fertilizers europe

Towards smart agriculture...

The challenge

Mineral fertilizers have an essential role to play in meeting the twin challenges of feeding an increasing world population and limiting climate change. At the vanguard of agriculture's green revolution, they are estimated to contribute today to more than half of the world's food production and protein supply.

Fertilizers Europe believes that the focus of European agricultural policy should be on improving the performance of the agricultural sector in terms of its productivity and efficiency. This will enable European farmers to increase Europe's self-sufficiency and its contribution to global food needs, as well as lead to more sustainable agricultural production. The sustainable intensification of European agriculture through the efficient use of mineral fertilizers can help the sector respond to the main EU policy goals.

Directly Available Nitrogen (DAN) fertilizers offer farmers and agronomists a precise and reliable means of increasing food and energy production in an environmentally acceptable way. DAN fertilizers, based on nitrate and ammonium, combine the benefits of the two simplest forms of reactive nitrogen that are directly available to plants.

This brochure sets out the main aspects of the agronomic and environmental impact of different types of nitrogen fertilizer currently in use in Europe and the benefits of DAN fertilizers such as Ammonium Nitrate (AN), Calcium Ammonium Nitrate (CAN) and Ammonium Nitrosulphate.


the DAN family
“Use of the right form of nitrogen fertilizer is of great importance as different products have different environmental impacts,” Daniella.
“Combining good agricultural practice with DAN fertilizers enhances nitrogen-use efficiency and minimizes environmental losses,” Danny.
“Directly Available Nitrogen (DAN) fertilizers will put enough food on my table. Even when I am grown up,” Dani.
DAN
Directly Available Nitrogen

Contents

Nitrogen: essential to life

Over the years, the majority of European farmers have found directly available nitrogen (DAN) fertilizers to be an effective and efficient source of nitrogen for crops. However, other mineral sources of nitrogen are also used which interact with the soil in a different way. These differences need to be taken into account when evaluating their agronomic and environmental performance.

99% of the nitrogen on earth is stored in the atmosphere.

This nitrogen is not directly available to most plants.

NITROGEN IN NATURE

Nitrogen (N) is a vital element for plant life. It stimulates root growth and photosynthesis, as well as uptake of other plant nutrients such as phosphorus (P) and potassium (K). However, 99% of the nitrogen on earth is stored in the atmosphere and less than 1% is available in the earth's crust. The nitrogen molecules (N_2) in the atmosphere are chemically inactive and cannot be easily absorbed by plants.

Agriculture further depletes reactive nitrogen from the soil. Nitrogen is absorbed during plant growth and then exported from the field, mostly in protein, when crops are harvested. It needs to be restored by organic and mineral sources of nitrogen. Fertilizers, whether applied as manure or as mineral nitrogen, are therefore a key element of sustainable agriculture.

Lack of nitrogen results in declining soil fertility, low yields and low crop quality. On the other hand, excess nitrogen in the soil may move into the ground water, cause eutrophication of surface water or escape into the atmosphere, potentially causing pollution and warming of the climate.

MINERAL NUTRITION

The main mineral fertilizers come from naturally occurring raw materials which have been transformed into a more plant-available form by industrial processing:

- Nitrogen (N), taken from the air, is essential as an important component of plant proteins.
- Phosphorus (P), extracted from mined ores, is a component of nucleic acids and lipids, and is key to energy transfer.
- Potassium (K), extracted from mined ores, has an important role in plant metabolism, for photosynthesis, activation of enzymes, osmoregulation, etc.

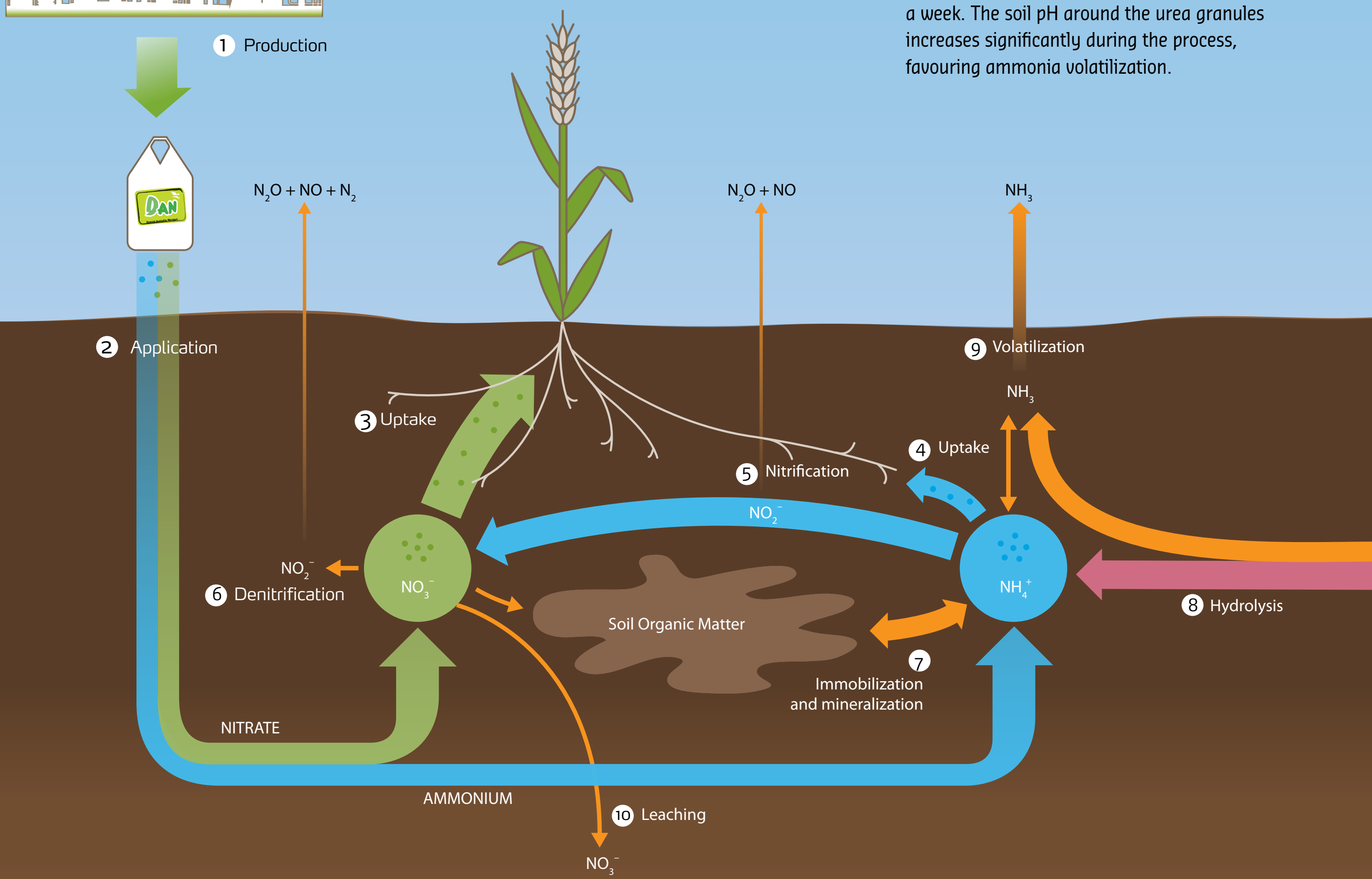
Principal mineral sources of nitrogen fertilizers in use in Europe are:

