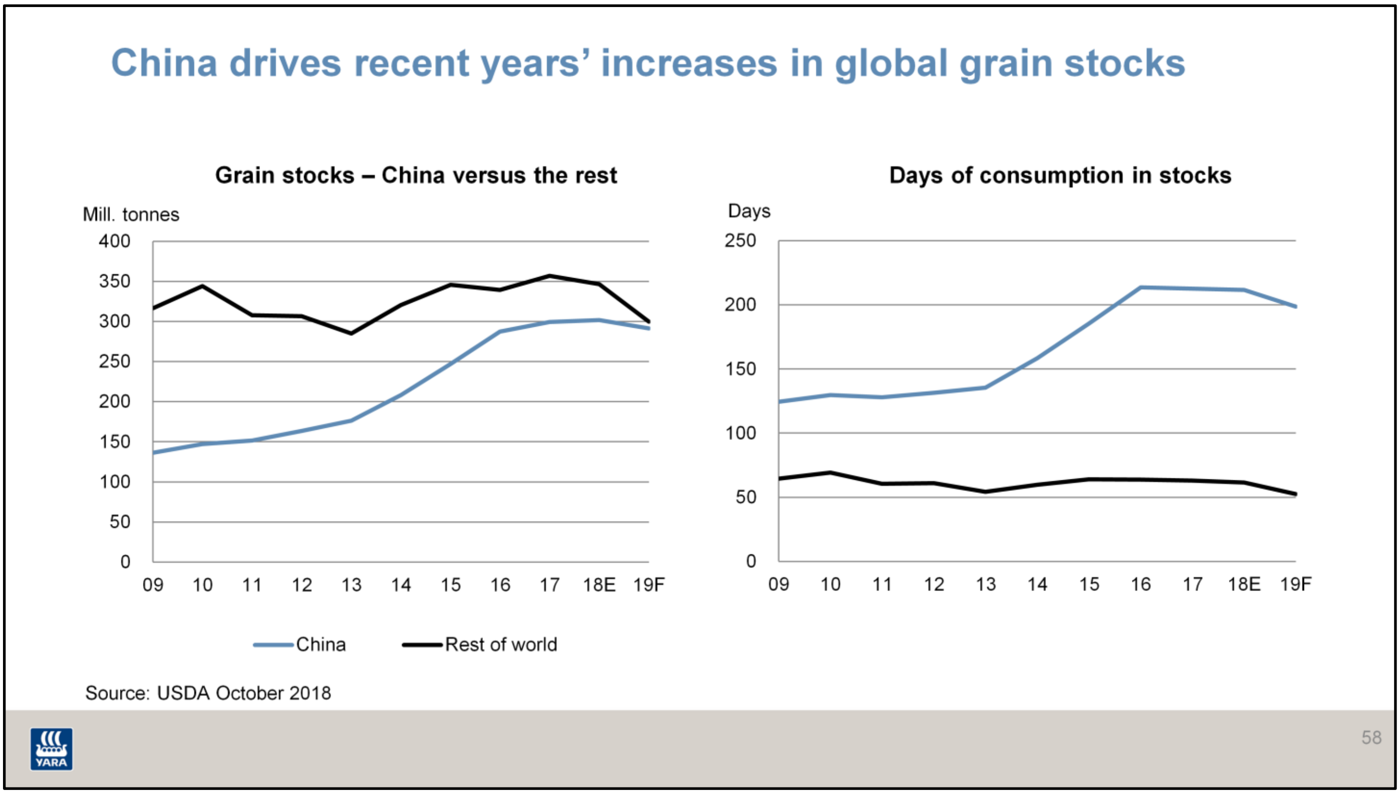
Global grain production needs to keep up with demand

Production needs to keep up with a steady growing consumption increase. With a growing world population the demand side will continue to grow going forward. Over time food prices need to be high enough to attract investment and growth in production. If prices are low and less grain is produced, demand will exceed supply and prices will increase.

Global grain production has exceeded consumption four years in a row, according to USDA, resulting in higher global grain inventories. This is expected to change this season, with lower ending inventories projected. The USDA projections are updated monthly and are available on https://www.usda.gov/oce/commodity/wasde/

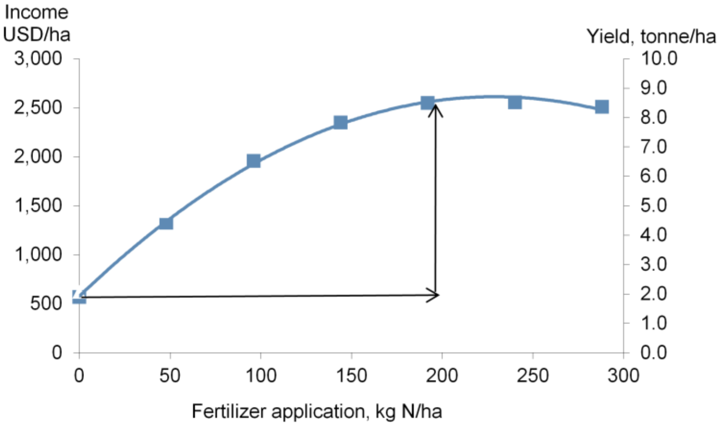


The last three years China has been the main contributor to increased grain stocks

Excluding China, global grain stocks have been quite stable, with very stable stocks to use ratio. So weather factors will remain key to grain price developments, even modest yield losses may trigger substantial improvements in pricing. There are no signs that China will reduce their grain inventories through substantial grain exports. Grain prices in China exceed global pricing, and product quality is variable.

Profitability of investment in mineral fertilizers

Yield response (monetary value) to N fertilizer rate



- The investment in nitrogen fertilizer is highly profitable for growers
- Fertilizer investment: 175 USD/ha
- Net return: 1,214 USD/ha
- **Net return ~ 7 x investment**

Source: Winter wheat yield data: Long term trial, Broadbalk, Rothamsted (since 1856).

Correct use of fertilizers can yield huge returns on investment

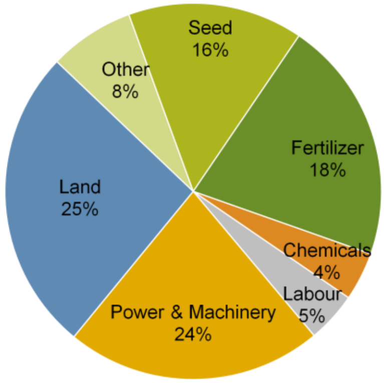
Using 192 kg N/ha (winter wheat in Europe), it is possible to produce 9.3 tonnes of grain per hectare. The fertilizer cost at this application level using CAN (27% N) at EUR 205/t (911 USD/kg N) would be 192 kg x 654 USD = 175 USD/ha

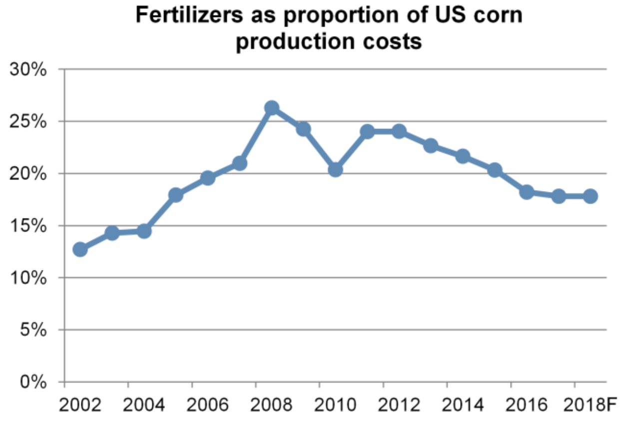
Using a wheat price of 192 USD/t, the farmer gets the following alternative revenue scenarios:
• Optimal nitrogen level: 9.30 t grain/ha * 192 USD = 1,786 USD/ha
• No nitrogen fertilizer added: 2.07 t grain/ha * 192 USD = 397 USD/ha

The difference in revenues is 1,389 USD/ha resulting from an input cost of 175 USD/ha, i.e. a return on investment of 790%.

Breakdown of grain production costs

Example: 2017F average US corn production costs

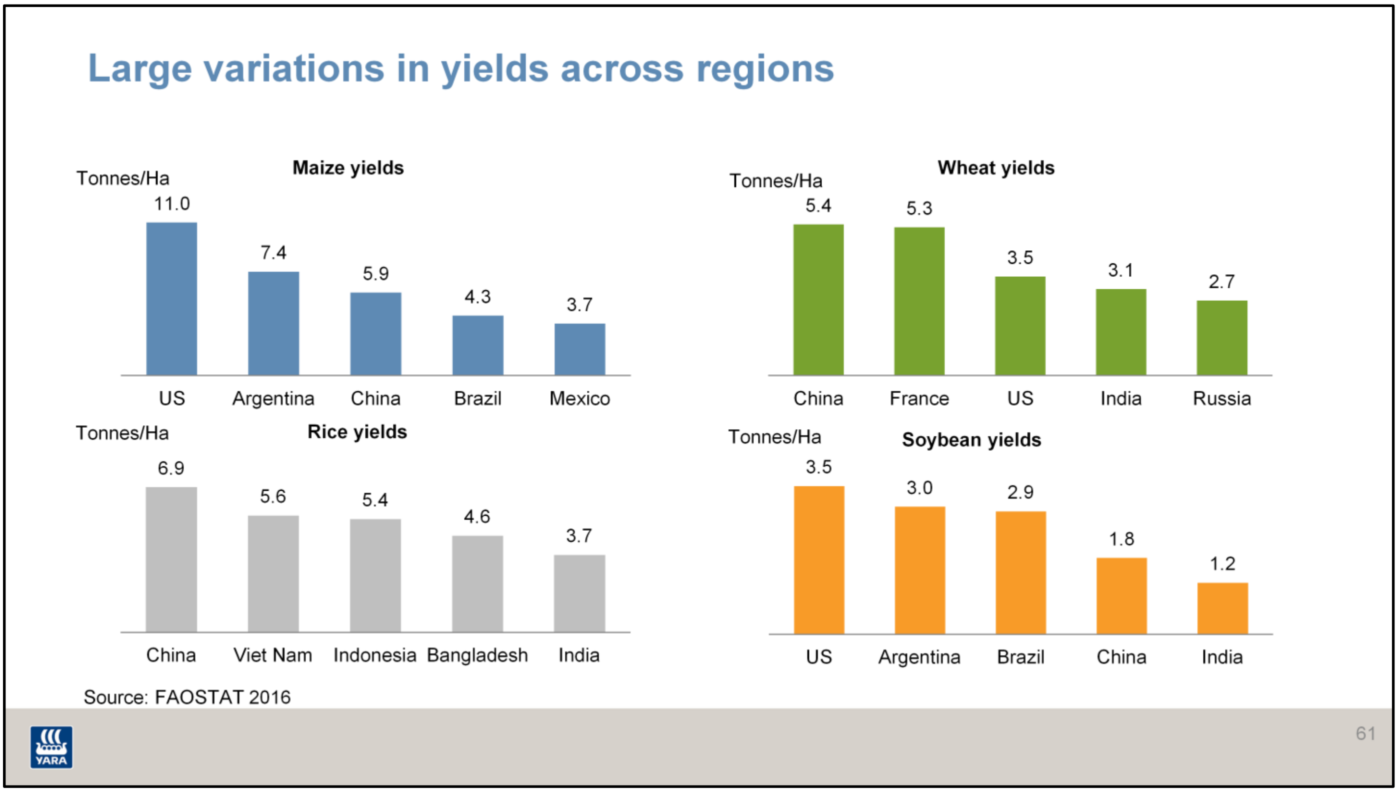




Source: USDA (Cost-of-production forecasts November 2017)

Fertilizer cost is less than 1/5 compared to total grain production cost

Fertilizer costs relative to total production costs of corn has been decreasing over the last three years and represent less than 20% in 2017F. For other major crops, the relative share is smaller varying from 6% for soybeans up to 11% for wheat.

