

A full range of products

FARMERS IN EUROPE HAVE ACCESS TO A WIDE VARIETY OF MINERAL FERTILIZERS BASED ON THE MAJOR PLANT NUTRIENTS AND SELECTED MICRONUTRIENTS.

Nitrogen-based products make up by far the largest fertilizer group, followed by fertilizers based on phosphorus and potassium.

Production of the large range of fertilizers that are easy to handle and have reliable nutrient release profiles requires the European fertilizer industry to transform millions of tons of naturally occurring raw materials such as air, natural gas and mined ores.

For nitrogen-based fertilizers, the production process first involves mixing nitrogen from the air with hydrogen from natural gas at high temperature and pressure in the Haber-Bosch process to create ammonia, the main building block for nitrogen-based fertilizers.

The ammonia is then either mixed with nitric acid to produce nitrate fertilizers, such as ammonium nitrate (AN), or with liquid carbon dioxide to create urea fertilizers. Both these products can also be further mixed with water to form UAN (urea-ammonium nitrate) liquid solutions.

Both phosphorus and potassium-based fertilizers are produced from mined ores. Phosphate rock is crushed and primarily treated with sulphuric acid to produce phosphoric acid, which is either concentrated or mixed with ammonia to make a range of phosphate (P_2O_5) fertilizers.

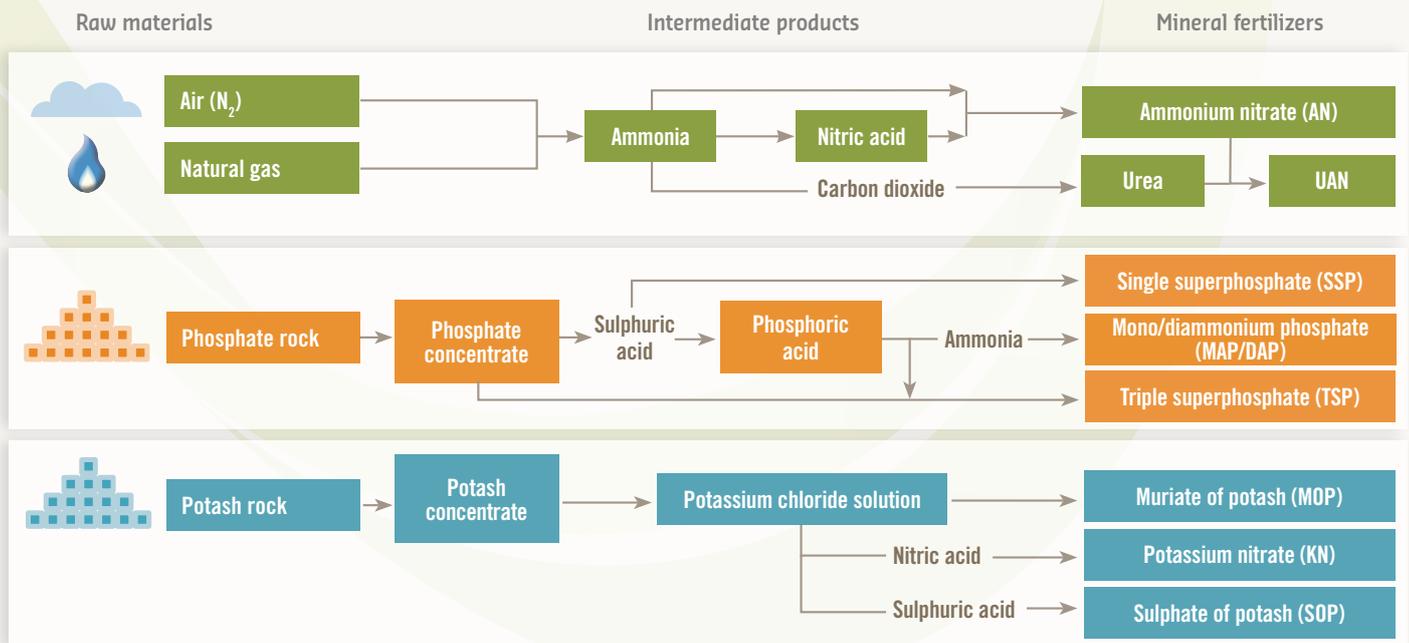
Potash ores are usually rich in both potassium and sodium chloride (KCl and NaCl). Typically, the ore is dissolved in hot water and the NaCl separated out, before the resulting KCl solution is concentrated by evaporation to create muriate of potash (MOP) fertilizer.