- Ammonium nitrate (AN) contains nitrogen as NH_4^+ (ammonium) and as NO_3^- (nitrate) in equal portions.
- Calcium ammonium nitrate (CAN) contains in addition dolomite or limestone.
- Urea ammonium nitrate (UAN) is an aqueous solution of urea and ammonium nitrate.
- Urea contains nitrogen in its amide (NH_2) form.

Understanding the nitrogen cycle

NITROGEN UNDERGOES TRANSFORMATIONS IN THE SOIL, DEPENDING ON THE COMPOSITION OF THE NITROGEN APPLIED. WHILE NITRATE IS TAKEN UP DIRECTLY BY THE PLANT, LOSSES CAN OCCUR WHEN AMMONIUM AND UREA NEED TO BE FIRST TRANSFORMED INTO NITRATE.

1. Energy in the form of natural gas is combined with nitrogen from the air to form ammonia, the principal building block of nitrogen fertilizers (AN, urea).
2. Nitrogen fertilizer can be applied in the form of mineral nitrogen, ammonium, nitrate, urea or a mix, and organic fertilizers and manure containing complex organic nitrogen compounds and ammonium.
3. Uptake of nitrate is rapid due to its high mobility. Most plants prefer nitrate over ammonium.
4. Uptake of ammonium is slower than nitrate. Ammonium is bound to clay particles in the soil and roots have to reach it. Most of the ammonium is therefore nitrified before it is taken-up by plants.
5. Nitrification by soil bacteria converts ammonium into nitrate in a period of a few days to a few weeks. Nitrous oxide and nitric oxide are lost to the atmosphere during the process.
6. Denitrification occurs when micro-organisms lack oxygen (water logging and soil compaction). In this process soil bacteria convert nitrate and nitrite into gaseous nitrous oxide, nitric oxide and nitrogen. These are lost to the atmosphere.
7. Immobilization transforms mineral nitrogen into soil organic matter. Activity of soil microbes is mainly stimulated by ammonium. Immobilized nitrogen it is not immediately available for plant uptake, but needs to be mineralized first. Mineralization of soil organic matter (and manure) releases ammonium into the soil.
8. Hydrolysis of urea by soil enzymes converts urea into ammonium and CO_2 gas. Depending on temperature, hydrolysis takes between a day and a week. The soil pH around the urea granules increases significantly during the process, favouring ammonia volatilization.



Transformation of urea, ammonium and nitrate in the soil. Urea suffers the highest transformation losses, nitrate the lowest.

PRODUCT	NITROGEN CONTENT		
	urea-N $CO(NH_2)_2$ → *Hydrolysis* →	ammonium-N (NH_4^+) → *Nitrification* →	nitrate-N (NO_3^-) → *Uptake*
Ammonium Nitrate		50%	50%
Calcium Ammonium Nitrate		50%	50%
Urea Ammonium Nitrate	50%	25%	25%
Urea	100%		

Common forms of mineral nitrogen fertilizer contain nitrogen as nitrate, ammonium or amide in different proportions. Only nitrate is easily taken up by plants. Amide and ammonium are transformed into nitrate by hydrolysis and nitrification.

9 Ammonia volatilization occurs when ammonium is converted to ammonia, which is lost to the atmosphere. A high soil pH level favours this conversion. If it takes place at the soil surface, losses are highest. These two conditions are met when urea is spread and not immediately incorporated and absorbed.

10 Leaching of nitrate occurs mainly in winter when rainfall washes residual and mineralized nitrates below the root zone. Accurate fertilization reduces leaching during and after the growth period.

Nitrogen from nitrate

Nitrate (NO_3^-) is easily absorbed by plants at high rates. Unlike urea or ammonium, it is immediately and fully available as a nutrient. Nitrate is highly mobile in the soil and reaches the plant roots quickly. Applying nitrogen as ammonium nitrate or calcium ammonium nitrate therefore provides a directly available nutrient supply.

The uptake of negatively charged nitrate is associated with uptake of positively charged nutrients such as magnesium, calcium and potassium.

It is important to note that essentially all the nitrogen in the soil, whether applied as urea, ammonium or nitrate, ends up as nitrate before plants take it up. If nitrate is applied directly, losses from the transformation of urea to ammonium and from ammonium to nitrate are avoided.

Nitrogen from ammonium

Ammonium (NH_4^+) is absorbed by plants at low rates. The positively charged ion is fixed to soil minerals and is less mobile than nitrate (NO_3^-). Plant roots therefore need to grow towards the ammonium. Most of the ammonium is transformed into nitrate by soil microbes. This nitrification process depends on temperature and takes between one and several weeks.