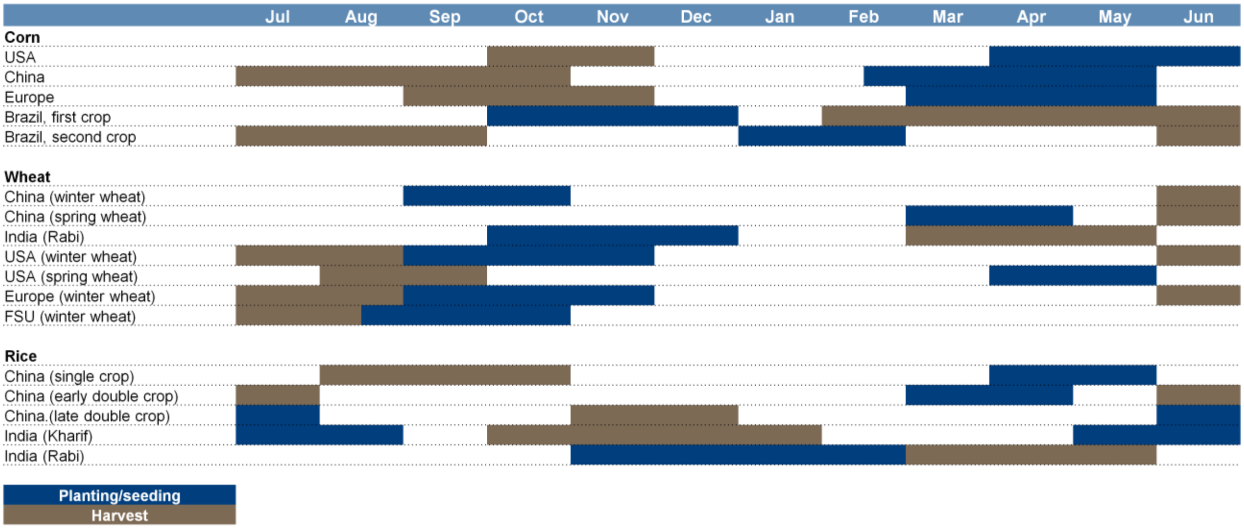


Yield differences

There are large regional yield variations. These variations reflect among other things differences in agricultural practices including fertilization intensity as shown on the previous page.

Weather and differences in soil quality mean that not all regions can achieve the same yields. However, the large differences observed clearly indicate that by using the right techniques, including a correct fertilization, yields and grain production can be increased significantly.

Seasonality in fertilizer consumption



Source: USDA

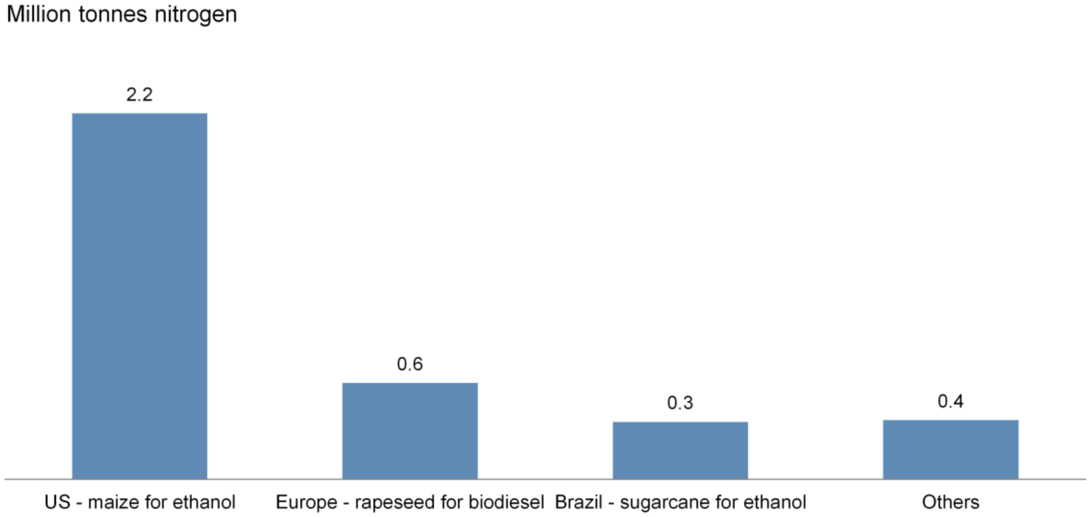
Fertilizer is a seasonal business

The seasonality is to a large extent linked to weather. Hence, there are large regional differences in when crops are planted and harvested and therefore when fertilizer is being applied.

Fertilizer is typically applied when seeds are planted, implying that the main application on the northern Hemisphere is during the first half of the calendar year while on the southern Hemisphere it is during the second half of the calendar year. Winter wheat is an exception, while planting typically is done in the second half of the year, fertilizer application is done in the spring.

In certain countries, certain crops are harvested twice a year, this applies especially to countries on the southern hemisphere like India and Brazil.

N-fertilizer consumption from biofuels production



Source: Yara estimates 2017

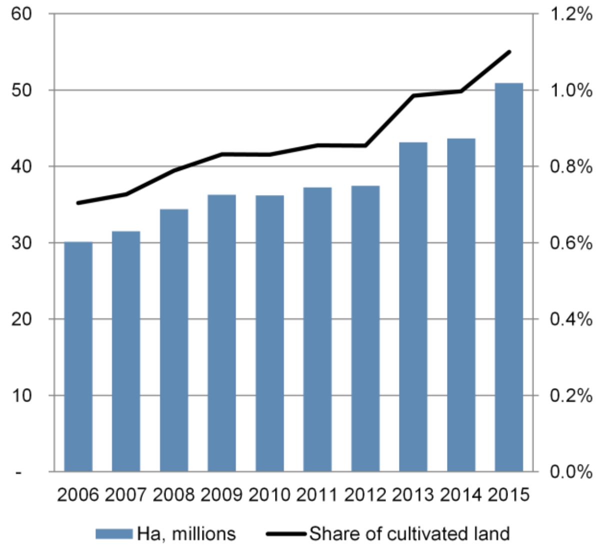
Biofuel crops boost fertilizer consumption

World N-fertilizer consumption due to biofuels production was estimated to be 3.4 million tonnes N in the 2016/17 growing season. This corresponds roughly to 3.2% of global nitrogen consumption.

With around 1/3 of US corn production supplying ethanol production, the US is by far the main contributor, accounting for more than 60% of all nitrogen being consumed for biofuels production.

Organic farming represents a marginal share of total cultivated land

- The principles of crop nutrition are also valid for organic farms
- Organic farms use manure and crop residues to deliver minerals to their crops
- Organic farming is a niche market, mainly for consumers in the developed world



Source: Organic-world.net

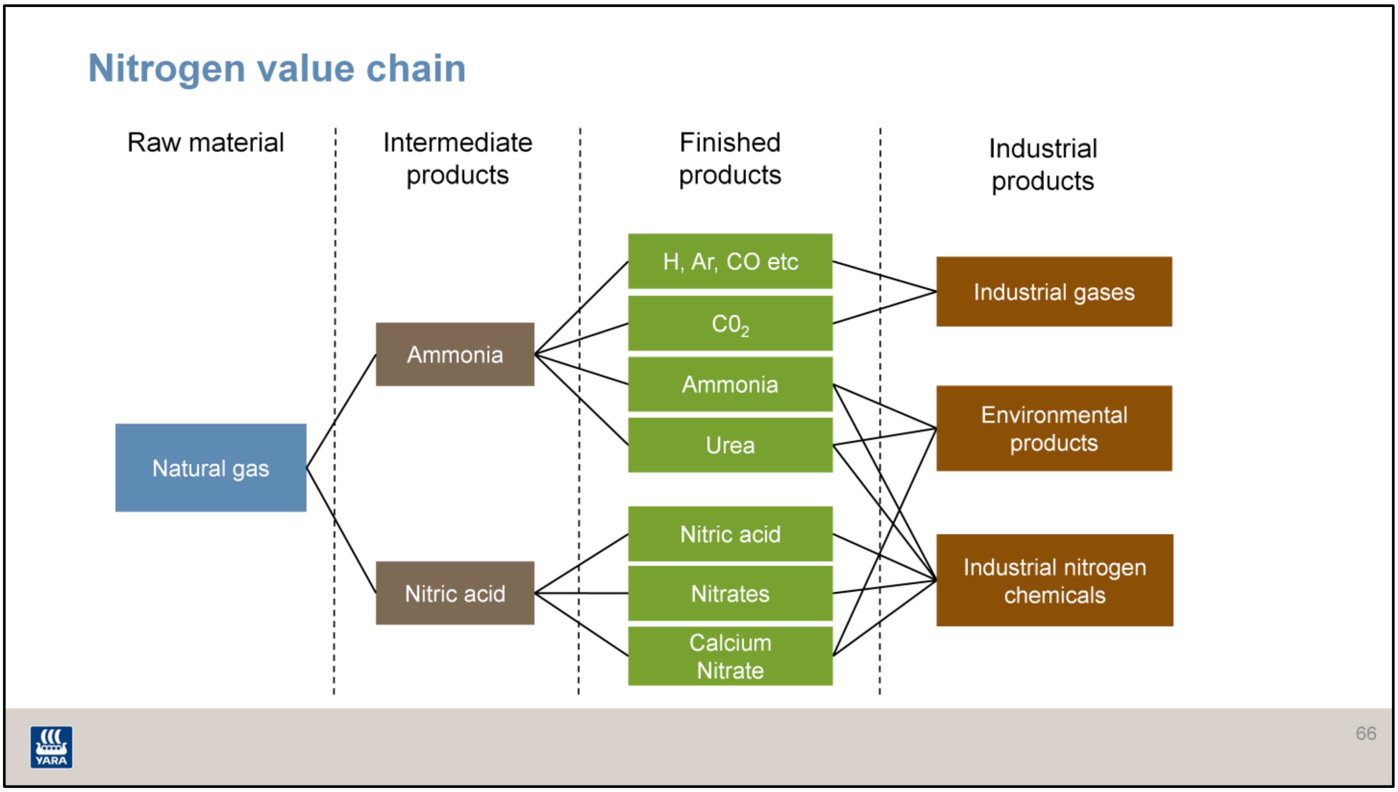
Organic farming accounts for 1% of cultivated land

51 million hectares of agricultural land were managed organically in 2015, up from 44 million hectares in 2014.