The potassium chloride may then be further treated with nitric or sulphuric acid to produce potassium nitrate (KN) or potassium sulphate (SOP) fertilizers.

Detailed descriptions of the major fertilizer production processes can be found in the Fertilizers Europe Infinite Product Stewardship brochure.

Different fertilizer products have different release profiles and need different spreader settings for efficient application.

PRODUCTION OF MAIN FERTILIZER PRODUCTS





Chemically produced homogenous complex fertilizer (left) compared with a multinutrient blend of non-size-matched N, P and K components.



The type of particle depends on the production process: granular ammonium nitrate, NPK and crystalline calcium nitrate all need different spreader settings..



Fertilizers must be free flowing to assure easy handling and uniform spreading.

Straight & compound fertilizers

Fertilizers are available in straight and compound forms, based on one major nutrient or two or more nutrients respectively.

Straight fertilizers account for the majority (78%) of total fertilizer use in Europe and producers offer a full range of products, often based on meeting the needs of a specific crop. Compound NPK fertilizers account for the remaining consumption and primarily are available in two distinct types: blended and complex fertilizers.

Blended fertilizers are produced by dry mixing two or more intermediate fertilizer materials. In high quality blends, the component granules or particles are precisely matched in size and other physical characteristics so they do not separate (segregate) during handling, which can result in the uneven distribution of nutrients on the field.

Complex fertilizers contain at least two primary nutrients and are usually produced chemically. These have the advantage that each of the components is present in every granule. The granules are of a uniform size range and defined composition, so present no risk of segregation.

The majority of compound fertilizers produced in Europe are complex products and manufacturers supply a range with nutrients in different proportions. For example, a 15:15:15 compound NPK fertilizer will contain 15% N, 15% P₂O₅ and 15% K₂O in each granule.

Handling characteristics

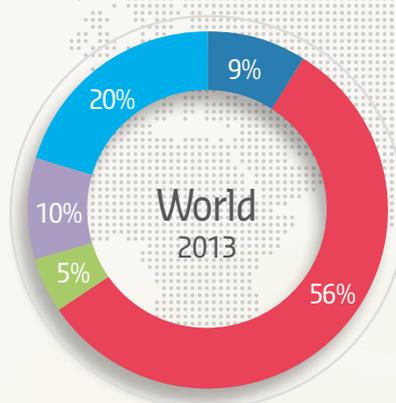
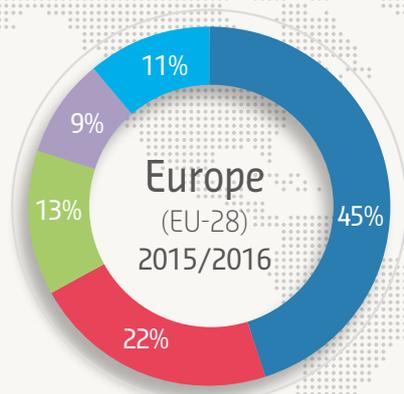
Today's highly mechanised fertilizer application equipment requires that solid fertilizers are free flowing to assure easy handling and uniform, accurate spreading patterns.

The industry produces individual fertilizers with particles within a narrow size range and which are sufficiently robust not to disintegrate during transport and spreading. The quality of fertilizer raw materials, intermediates and finished product are extensively checked during the production process.

Nitrogen fertilizers

The majority of nitrogen fertilizers applied in Europe are straight fertilizers. The main products are nitrate-based fertilizers, such as ammonium nitrate (AN) and calcium ammonium nitrate (CAN), which are well suited to most European soils and climatic conditions, and urea and urea ammonium nitrate (UAN) aqueous solution, which are widely used in other parts of the world.