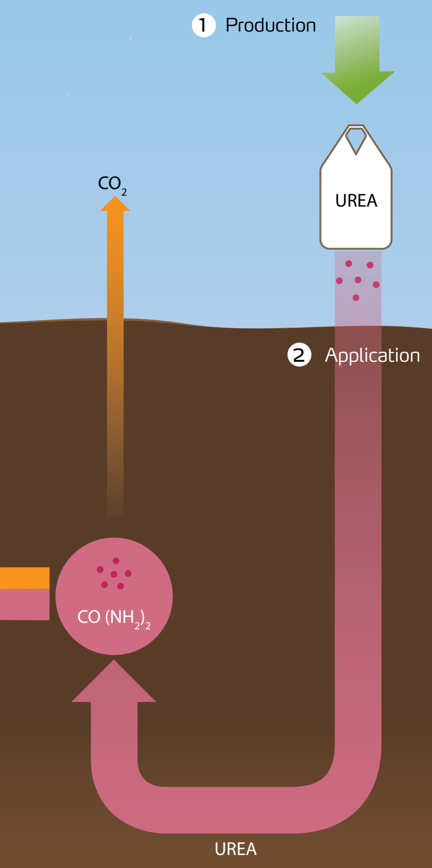
Another part of the ammonium is immobilized by soil microbes and released only over longer periods of time, thus building up soil organic matter.

Nitrogen from urea

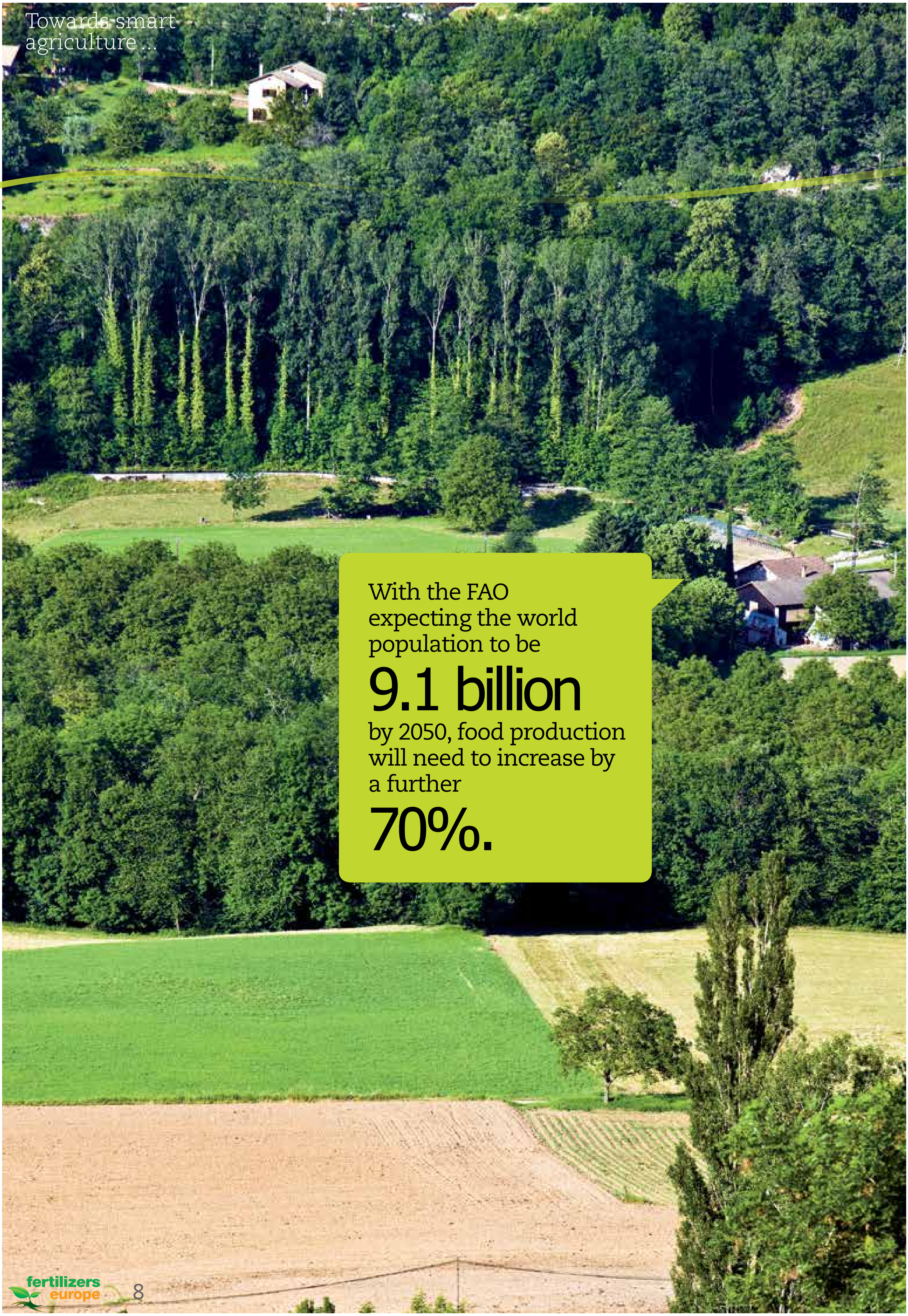
Plant roots do not directly absorb the ureic form of nitrogen in significant quantities. Urea needs to be first hydrolysed to ammonium by soil enzymes, which takes between a day and a week, depending on temperature. Moisture is required for hydrolysis.

The ammonium generated by urea hydrolysis does not, however, behave exactly as the ammonium from ammonium nitrate. Hydrolysis of urea results in a short-term alkalinization in the immediate vicinity of the urea grain applied. It shifts the natural balance between ammonium (NH_4^+) and ammonia gas (NH_3) to the latter form, resulting in volatilization losses. The use of a urease inhibitor can help mitigate these.