Almost two-thirds of the agricultural land under organic management is grassland (33 million hectares).

With most of the land cultivated organically being grassland with low productivity, the impact of organic farming on fertilizer demand is limited.

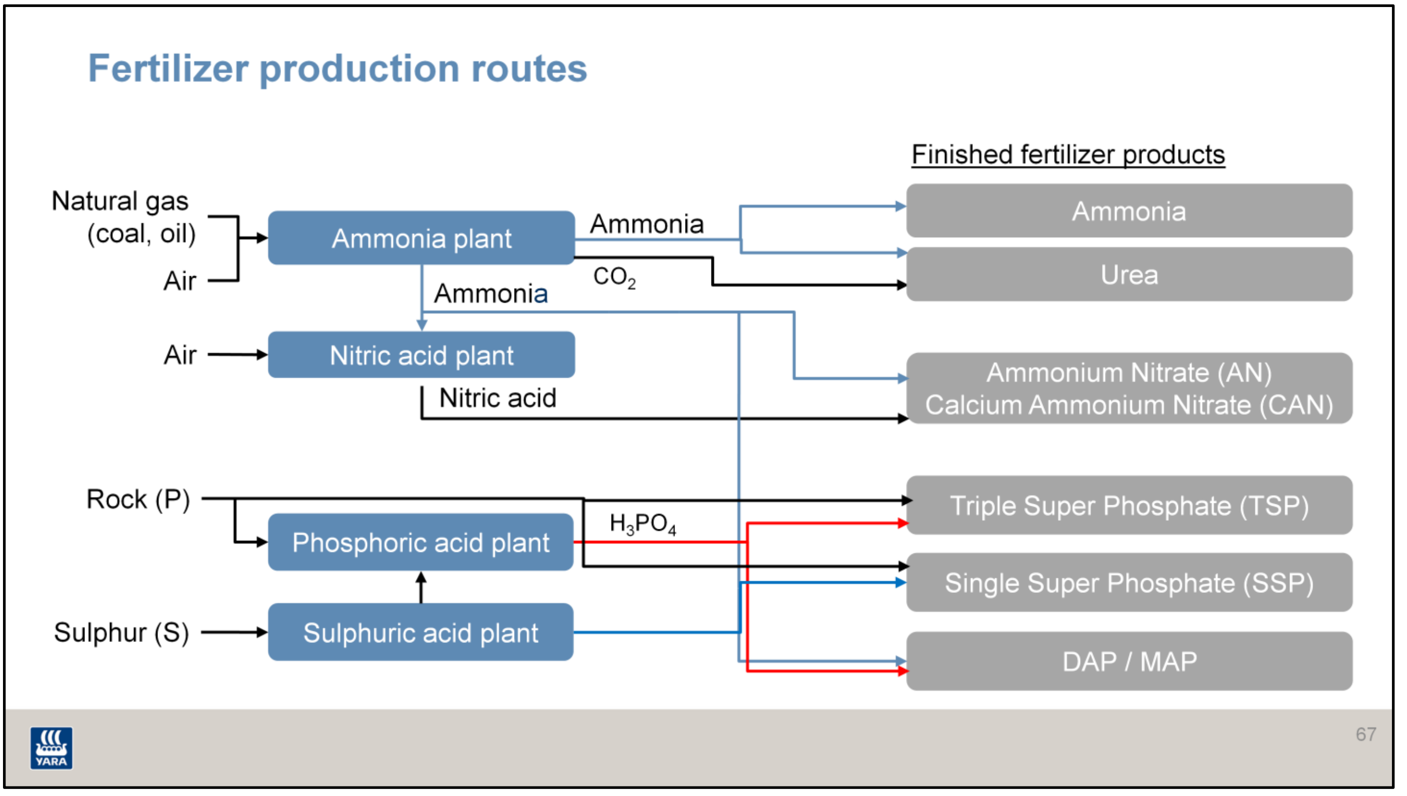
Drivers of supply



Natural gas is the major nitrogen cost driver

With a gas price of 6-8 USD per MMBtu, natural gas constitutes about 90% of ammonia cash production costs which is why almost all new nitrogen capacity (excluding China) is being built in low cost gas areas such as the Middle East, Northern Africa and North America.

Ammonia is an intermediate product for all nitrogen fertilizer, while nitric acid is a second intermediate product for the production of, e.g. nitrates. Finished fertilizer products are urea, nitrates (CAN, AN), NPK and others. Industrial products range from high purity carbon dioxide and basic nitrogen chemicals to industrial applications of upgraded fertilizer products.



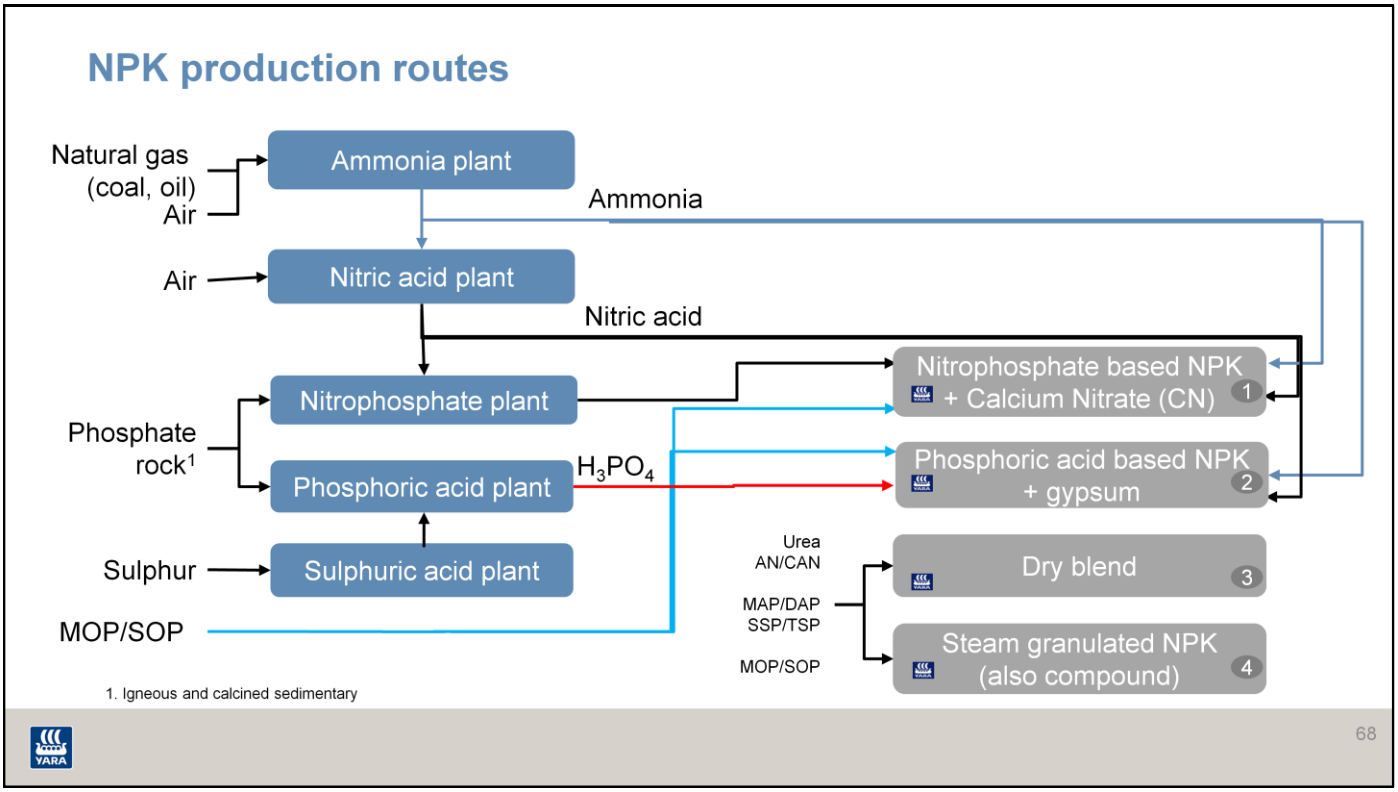
Industrial production of fertilizers involves several chemical processes

The basis for producing nitrogen fertilizers is ammonia, which is produced in industrial scale by combining nitrogen in the air with hydrogen in natural gas, under high temperature and pressure and in the presence of catalysts. This process for producing ammonia is called the ‘Haber-Bosch’ process.

Phosphorus is produced from phosphate rock by digesting the latter with a strong acid. It is then combined with ammonia to form Di-ammonium phosphate (DAP) or Mono-ammonium phosphate (MAP) through a process called ammonization.

Potassium is mined from salt deposits. Large potash deposits are found in Canada and Russia, which are the world’s major producers of this nutrient.

Phosphate and potash are sold separately or combined with, e.g. nitrogen, in NPK fertilizers.
The side streams of the main production process (e.g. gases, nitrogen chemicals) can be utilized for industrial products



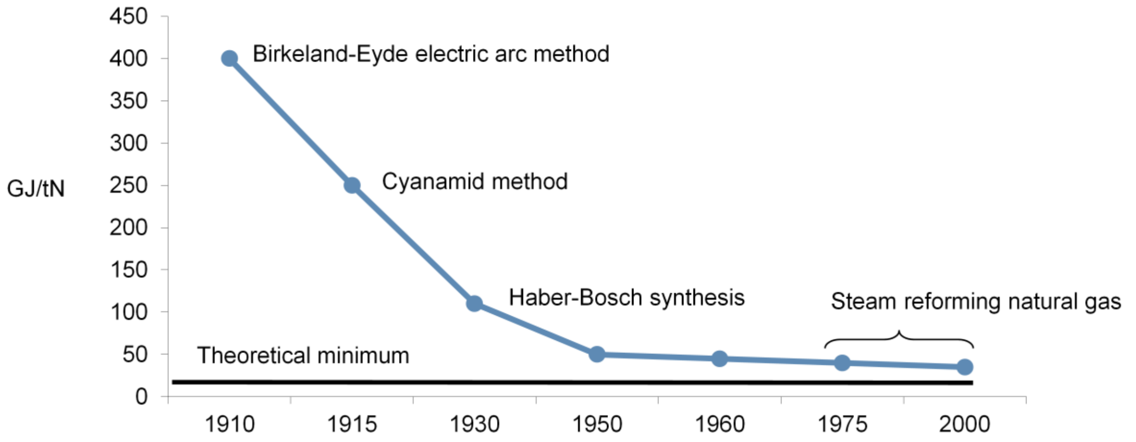
Four different ways to produce NPK fertilizers

Chemically produced NPK fertilizers are made by one of two production routes:
1) the nitrophosphate process or
2) the sulphuric acid (mixed-acid) process.