NITROGEN FERTILIZER CONSUMPTION (%N)



- AN is a mixture of ammonium and nitrate, with a nitrogen concentration ranging from 32% to 34.5%. Half the nitrogen is in the nitrate (NO_3^-) form, which is immediately available to plants, and the other half in the ammonium (NH_4^+) form. AN is the most commonly used straight nitrogen fertilizer in the UK (68%) and France (38%) and accounts for 21% of total nitrogen fertilizer consumption in Europe.
- CAN is a mixture of ammonium nitrate and a minimum of 20% calcium/magnesium carbonate. It is another concentrated source of nitrogen (25% to 28% N) and overall is the most popular straight nitrogen fertilizer in Europe.
- Urea, based on nitrogen in the amide (NH_2) form, is the most concentrated solid nitrogen fertilizer (46% N) accounting for 22% of nitrogen fertilizer use in Europe. However, with urea the availability of plant-available nitrogen is delayed, particularly in cold weather, because it has first to be transformed into ammonium and then into the nitrate form. Since this transformation is dependant on soil temperature, in Europe its use is traditionally strong in areas bordering the Mediterranean.
- Liquid solutions represent 13% of nitrogen consumption in Europe. The most typical, UAN, is made using 50% urea and 50% ammonium nitrate in water (forming a fully dissolved clear liquid fertilizer with 28-32% nitrogen content). UAN offers farmers the advantage of reduced handling but it requires special storage facilities and transport equipment.

Other straight nitrogen fertilizers include ammonium sulphate and ammonium sulphate nitrate, calcium nitrate, sodium nitrate, Chilean nitrate and anhydrous ammonia.

- Ammonium sulphate has a relatively low nitrogen content (21%, all of which is in the ammonium form). But it also contains 24% sulphur, another essential plant nutrient.

Ammonium sulphate nitrate is a combination of ammonium sulphate and ammonium nitrate. A typical grade contains 26% N (7.5% as NO_3^- ; 18.5% as NH_4^+) and 14% sulphur (as S).

- Calcium nitrate contains 14.4% nitrogen in the nitrate form and 19% water-soluble calcium. Due to its quick action, it is a form of nitrogen particularly suited to fast growing vegetable crops as well as fruit trees.
- Sodium nitrate and Chilean nitrate are used in small volumes on specialised crops, while anhydrous ammonia (82% N), which is applied by injection into the soil, represents less than 1% of total nitrogen fertilizer use in Europe.

➤ Speciality nitrogen products

Certain weather and soil conditions can lead to nitrogen immobilization, denitrification, volatilization or leaching, all reducing fertilizer efficiency. In response, the industry has developed special types of fertilizers designed to reduce these effects. They include foliar, slow and controlled release fertilizers, as well as fertilizer additives such as urease and nitrification inhibitors.

- In certain situations nitrogen can be very efficiently taken up through the leaves of a plant and foliar fertilizers can be used to avoid the immobilization or leaching of soil-applied nitrogen. However, the quantity of nitrogen which can be applied using foliar sprays is limited and in practice they are primarily used to supplement soil-applied nitrogen.
- Slow and controlled release fertilizers contain nitrogen and sometimes other nutrients in forms that either delay or extend their availability to match crop uptake.

Nitrate-based fertilizers are the most commonly used straight fertilizers in Europe.

Typically, slow release fertilizers rely on the inherent water insolubility of the material containing the nitrogen, while controlled release products are made through modification of the fertilizer particle through a coating or an encapsulating membrane.

Most controlled release fertilizers release nutrients over 3, 6, 9 or 12 month periods. Slow release fertilizers (based on urea-aldehyde) are designed mainly for professional use on turf and in nurseries and gardens.

➤ Inhibitors

Urease inhibitors are chemical compounds that delay the first step of degradation of urea in the soil, the hydrolysis that can create NH_3 emissions and which may occur before its transformation to ammonium.

Nitrification inhibitors are chemical compounds that delay the nitrification of ammonium by suppressing the activity of nitrosomonas bacteria in the soil. The objective is to preserve the ammonium in its soil-stable form and slow its conversion to nitrate. This temporarily reduces the proportion of nitrate in the soil, and thus the potential for leaching losses or the formation of N_2O gas.

As the cost of controlled-release fertilizers with inhibitors is significantly higher than that of conventional products, their use has largely been restricted to high value crops, specific cultivation systems and non-agricultural, high-value sectors (horticulture, nurseries, greenhouses, etc.) With the introduction of controlled-release urea, however, this is changing fast.