These losses are the main reason for the lower N-efficiency observed with urea. This is also the reason why urea, whenever possible, should be incorporated into the soil immediately upon application.



CO_2	carbon dioxide (gas)
$CO(NH_2)_2$	urea
NH_3	ammonia (gas)
NH_4^+	ammonium
NO_3^-	nitrate
NO_2^-	nitrite
NO	nitric oxide (gas)
N_2O	nitrous oxide (gas)
N_2	nitrogen (gas)



With the FAO expecting the world population to be

9.1 billion

by 2050, food production will need to increase by a further

70%.

Feeding the world

An expanding world population and increasing environmental concerns are putting agriculture under a whole new spotlight. How can agricultural policy reconcile food security and environmental protection? How can agronomic performance be weighed against environmental burden? What is the role of mineral fertilizers and what are the best choices?

MEETING EUROPE'S FOOD NEEDS

As highlighted by the FAO, during the past half-century the "green revolution" has tripled food production, thanks largely to the use of mineral fertilizers. At the same time, the world population has increased from 3 to 7 billion people.

The population is increasing but available arable land is limited (Fig.1). With the FAO expecting the world population to be 9.1 billion people by 2050, food production will need to increase by a further 70%. In addition, the decreasing amount of land available for conversion to agriculture means that optimizing production from existing agricultural area is a necessity. [ref.1]

European agriculture is one of the most efficient and productive worldwide. Nevertheless, the European Union has emerged as the world's largest importer of agricultural commodities. Europe's imports exceed its exports by 65 million tons, with an increase of 40% over the last decade. The area outside the European Union required for producing these imports amounts to almost 35 million hectares, approximately the size of Germany [ref.2].

Further progress in yield and productivity are required to meet the challenges of the 21st century. Mineral fertilizers are essential to support the efficient use of arable land and can help to ensure food security on a global scale, protect existing forests and grassland from conversion to arable land, therefore avoiding land use change and related carbon losses.

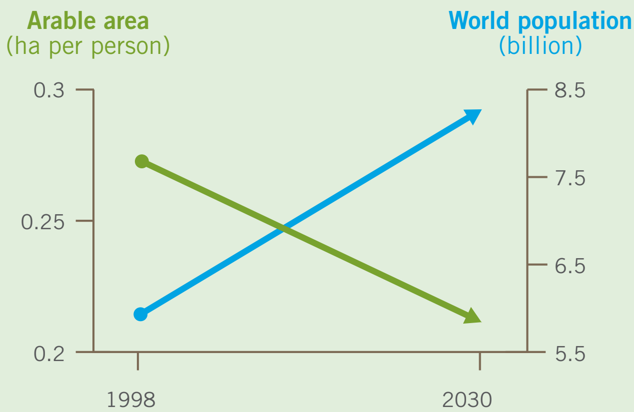
As illustrated earlier, using the right form of nitrogen, such as that provide by DAN fertilizers, is of major importance.

Using the right form of nitrogen, such as that from DAN fertilizers, is of major importance.

It can help feed the world and preserve the environment.

Fig. 1

WORLD POPULATION VERSUS AVAILABLE ARABLE LAND 1995 - 2030



The world population is increasing but available arable land is limited [ref. 1].

Optimizing yield and quality

Use of the right source of fertilizer is essential. Different mineral sources of nitrogen have different effects on yield and crop quality. This has been well known by European farmers for decades.

The different performance of mineral nitrogen sources is mainly due to differences in losses, especially volatilization but also leaching. Some of these losses are aggravated by a mismatch between the nitrogen supply and the plant uptake.

Field studies in France, Germany and the United Kingdom have shown that DAN fertilizers have consistently returned higher yields and better crop quality than urea. Most underperformance observed with UAN and urea can be compensated for by a higher nitrogen dosage, although at the cost of increased environmental burden.

95% of European farmers rely on mineral fertilizers.

Best Agricultural Practice and precision farming tools can enhance fertilizer efficiency and minimize nitrogen losses.

France (Fig. 2)

At the optimum N rate which was on average 182 kg/ha, ammonium nitrate produced 0.26 t more yield and 0.75 points higher protein content than UAN. An additional 27 kg N/ha (15%) from UAN was needed to reach the economic optimum [ref. 3].

Germany (Fig. 3)

In Germany, 55 field trials were conducted between 2004 and 2010 with winter cereals and various soil types. With the optimum N rate being on average 210 kg/ha, calcium ammonium nitrate produced 2% more yield and 0.23 points higher protein content than urea. An additional 15 kg N/ha (7.1%) from urea was needed to reach the economic optimum [ref. 4].

United Kingdom (Figs. 4,5,6)

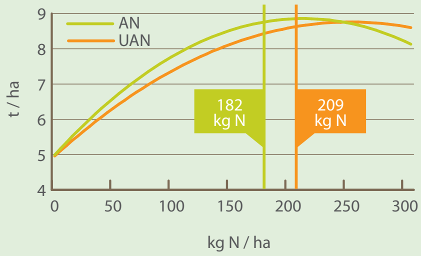
The most extensive study comparing different forms of nitrogen fertilizers was performed on behalf of the UK government's Department for Environment, Food and Rural Affairs (Defra) between 2003 and 2005 [ref. 5]. Besides quantitative differences, the study highlighted the variability of results observed with urea and UAN. Therefore the additional nitrogen application rates required with urea and UAN cannot be predicted with the same reliability as with ammonium nitrate.

France (Fig. 7)

Results of the ADA experiment in France (AN vs urea) demonstrate that, over the long term (year after year repeated use), AN gave a better nitrogen efficiency compared to urea. At any application rate, the yield with AN is greater by 4 to 6% compared to urea with wheat and rapeseed. An extra dose of 40 kg N is necessary with urea to obtain the same yield [ref. 6].