Phosphorus is produced from phosphate rock by digesting the latter with a strong acid (nitric acid or sulphuric acid). Potassium and other salts are added. The solution containing nitrogen in ammoniacal (NH_4) and nitrate (NH_3) form, phosphorus and potassium is either granulated or prilled. The result is a compound NPK where all the nutrients are included in one fertilizer particle. In addition the fertilizers may contain secondary nutrients (sulphur and magnesium) and/or micronutrients such as boron, zink and iron.

3) In a dry blended NPK, nitrogen, phosphorus and potassium raw materials in solid form are blended together in a bulk mixer.
4) The production of compound fertilizers by steam granulation, all the raw materials are in their solid (powder) form and mixed and granulated in the presence of water, steam and heat.

Nitrogen technology evolution



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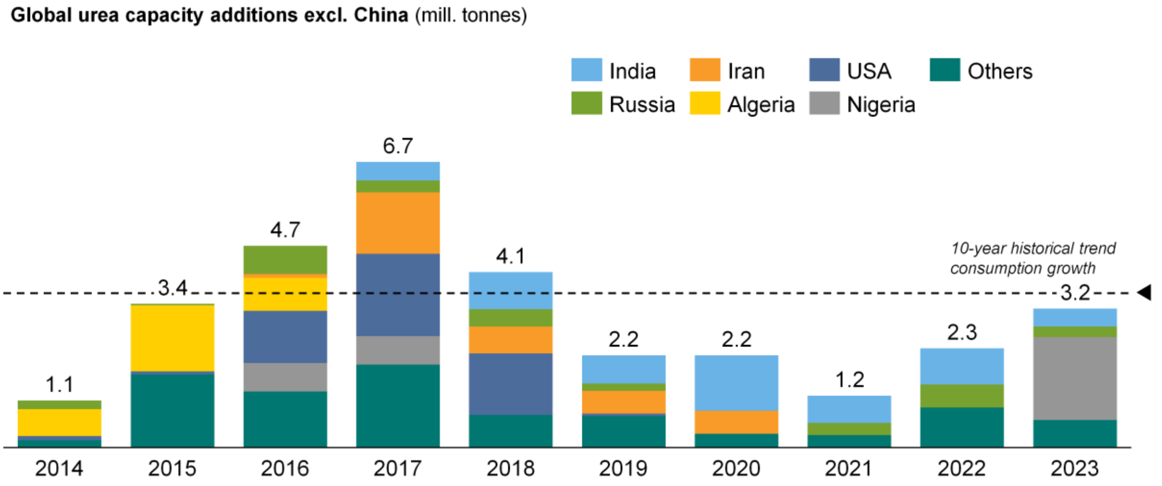
Reduced energy consumption in nitrogen manufacturing

The Haber-Bosch synthesis has not been challenged for almost 80 years, but technology development in the 20th century has reduced energy consumption down towards the practical and theoretical minimum.

The energy base has changed, and technological advances have improved energy efficiency significantly. The graph illustrates that the industry is now more sensitive to energy price than developments in technology.

Most nitrogen fertilizer plants utilize natural gas. However, any type of hydrocarbon or coal can be used. In China most plants use coal. Energy consumption can vary significantly. For an efficient plant using natural gas it takes approximately 33 MMBtu of natural gas to produce one tonne of ammonia (35 GJ). This translates into 40 MMBtu per ton nitrogen (42 GJ/tN). Converting ammonia to urea requires another 3 to 4 MMBtu per tonne urea. This translates into about 48 MMBtu per ton nitrogen (51 GJ/tN)). As a rule of thumb, ammonia plants using coal require between 50 per cent and 100 per cent more energy per unit of nitrogen produced.

Projected nitrogen capacity additions outside China



Source: CRU September 2018

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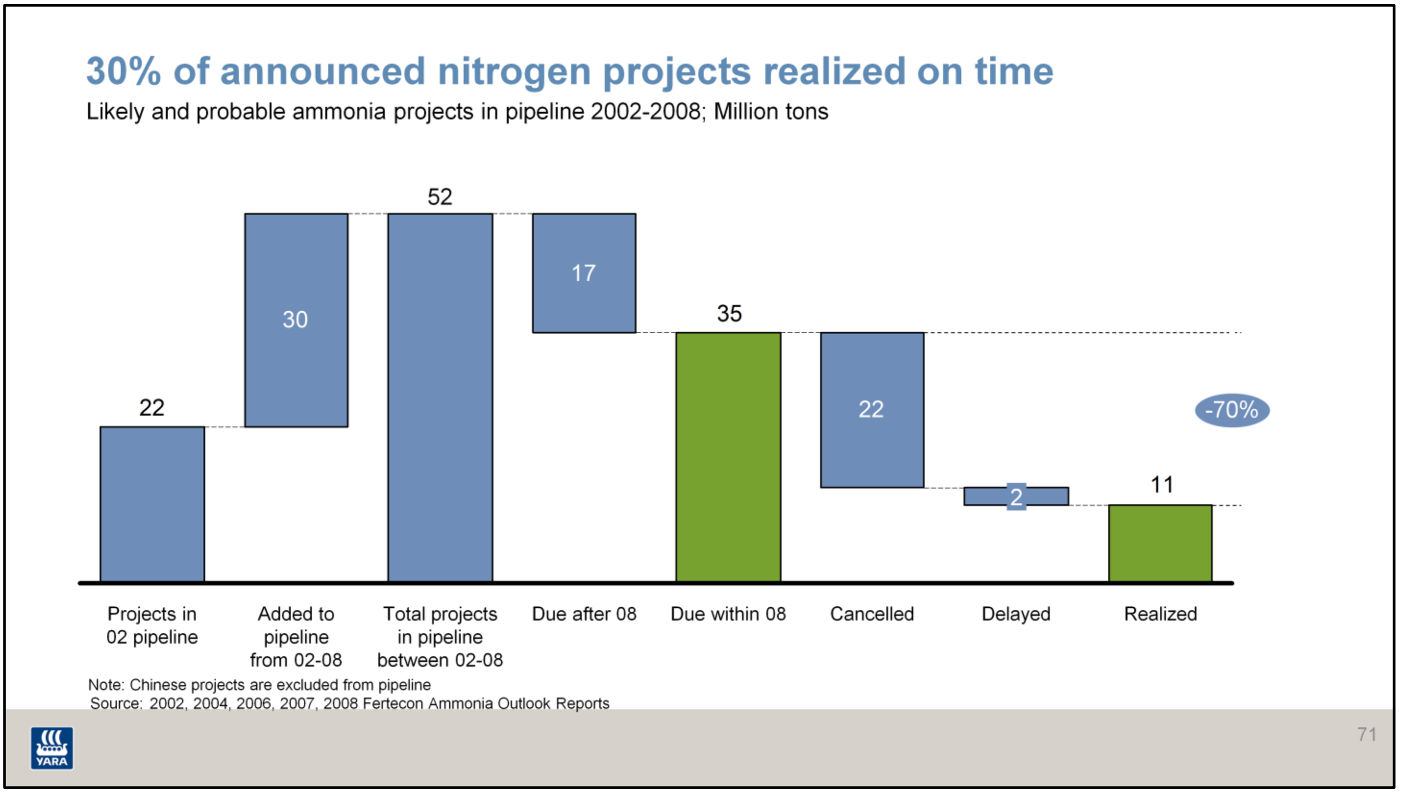
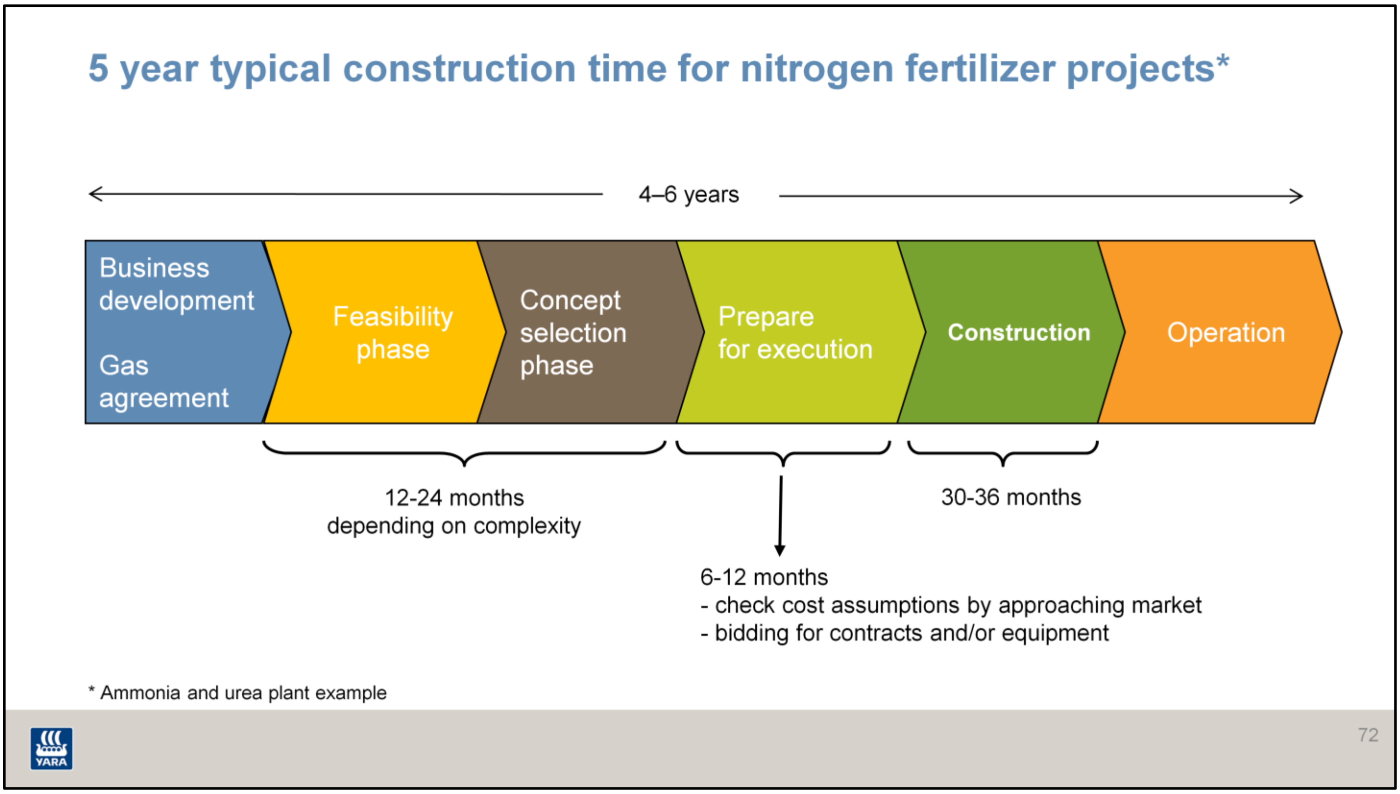
Urea capacity growth higher than consumption growth for the last years

Excluding China, the growth in nitrogen capacity over the last years has exceeded consumption growth meaning there has been less need for Chinese urea exports. Beyond 2018, the global urea supply-demand balance looks set to gradually improve as nitrogen supply growth is forecast to reduce significantly after 2018.



History shows that many ammonia projects are cancelled or delayed

Of the 35 ammonia projects in pipeline in 2002 to be completed within 2008, only 11 were realized.

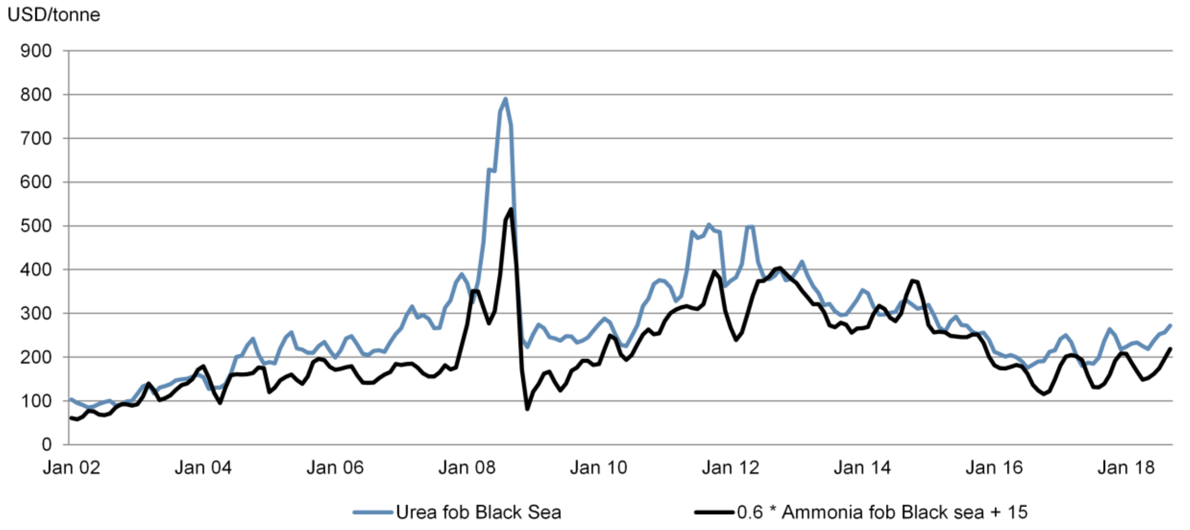


Long lead-time on projects

Over the last years it has typically taken at least 5-6 years from a project for a new ammonia and urea plant is initiated until the new plant is operational, even without unexpected delays.

Price relations

Upgrading margins from ammonia to urea



Source: Average of international publications

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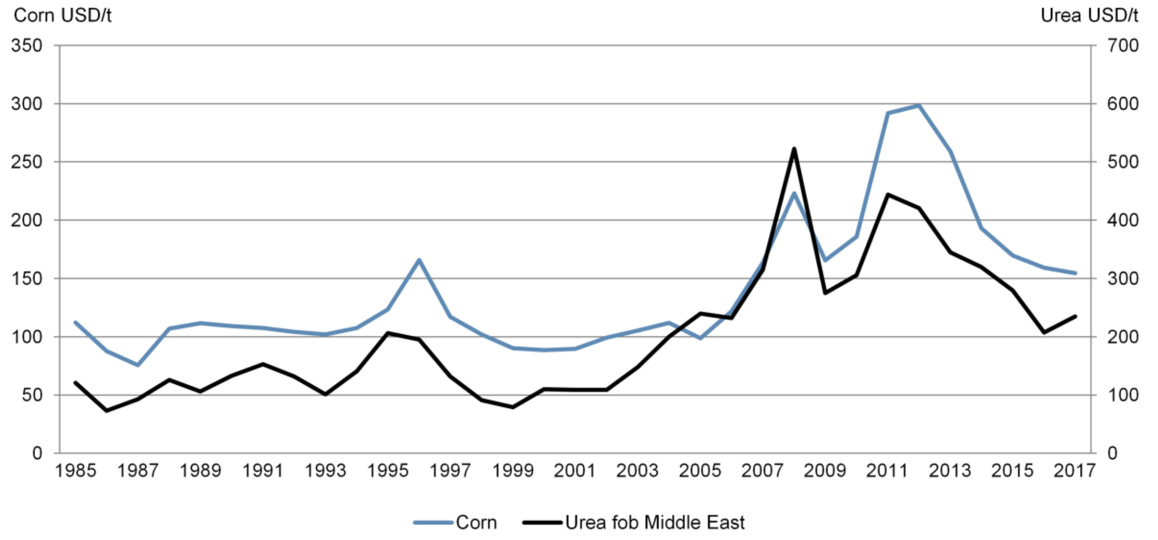
Upgrading margin for converting ammonia into urea

While energy costs for the ammonia swing producers set a price floor for ammonia, the ammonia price sets a floor for the urea price. If the urea price drops below this floor, more ammonia will be offered for sale, less urea will be sold, and the relationship will be restored.

In a tight supply/demand scenario for nitrogen where there is a demand driven urea margin, the correlation is lower. Such a scenario is often seen during periods with strong prices for agricultural soft commodities. Currently, the main swing producer for urea, China, has a higher cost base than the swing producer for ammonia, generating significant upgrading margins even if supply is plentiful.

Grain prices important for fertilizer demand

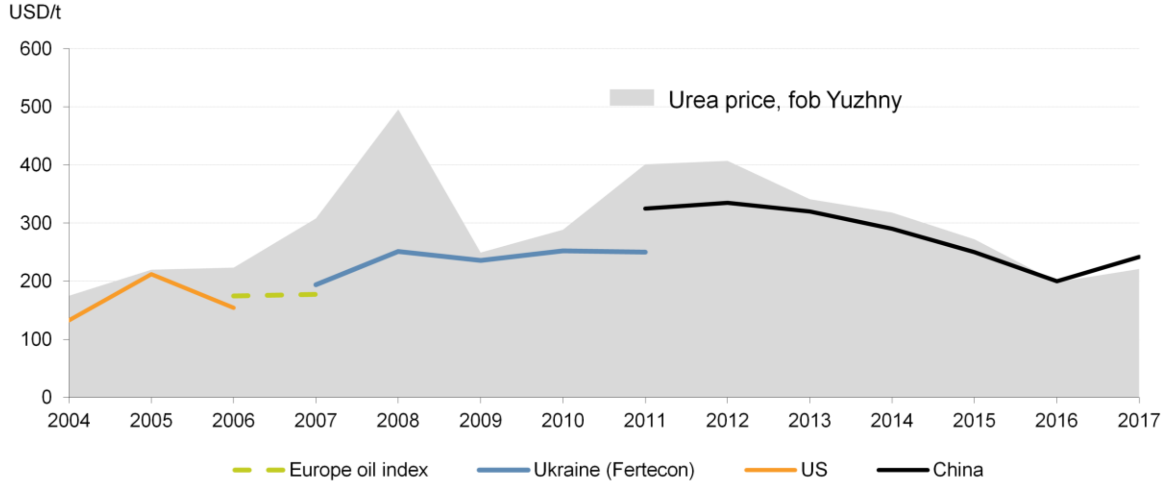


Source: World Bank, Fertilizer publications

Correlation between long-term grain and fertilizer prices

Variations in grain prices (corn or wheat) explain approximately 50% of the variations in the urea price, making grain prices one of the most important factors driving fertilizer prices.

The urea market has been supply-driven since 2014

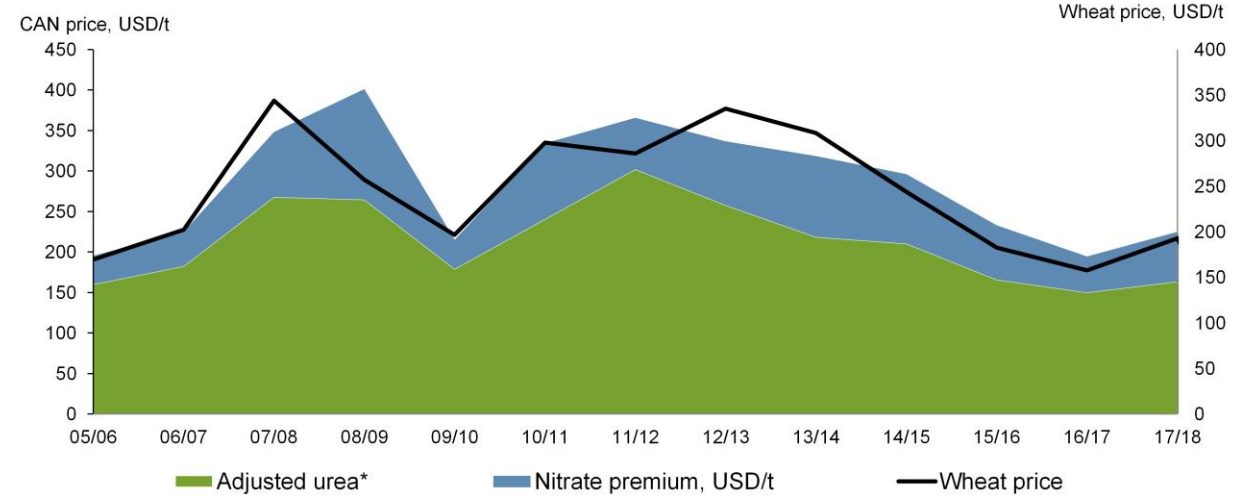


Source: Fertecon (Ukraine), Yara estimates

Average demand-driven margin of USD 70/t

The location of swing urea production has varied over the past decade, from the US Gulf, via Ukraine and now China. However, urea prices have only been supply-driven for shorter periods at a time, with the average demand-driven margin for the period 2004 – 2013 approximately USD 70 per ton. From 2014 the market has been supply-driven, with China as the swing producer. In 2017, global prices have at times dropped below the Chinese floor, as required volumes from China have dropped substantially.