Fig. 2

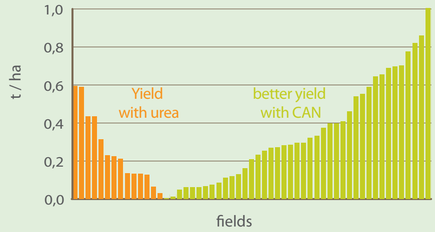
YIELD COMPARISON RESPONSE CURVES FOR AN AND UAN IN FRANCE



The N response curves for the trials indicate that on average an additional 27 kg of nitrogen would have been needed with UAN to reach economic optimum [ref. 3].

Fig. 3

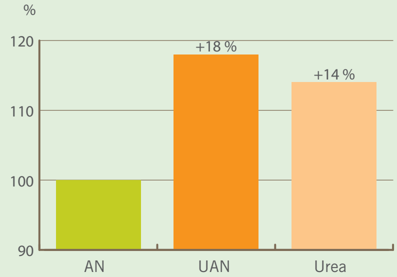
YIELD COMPARISON AN/UREA AT 55 LOCATIONS IN GERMANY



Out of 55 fields fertilized at N-optimum in Germany, 75% produced a better yield with calcium ammonium nitrate and 25% produced a better yield with urea [ref. 4].

Fig. 4

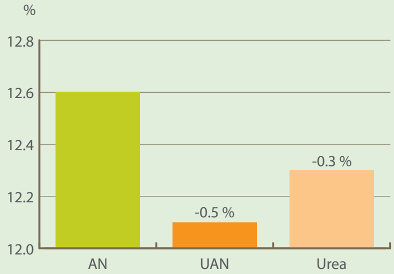
EXTRA N REQUIRED FOR SAME YIELD



To maintain the same yield, significantly more nitrogen was needed from urea and UAN than from ammonium nitrate [ref. 5].

Fig. 5

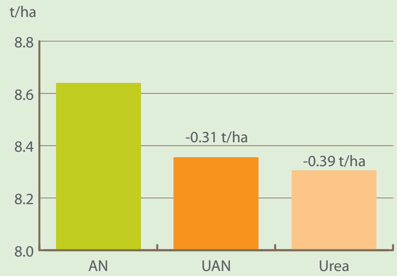
PROTEIN CONTENT AT IDENTICAL N RATE



Protein content was lower on fields fertilized with urea or UAN than with ammonium nitrate [ref. 5].

Fig. 6

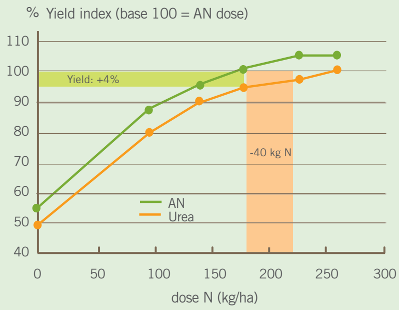
YIELD AT IDENTICAL N RATE



Yield was also lower with urea and UAN than with ammonium nitrate [ref. 5].

Fig. 7

NITROGEN EFFICIENCY



Effect over time of different forms of N supplied. (Réseau ADA 2008-2011, 30 test results on rape, wheat, barley) [ref 6].

Preserving the environment

DIRECTLY AVAILABLE NITROGEN (DAN) FERTILIZERS (AMMONIUM NITRATE AND CALCIUM AMMONIUM NITRATE) HAVE DEMONSTRATED CLEAR ENVIRONMENTAL ADVANTAGES OVER OTHER FORMS OF NITROGEN FERTILIZER. THEY DISPLAY A LOWER CARBON FOOTPRINT OVER THEIR LIFE-CYCLE, INCLUDING PRODUCTION AND APPLICATION AND A LOWER AMMONIA VOLATILIZATION, EVEN IF THEY ARE NOT INCORPORATED INTO THE SOIL.

Fig. 8

AVERAGE AMMONIA EMISSIONS PER KG OF NITROGEN APPLIED FOR DIFFERENT FERTILIZER TYPES

VOLATILIZATION LOSSES [% N]	ARABLE LAND		GRASSLAND	
	EMEP	Defra	EMEP	Defra
CAN AN	0.6%	3 (-3-10)%	1.6%	2 (-4-13)%
UAN	6%	14 (8-17)%	12%	N.A.
Urea	11.5%	22 (2-43)%	23%	27 (10-58)%

The table includes data from the official European Emission Inventory (EMEP) as well as from a UK Government Department of Environment, Food and Rural Affairs (Defra) study. In all cases, volatilization losses are significantly higher with urea and UAN than with (calcium) ammonium nitrate [refs. 7,8,9].

Reducing ammonia emissions to air

The European Emission Inventory (EMEP) estimates that 94% of all ammonia emissions are caused by agriculture with around 80% of these emissions coming from organic sources.

Ammonia volatilization is a direct loss of nitrogen, and thus a significant environmental burden. Volatilized ammonia travels beyond national borders, causing acidification and eutrophication of land and water. Additionally, volatilised ammonia contributes significantly to the formation of microparticles (PM 2.5) which can contribute to severe health problems. For this reason, the UN/ECE Gothenburg Protocol and the EU National Emissions Ceiling Directive are proposing measures and limits to control ammonia emissions from any source.

It has long been known that urea or UAN causes higher volatilization losses than ammonium nitrate or calcium ammonium nitrate. Ammonia losses from urea can be reduced by its incorporation into the soil after spreading. However, this is only practicable for spring sown crops.

Losses from grassland are generally considered to be greater than those from arable soils, as fertilizers are typically surface-spread (Fig 8).

The use of urea fertilizer triggers losses of up to 58% N in the form of ammonia, depending on local natural conditions. Available measures for mitigating ammonia from agriculture include low N feeds, low emission housing for cattle, pigs and poultry, air scrubbing, covered slurry storage, low ammonia application of slurry and solid manures, incineration of poultry manure, and urea substitution (UNECE, 2007).

Controlling leaching

Elevated nitrate concentrations in ground and surface water are undesirable. The EU Nitrates Directive of 1991 has set the tolerable limit to 50 mg/l. Fundamentally nitrate leaching is independent of the source of nitrogen. It can result from soil organic matter, organic manure or mineral fertilizers if not applied properly.