Nitrate premium is mainly a function of crop prices and marketing



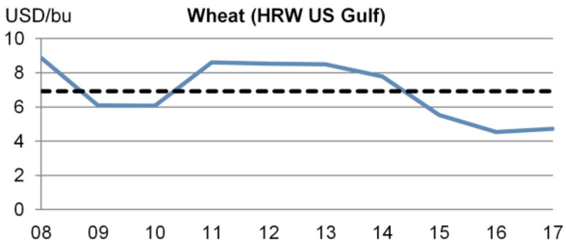
Source: World Bank, Fertilizer publications

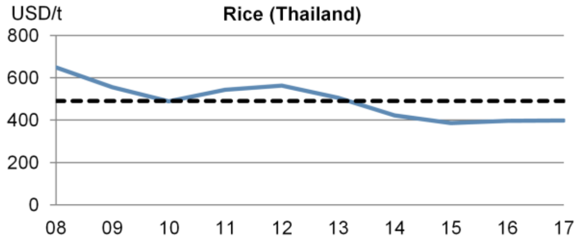
* Urea fob Black sea adjusted for import costs into Europe and nitrogen content similar to CAN

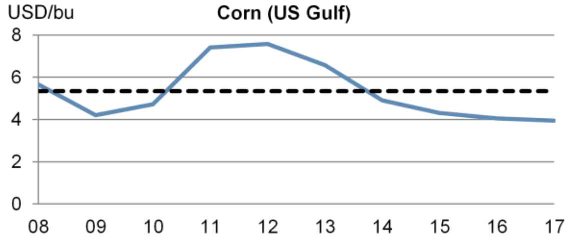
Urea prices determine the price range for nitrates

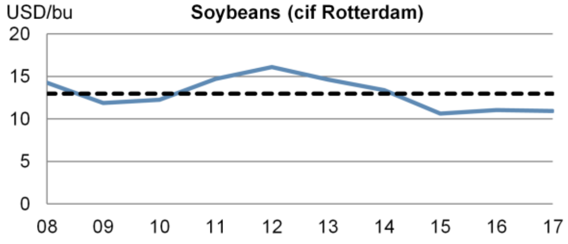
There is a strong correlation between urea and nitrate prices, as they to some extent are substitutes. For agronomic reasons linked to the effectiveness of the nitrogen form, farmers are willing to pay a higher price per unit nitrogen from nitrates than from urea. The correlation is stronger in the medium to long term than within a season. However, crop prices are also an important factor that impacts the nitrate price and the nitrate premium. The higher the crop value is, the more willing the farmer is to pay a premium for a product that gives a higher yield and quality.

Grain/oilseed prices – yearly averages





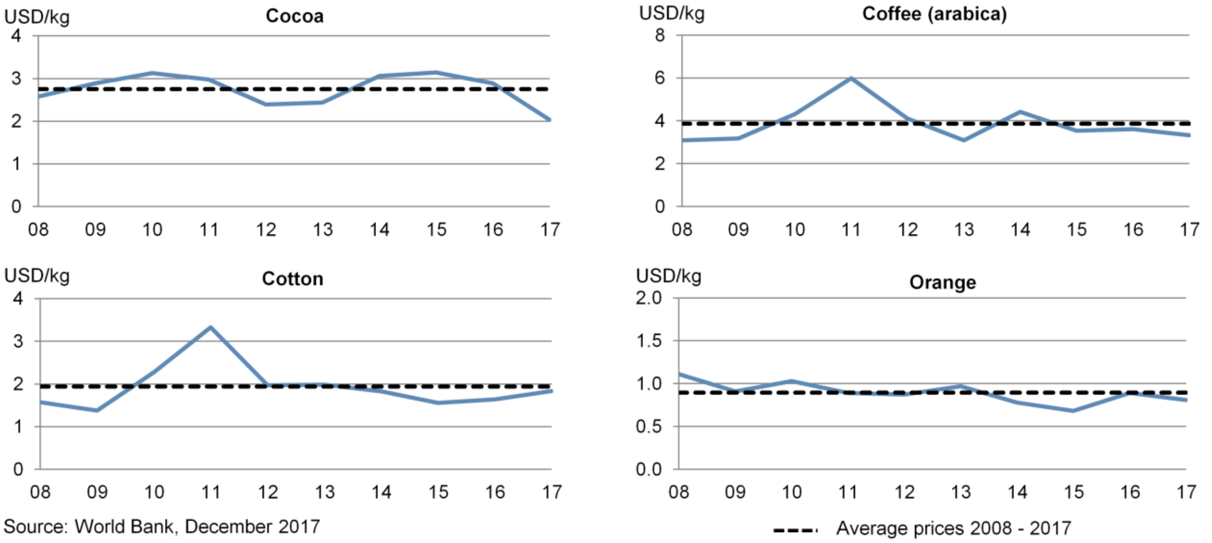




Source: World Bank, December 2017

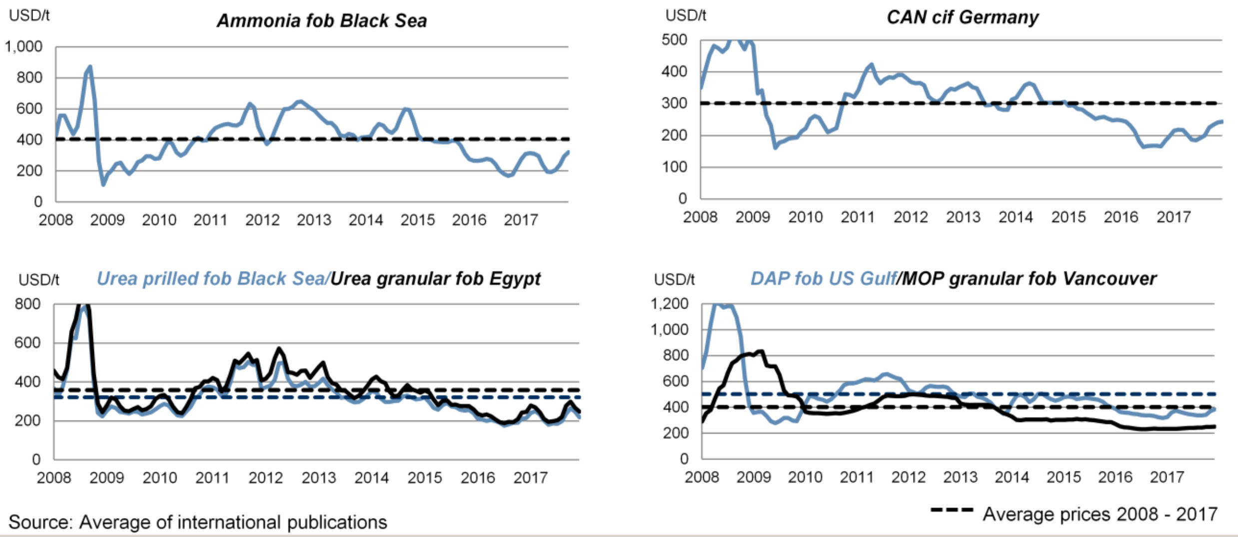
---- Average prices 2008 - 2017

Cash crop prices – yearly averages



Source: World Bank, December 2017

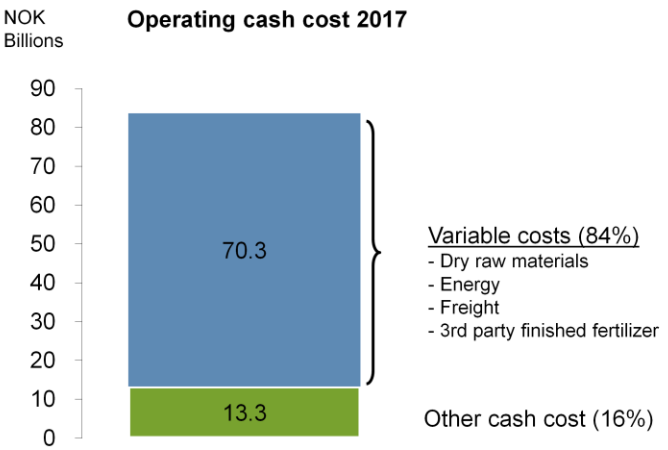
10-year fertilizer prices – monthly averages



Source: Average of international publications

Production economics

Yara's operating cash costs are mainly variable



- Temporary plant closures can be carried out with limited stop/start costs
- Example for ammonia/urea plants:
  - Typically half a week to stop and a week to start
  - Cost of stopping is 2 days energy consumption
  - Cost of starting is 3 days energy consumption

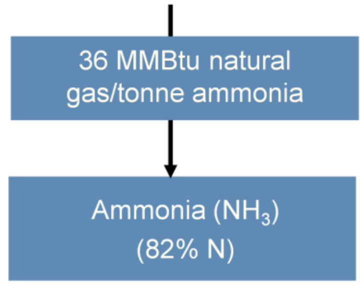
Production economics

Approximately 84% of Yara's operational cash costs are raw materials, energy and freight. A major part of these purchases can be terminated on short notice, reducing the financial consequences of delivery slow-downs.

Yara's plants can be stopped at short notice and at low cost as response to decline in deliveries or to take advantage of cheaper imported ammonia.

Ammonia cash cost build-up – example

	Gas price:	4	USD/MMBtu
x	Gas consumption:	36	MMBtu/mt NH_3
=	Gas cost:	144	USD/mt NH_3
+	Other prod. cost:	29	USD/mt NH_3
=	Total cash cost	173	USD/mt NH_3



Typical natural gas consumption for ammonia production

Source: Blue Johnson & Associates.

Natural gas costs the most important cost component

With a natural gas price of USD 4/MMBtu gas cost represents around 80% of the ammonia production cash costs in this example. One dollar increase in gas cost gives USD 36 higher gas costs.

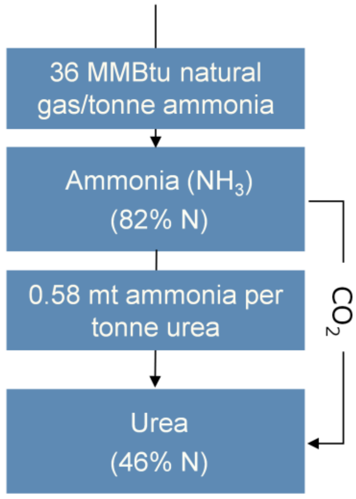
Most of the “other production costs” are fixed costs and therefore subject to scale advantages.

A new highly efficient plant may use natural gas in the low thirties range to produce one tonne of ammonia; the corresponding figure for old, poorly maintained plants will be in the mid-forties.

All cost estimates are fob plant cash costs excluding load-out, depreciation, corporate overhead and debt service for a US proxy plant located in Louisiana (~1,300 mt per day capacity).

Urea cash cost build-up – example

	Ammonia price:	173	USD/mt NH_3
x	Ammonia use:	0.58	NH_3/mt urea
=	Ammonia cost	100	USD/mt urea
+	Process gas cost*	21	USD/mt urea
+	Other prod. cost**:	25	USD/mt urea
=	Total cash cost	146	USD/mt urea



* Process gas cost is linked to natural gas price

** Including load-out

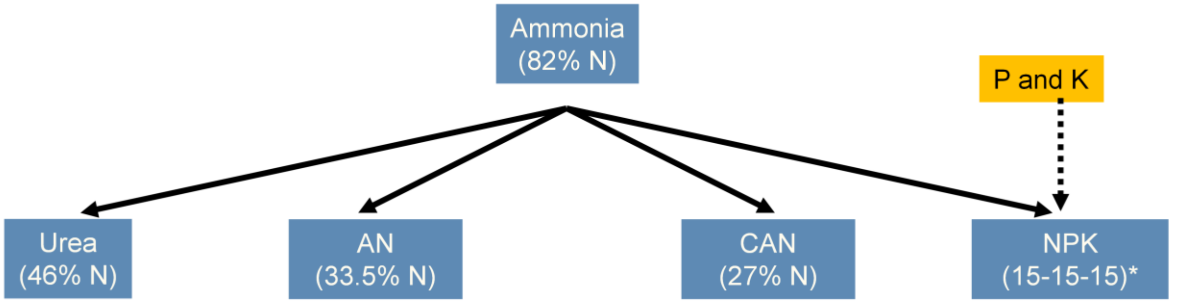
Source: Blue Johnson & Associates.

Ammonia is the main input for urea production

Typically, it takes 0.58 tonne ammonia for each tonne urea. If we add the gas cost in ammonia (USD 100) and the additional process gas costs needed for the production of urea (5.2 MMBtu x USD 4/MMBtu = USD 21), natural gas represents around 80% of the total production cash cost.

All cost estimates are fob plant cash costs excluding depreciation, corporate overhead and debt service for a US proxy plant located in Louisiana (~1,300 mt per day capacity).

Theoretical consumption factors



- Price comparisons should always be based on nutrient tons, not product tons

* There are many NPK formulas; 15-15-15 is one example

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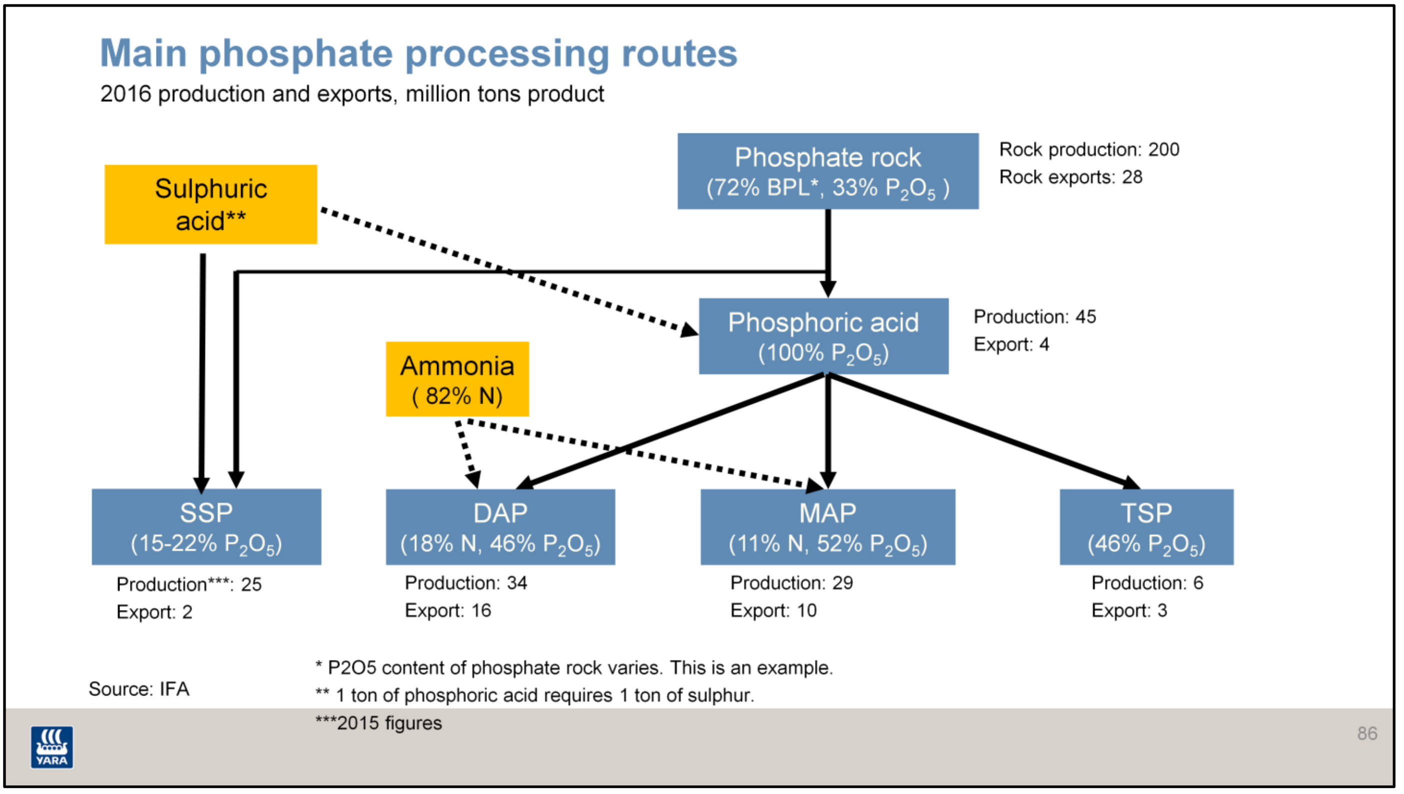
Consumption factors to compare price movements

As shown in the costing example for urea, the real ammonia consumption factor is above the theoretical consumption factor, which is based on nitrogen (N) content. The difference varies between plants according to their energy efficiency. Using the theoretical consumption factors is easier when making calculations. If the N content for a product is known (46% N in urea), the ammonia consumption factor can easily be calculated by dividing the figure with the N content in ammonia (0.46/0.82 = 0.56).

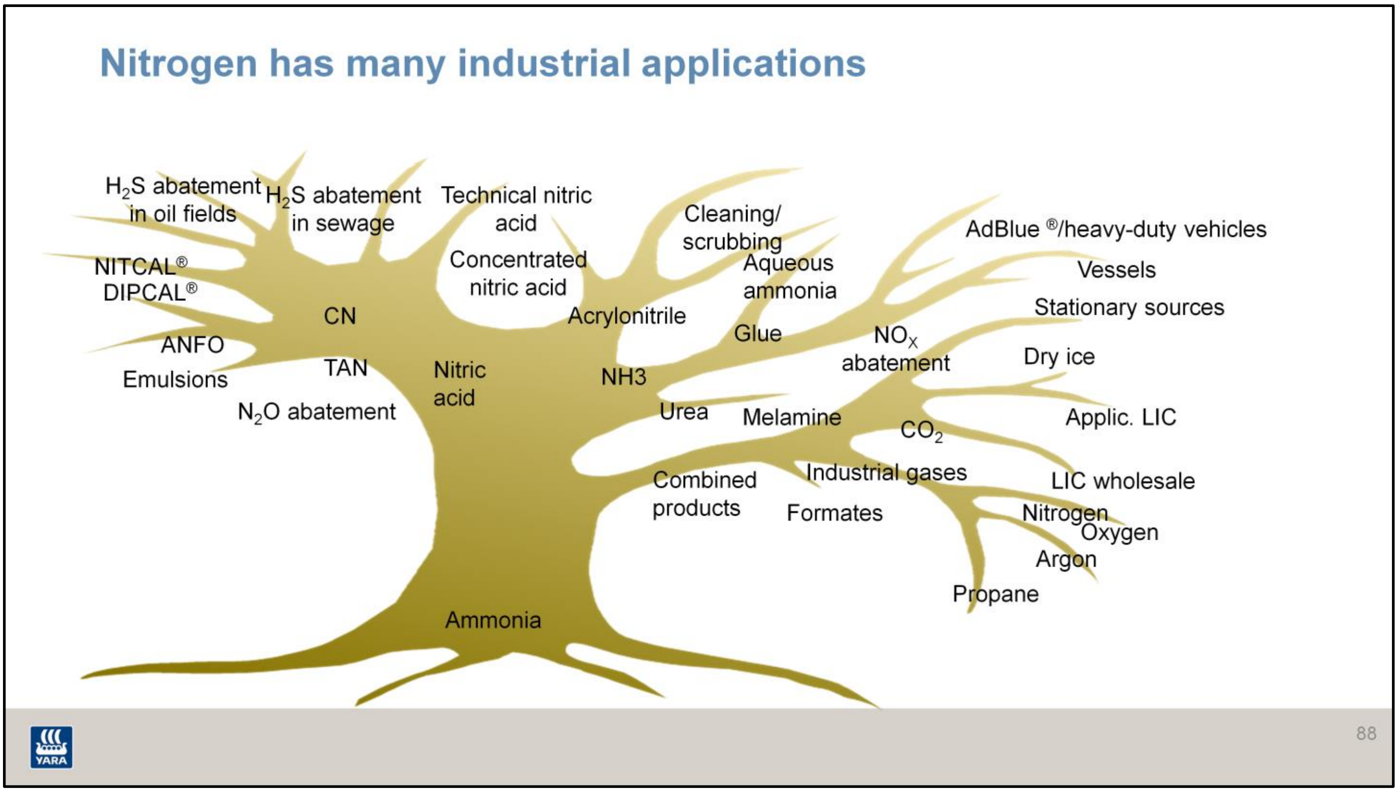
Based on this illustration, it is possible to follow relative variation in the various nitrogen prices. As an example, if ammonia becomes USD10/mt more expensive, the production cost of urea increases by 10 * 0.56 (0.46/0.82) = 5.6USD/mt. Similarly, if the urea price increases by USD10/mt, a price increase of 10 * (0.27/0.46) = USD5.9/mt of CAN would keep the relative pricing at the same level.