Nitrate leaching occurs when the soil is saturated with water and nitrate is washed beyond the root zone by percolating rainfall or irrigation. Nitrate is not bound to soil particles and remains in the soil solution, where it moves freely with the soil water. Ammonium is mainly bound to clay particles in the soil and thus less prone to leaching.

Urea is rapidly transformed into ammonium through hydrolysis and later on in nitrate form by microbial activity which results in emissions release outside of the growth period. In addition, the urea molecule is very mobile and can be washed directly to the subsoil by heavy rainfall upon application.

During the growing period, there is hardly any leaching. Most loss of nitrate to water occurs outside the cropping period during winter. The overall objective is therefore to minimize soil nitrate concentrations at the end of the cropping period.

For winter cereals, nitrogen application up to the economic optimum rate will maximize yield while significantly decreasing soil nitrate concentration after harvest, and therefore the risk of leaching. The optimum nitrogen application rate also minimizes residual nitrogen (Fig. 9).

Nitrate leaching occurs regardless of the source of nitrogen.

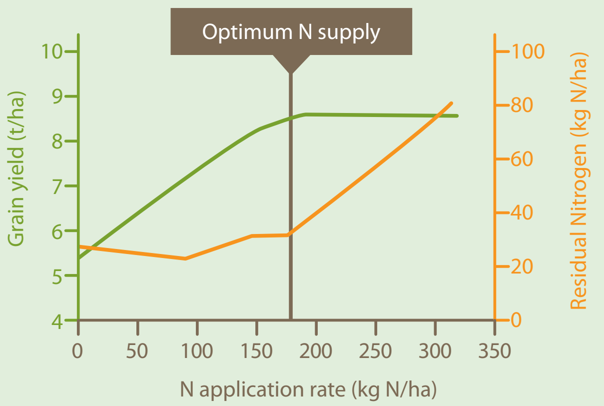
It can be minimized by using Best Agricultural Practice.

Leaching can be minimized by:

- Determination of soil nitrogen content by appropriate sampling and analysis
- Split nitrogen applications to ensure rapid take-up by plants at the period of growth
- Use of DAN fertilizers with a quick, predictable nitrogen release, such as ammonium nitrate
- Adjusting nitrogen application to real crop needs, whenever possible, by use of precision farming tools
- Allowing for a deep and extensive root system as to utilize nitrogen more efficiently
- Maintaining a porous soil structure
- Absorbing residual nitrogen by catch-and-cover crops
- Ensuring balanced nutrition so that the available nitrogen can be taken-up.

Fig. 9

GRAIN YIELD AND RESIDUAL NITROGEN VERSUS N APPLICATION RATE



Residual nitrogen in the soil after harvesting, and thus the risk of leaching, significantly decreases at optimum N application rate. [ref. 10].

Different fertilizers have different agronomic and environmental impacts. To assess the impact of a nitrogen fertilizer, a life-cycle analysis needs to be performed.

DAN fertilizers historically perform better in Europe.

Optimized production of fertilizers

Mineral nitrogen fertilizers are produced by extracting nitrogen from the atmosphere. The process requires energy and releases CO_2, a greenhouse gas contributing to climate change. Due to continuous improvements, European fertilizer installations, are today operating near the technological energy minimum with ammonia installations in Europe currently amongst the best in the world (Fig. 10 and 11).

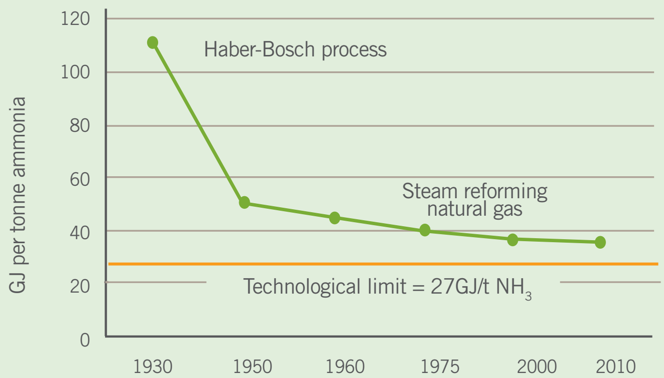
In addition to carbon dioxide, fertilizer production can release nitrous oxide, a powerful greenhouse gas. New catalyst technology has been installed by Fertilizers Europe members to abate most of the nitrous oxide released during production.

The impact on climate change of a fertilizer can be measured by its carbon footprint which is expressed as kg CO_2-eq per kg nitrogen produced. However, to understand the true climate impact of a product, a life-cycle analysis (LCA) needs to be performed covering all the steps from production to uptake by plants. A detailed comparison of the respective life-cycle carbon footprints for different fertilizer types is also given in the next section (Fig. 12).

In the future, if carbon capture and storage technology becomes available, nitrate fertilizer will become even more the preferred choice. In general CO_2 from industrial processes and power generation need a costly purification/ concentration process before becoming available for CCS. With DAN fertilizer production the CO_2 is already pure and ready for CCS use.

Fig. 10

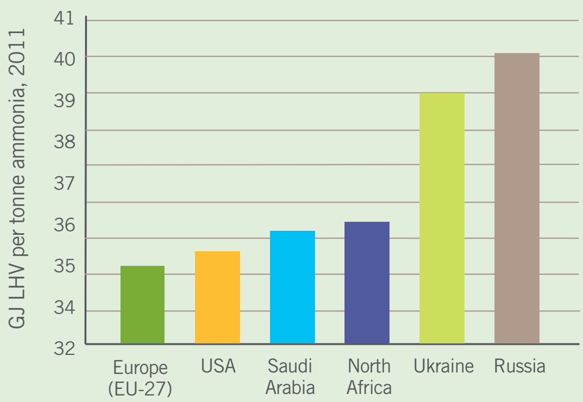
PROGRESS IN ENERGY EFFICIENCY FOR PRODUCING AMMONIA



The energy consumption of European fertilizer plants has decreased over time and is today near the theoretical technological limit [ref. 11].