Phosphate processing routes

The three main phosphate finished fertilizer products are diammonium phosphate (DAP), monammonium phosphate (MAP) and triple superphosphate (TSP), all of which are based on phosphate rock processed via intermediate production of phosphoric acid. Single superphosphate (SSP) is produced by the reaction of sulphuric acid and phosphate rock. It is an important fertilizer product, despite its relatively low P2O5 content (ranging between 15 and 22% P2O5) due to its high water-solubility and its effectiveness as a source of secondary nutrients: sulphur (10-12% S in the readily available form of sulphate) and calcium.

Industrial applications



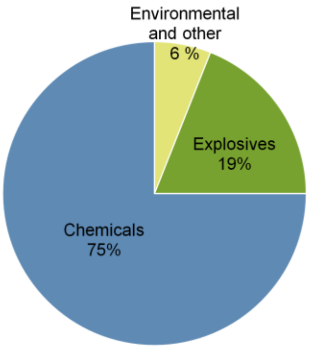
Main industrial products and applications

The ammonia nitrogen route provides opportunities in industrial processes where ammonia, urea or nitric acid can be used as traded raw materials. Examples are urea for the glue industry and ammonia for acrylonitrile producers (textile fibres). Other downstream applications are abatement of NO_x gases from power plants, industry and vehicles.

Another branch of the Industrial tree is nitric acid, where derived products are technical grade ammonium nitrates for explosives, and calcium nitrate for a range of applications including odour control, waste water treatment, treatment of drilling fluids, and catalyst applications for the production of rubber gloves.

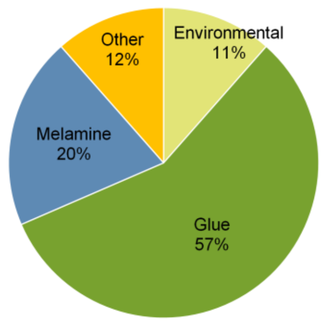
Industrial use accounts for 21% of global nitrogen consumption

~31.5 million tonnes N



~21% of total nitrogen consumption

~10 million tonnes N as urea



~13-14% of total urea consumption

Source: Yara estimates 2017, IFA, Fertecon, CRU, Integer

Multiple products and applications

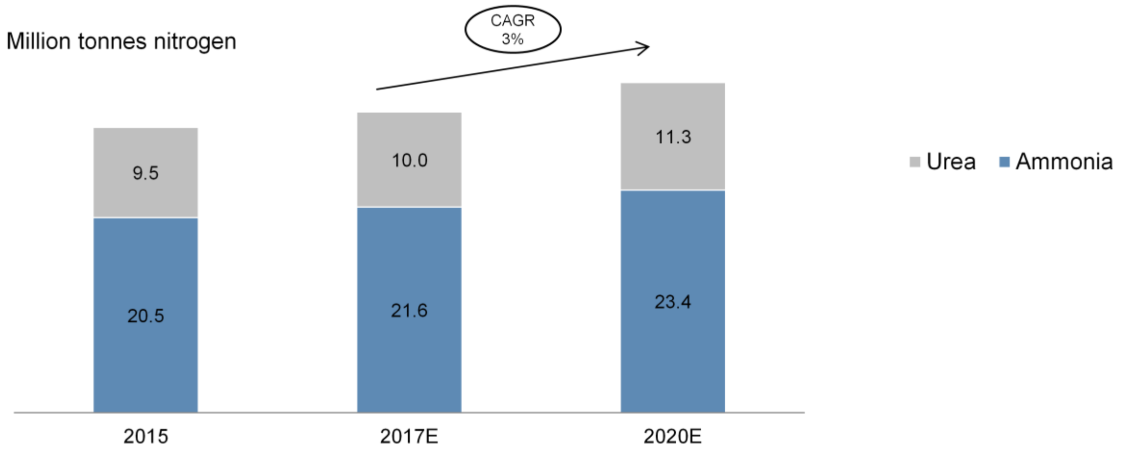
Chemicals is the largest segment where GDP growth in industrialized markets represents the key growth driver.

Environmental applications is the fastest growing segment, growth is driven by legislation and by the need to treat NO_x emissions from heavy-duty trucks and in the power sector.

Technical ammonium nitrate (TAN) is the most global of all Industrial business units, where Yara already is the world’s largest independent supplier of technical nitrates to the civil explosives industry. Asia and Australia are expected to drive growth in this business, with Europe and the US being more mature markets.

As industrial demand has a lower share of total urea demand than for nitrogen in total, the effect for the urea market is less. Industrial use of urea covers roughly 30-35% of total industrial nitrogen demand.

Global demand development of nitrogen chemicals for industrial applications is strong



Demand growth for Industrial applications
is estimated to ~3 % annually

Source: Yara estimates, IFA, Fertecon, CRU, Integer

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The pace of growth in nitrogen chemicals for Industrial applications is higher than for N-fertilizer growth

Reagents, technology and services to improve air quality

Nitrogen oxides (NOx) are a major air quality issue causing serious problems mostly in urban centers related to both the environment and human health. Legislation around the world drives the business growth.

- **Air 1™ AdBlue/DEF** is a generic name for urea-based solution (32.5% liquid urea) Air 1 is Yaras brand name for AdBlue that is used with the selective catalytic reduction system (SCR) to reduce emissions of oxides of nitrogen from the exhaust of diesel vehicles such as trucks, passenger cars and off-road vehicles
- **NOxcare™** As a world leader in reagents like urea and ammonia in combination with our experience in abatement systems like SNCR and SCR technology Yara offers its clients one of the most comprehensive and effective solutions to reduce NO_x emissions in industrial power plants and utilities.
- In the maritime segment Yara offers SCR and scrubber technologies to abate NOx and SOx (sulphuric oxide) emissions.

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Effective abatement of nitrogen oxides

NO_x emissions produce smog which is highly toxic to humans. Most national governments have given commitments, and are implementing legislation to reduce NO_x emissions and improve the air quality

Yara was at the forefront of product development when we created a new product for an application linked to NO_x abatement. This product is now called AdBlue, which is utilized with SCR technology for NO_x abatement in heavy-duty trucks, passenger cars and non-road vehicles such as tractors, construction and mining vehicles and trains. Yara is the world's largest producer of AdBlue, and its Air1 brand is the only global brand.

Similar technology, based on ammonia and/or urea, is used to reduce emissions of industrial installations such as power plants, cement factories, waste incinerators etc.

Europe is expected to progressively apply more stringent NO_x emission limits. Also in the marine segment legislations on NOx and SOx are being implemented.

Calcium Nitrate applications in wastewater treatment, concrete manufacturing, oil fields and latex industries

- **Nutriox™** provides H2S prevention for Corrosion, Odor and Toxicity control of municipal and industrial waste water systems
- **Nitcal™** is a multifunctional concrete admixture serving concrete admixtures companies around the world
- **PetroCare™** prevents well souring and supports drilling in oilfields around the world, for both the oil majors and the service companies that serve them
- **Dipcal™** is the premier dipping coagulant for the latex industry
- Other important applications are in the ceramics, bio-gas and solar CSP industries

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H_2S abatement for waste water

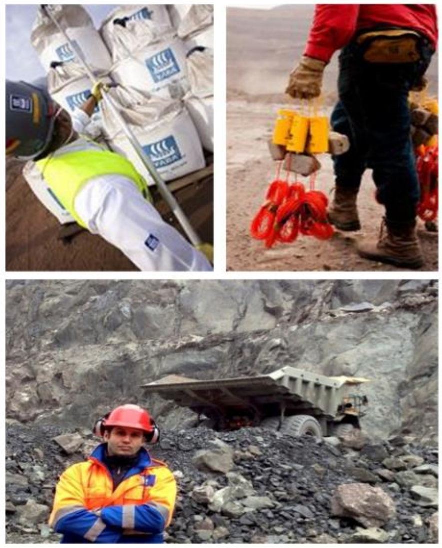
The presence of hydrogen sulphide (H_2S) in waste water and sludge is defined as a septic condition. By preventing septic conditions from arising, negative effects like odors, health hazards, corrosion and reduced efficiency of the treatment plant, can be eliminated or reduced.

Yara's calcium nitrate based septicity control process is a natural biological method of preventing septicity and removing H_2S by controlled dosage of nitrate. It can be used both for municipal sewer systems and industrial wastewater and sludge, and is non-toxic, non-corrosive, pH-neutral and safe-to-handle.

Nitrate-based products are also used to reduce H_2S toxic emissions in oil fields and pipelines.

Technical Nitrates for Civil Explosives

- Various grades of Ammonium Nitrate and Calcium Nitrate for use in the civil explosives and mining industries
- Largest customer segments are civil explosives companies, open-pit coal and iron mining sectors



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Technical AN: the main raw material for civil explosives

Technical ammonium nitrate is the main raw material for ANFO (Ammonium Nitrate Fuel Oil) which is the most used and most economical civil explosive currently on the market. The main civil explosive market segments are mining and infrastructure development.

ANFO was developed 40 years ago and has grown to be the most widely used industrial blasting agent in the world, due to its excellent manufacturing, handling and storage properties, low cost per energy unit, high safety levels and outstanding performance.

Calcium nitrate is used as a secondary nitrate in emulsion explosives. It extends the shelf life of the emulsion, increases the solubility of the ammonium nitrate and increases the total energy content of the emulsion.

Animal Feed industry with several nutritional products based on core chemicals

- **Feed Phosphates**
  - Macro-minerals such as phosphorus and calcium are essential elements to sustain healthy and productive animal growth
- **Feed Acidifiers**
  - Antimicrobial effect and lowering pH, replace AGP (antibiotic growth promoter) and effective against salmonella and moulds
- **Feed Urea**
  - Source of NPN (non-protein nitrogen) used by rumen micro-organisms forming proteins, replacing part of vegetable protein
- **Ammonia for fermentation**
  - Amino acids like lysine, methionine, threonine are essential to add to lower total use of protein

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Animal Feed industry with several nutritional products based on core chemicals

Sources of market information

- **Fertilizer market information**
  - Argus — www.argusmedia.com
  - Fertecon — www.fertecon.com
  - Fertilizer Week — www.cruonline.crugroup.com
  - Profercy — www.profercy.com
  - The Market — www.icispricing.com
  - Green Markets (USA) — www.fertilizerpricing.com
  - Beijing Orient Business (China) — www.boabc.com
  - China Fertilizer Market Week — www.fertmarket.com
- **Fertilizer industry associations**
  - International Fertilizer Industry Association (IFA) — www.fertilizer.org
  - Fertilizers Europe (EFMA) — www.fertilizerseurope.com
- **Food and grain market information**
  - Food and Agriculture Organization of the UN — www.fao.org
  - International Grain Council — www.igc.org.uk
  - Chicago Board of Trade — www.cmegroup.com
  - World Bank commodity prices — www.worldbank.org
  - US Department of Agriculture (USDA) — www.usda.gov


Knowledge grows