Fig. 11

ENERGY EFFICIENCY OF AMMONIA PLANTS WORLDWIDE (REGIONAL AVERAGE)



The average energy efficiency of European ammonia plants are amongst the best in the world [ref. 12].

Mitigating climate change

PRODUCTION, TRANSPORTATION AND USE OF MINERAL FERTILIZERS CONTRIBUTE DIRECTLY AND INDIRECTLY TO GREENHOUSE GAS (GHG) EMISSIONS, NOTABLY CARBON DIOXIDE (CO_2) AND NITROUS OXIDE (N_2O).

Life-cycle analysis determines a fertilizer's overall GHG emissions and absorptions.

To achieve the same overall yield, the carbon footprint of DAN fertilizers is around 25% lower.

At the same time, fertilizers enhance agricultural productivity and stimulate CO_2 uptake by the crop and sequestration in the soil. They increase yield and reduce the necessity to cultivate new land, thus avoiding GHG emissions from land use change - land use change alone accounts for 12% of global GHG emissions [ref 13].

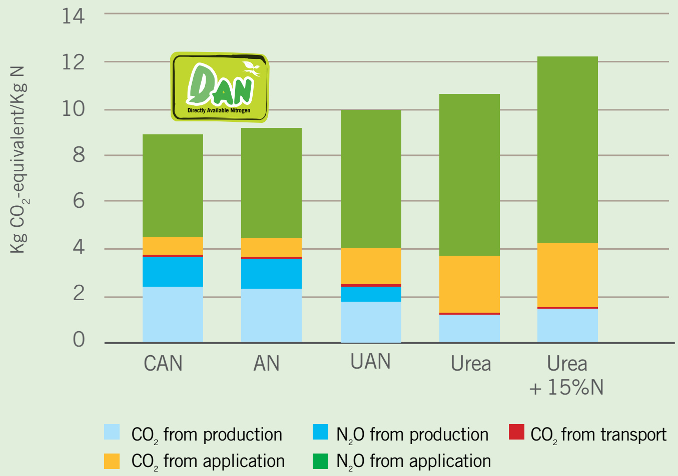
Life-cycle analysis of fertilizers determines GHG emissions and absorptions in fertilizer production, transportation and storage, as well as during application and crop growth (i.e. throughout every stage of the 'life' of a fertilizer). This provides a better understanding of what can and should be done to improve the overall carbon balance. To make different GHGs comparable, they are converted into CO_2- equivalents (CO_2-eq).

Different fertilizer types have different carbon footprints. Urea emits less CO_2 during production than ammonium nitrate. Upon spreading, this difference is reversed since urea releases the CO_2 contained in its molecule. On average, more N_2O is expected to be released from the soil after application of urea compared to a DAN fertilizer [ref 14].

The life cycle carbon footprint is therefore higher for urea than it is for DAN fertilizers. In addition, volatilization losses of urea and lower N-efficiency need to be compensated by a higher dosage of about 15%, adding to the carbon footprint. Thus, when measuring the carbon footprint of a fertilizer type it is crucial to compare the whole life cycle of the product (Fig. 12).

Fig. 12

COMPARATIVE CARBON EMISSIONS FROM DIFFERENT FERTILIZER TYPES



The life-cycle carbon footprint for ammonium nitrate is lower than for urea and UAN. When compensating for the lower efficiency of urea and UAN with a higher dosage, the difference is even more marked [ref. 15].

Towards best agricultural practice

THE GOLDEN RULE FOR NITROGEN FERTILIZER USE REMAINS SIMPLE: APPLY THE RIGHT PRODUCT AT THE RIGHT RATE, IN THE RIGHT PLACE, AT THE RIGHT TIME. FERTILIZERS WITH A RELIABLE RELEASE PROFILE AND PRECISE APPLICATION CHARACTERISTICS REDUCE LOSSES AND IMPROVE PLANT UPTAKE.

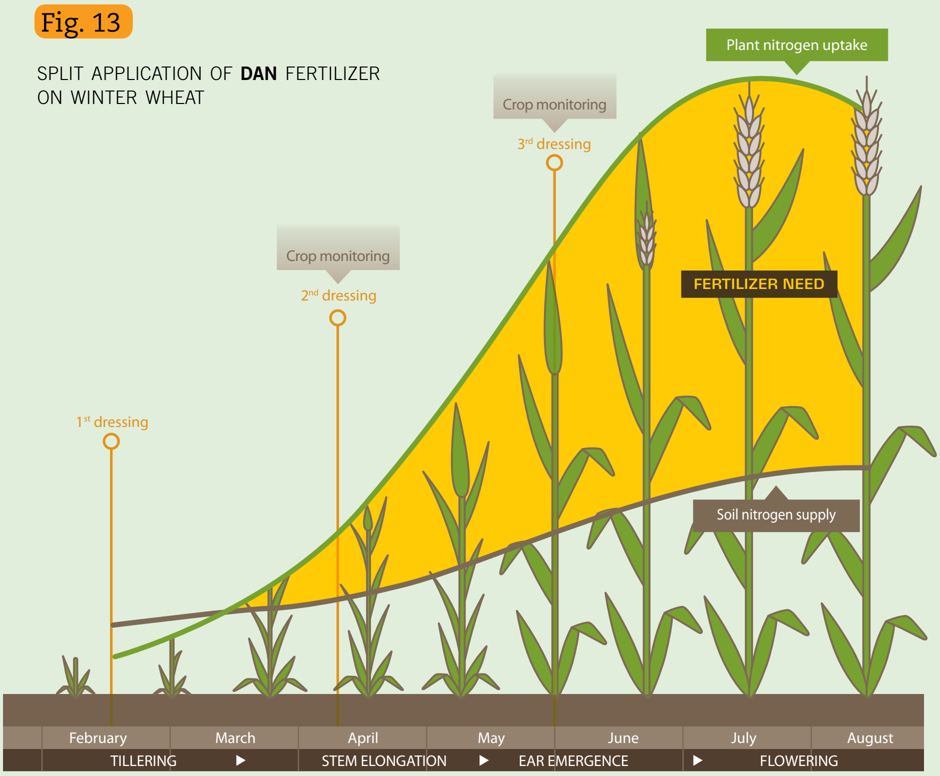
ENHANCING FERTILIZER EFFICIENCY

Matching fertilizer application with plant needs

Nitrogen needs to be available in sufficient quantities so that it does not limit plant growth and yield. However, excess nitrogen beyond short-term plant needs may be lost to the environment or result in luxury consumption. Matching nitrogen availability precisely to current plant needs and actual soil nutrient supply maximizes yield, minimizes environmental impact and optimizes profit (Fig. 13).

Fig. 13

SPLIT APPLICATION OF **DAN** FERTILIZER ON WINTER WHEAT



The actual fertilizer need depends on both soil nitrogen supply and plant need. Modern monitoring tools facilitate crop monitoring and help to adjust split applications accurately [ref. 4].

Split application is considered best agricultural practice under most conditions. Fertilizers offering a predictable release of plant-available nitrogen are best suited for split application.

This is the case for ammonium nitrate and calcium ammonium nitrate, but generally not for urea. Hydrolysis of urea and volatilization losses heavily depend on climatic conditions after spreading, especially on rainfall. These cannot be predicted reliably, resulting in either an under or oversupply of nitrogen.

The Defra study has highlighted the unreliability of urea, finding volatilization losses that varied from 2 to 58% of applied nitrogen.

Balanced nutrition is another prerequisite of economical fertilizer use. An insufficient supply of phosphorus, potassium or sulphur can diminish nitrogen-use efficiency. Regular soil sampling provides data on the actual supply of nutrients from the soil and the fertilizer needs.

Several tools are available on the market to measure plant nitrogen needs and to adjust fertilizer nitrogen applications correspondingly.

Ensuring spreading precision

Even spreading ensures an optimum nitrogen supply. Due to its higher bulk density and lower nitrogen concentration, DAN fertilizers offer more homogeneous spreading characteristics than urea. Wind can further degrade spreading homogeneity with urea, resulting in a significant local over or undersupply.

A study, conducted in Germany, compared the spreading loss of urea to calcium ammonium nitrate. With a spreading width of only 21 metres, a mild breeze of 4 m/s resulted in a 26% variation of application rate with urea, whereas it was only 6% with CAN [ref. 16].

Optimizing nitrogen fertilizer input

Precision farming tools can further enhance spreading accuracy. Sensor technology offers farmers real-time control over fertilizer application and GPS-based accounting of nutrient supply. The plant nitrogen need is measured continuously during spreading and, when used for spreading homogeneous nitrate fertilizers, guarantees the highest yield with the lowest nitrogen input.

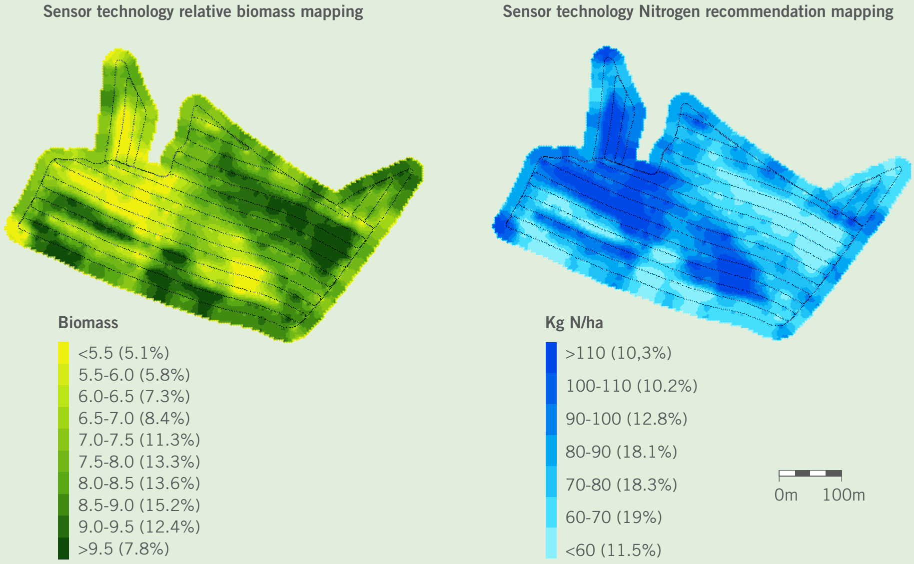
Many field trials have compared the use of sensor technology to common farming practice, demonstrating an increase in plant protein content of 0.2-1.2%, an increase in yield of 7% and a cut in nitrogen input of 12% (Fig. 14). This technology is also used with a satellite technology to produce spreading maps.

Addressing acidification

On certain soils, nitrogen fertilizers can have an acidifying effect, which needs to be corrected by liming. Applying fertilizers with high nitrogen efficiency reduces potential acidification and the liming requirement. Fertilizers such as calcium ammonium nitrate contain limestone or dolomite, providing further savings in cost and the time for lime application (Fig. 15).

Fig. 14

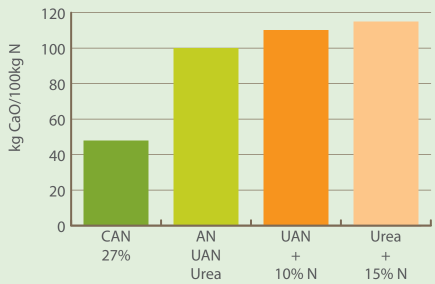
BIOMASS AND NITROGEN MAPPING



Nitrogen sensors automatically apply optimum nitrogen rates (blue) based on real time mapping of biomass and chlorophyll (green), avoiding both, over- and underfertilization. Winter wheat, Germany [ref. 17].

Fig. 15

LIME DEMAND



The lime demand of (calcium) ammonium nitrate is significantly lower than for urea [ref. 18].

Nitrogen sensors provide immediate information on actual nitrogen need.

DAN fertilizers enhance nitrogen efficiency and minimize losses.

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