Phosphorus fertilizers

The most common phosphate fertilizers are single superphosphate (SSP), triple superphosphate (TSP), mono-ammonium phosphate (MAP), di-ammonium phosphate (DAP) and ammonium polyphosphate liquid.

All phosphate products are highly water soluble. Ammonium phosphate is also a source of nitrogen. Both MAP and ammonium polyphosphate, either alone or with added potassium, make excellent starter fertilizers because of their high phosphorus-to-nitrogen ratios, water solubility and low production of free ammonia (NH_3), which can harm seeds.

Di-ammonium phosphate is often not recommended as a starter fertilizer because it produces free ammonia. Many starter fertilizers contain DAP, so it is critical that the fertilizer is accurately applied a safe distance (about 5 cm) from the seeds and that high application rates are avoided. Because phosphorus is relatively immobile in the soil, placement of the fertilizer where plant roots will have easy access to it is especially important.

PHOSPHATE (P_2O_5) CONTENT OF COMMON PHOSPHORUS FERTILIZERS (%)

Single superphosphate	18-20
Triple superphosphate	46
Mono-ammonium phosphate	52
Di-ammonium phosphate	46
Ammonium polyphosphate	34



Speciality products, such as slow or controlled-release fertilizers, contain nutrients in a form that either delays or extends their availability in order to more closely match crop uptake.



A number of fertilizer manufacturers produce fertilizers in which the ratio of nutrients is adjusted to meet the specific needs of certain crops or which has certain desirable physical characteristics such as solubility in water.

Soluble fertilizers are increasingly used in fertigation systems with irrigation water or as foliar sprays.

Potassium fertilizers

Potassium is also available in a range of fertilizers which contain potassium only or two or more nutrients.

- ▶ Potassium chloride (KCl), known as muriate of potash or MOP, accounts for about 95% of all potassium fertilizers used in agriculture. It is the cheapest per tonne of potassium and the most widely available.

In the form of fine crystals, muriate of potash can be readily incorporated into granular compound fertilizers or compacted into suitable sized particles to be spread by machine or used in fertilizer blends. Due to the presence of chloride, it is not recommended for use on sensitive crops.

- ▶ Potassium sulphate (K_2SO_4) or sulphate of potash (SOP) is more expensive per tonne than MOP as it contains both potassium and sulphur. It tends to be used for high value fruit and vegetable crops and with other crops where it improves crop quality, such as potatoes. As it contains no chloride, it can also be used with crops grown in saline soils, which occur in arid and semi-arid regions.
- ▶ Potassium nitrate (KNO_3), known as KN, contains potassium and nitrogen in the nitrate form which is readily available to crops.

Both potassium sulphate and potassium nitrate are also highly suitable for use in foliar sprays or in fertigation systems, where the nutrients are applied together with irrigation water.

THE COMPONENTS OF MAJOR POTASH FERTILIZERS

Potassium chloride KCl (muriate of potash)	60% K_2O	
Potassium sulphate K_2SO_4 (sulphate of potash)	50% K_2O	45% SO_3
Potassium nitrate KNO_3 (nitrate of potash)	46% K_2O	13% N

Calcium, magnesium and sulphur fertilizers

Calcium (Ca), magnesium (Mg) and sulphur (S) are essential secondary plant nutrients. They are not usually applied as straight fertilizers but in combination with the primary nutrients N, P, and K.

Sulphur is often added to straight N fertilizers such as ammonium nitrate or urea. Other sulphur sources are single superphosphate (SSP), potassium sulphate (SOP) and potassium magnesium sulphate (Kainite), the latter also containing magnesium.



Special fertilizers add important micronutrients such as iron, manganese, boron, zinc and copper.



Kieserite is a magnesium sulphate mineral that is mined and also used as fertilizer in agriculture, mainly to correct magnesium deficiencies. Calcium is mainly applied as calcium nitrate, gypsum (calcium sulphate) or lime/dolomite (calcium carbonate), of which calcium nitrate is the only readily plant available source of calcium.

Micronutrient fertilizers

Today, a large number of special fertilizers are available to supply plants with important micronutrients such as iron, manganese, boron, zinc and copper.

These can be either inorganic or organic compounds, with the inorganic varieties further divided into water-soluble and non-soluble products.

- Ferrous sulphate (20% Fe, 18.8% S) is the most commonly used inorganic source of iron. It is not effective as a soil-applied material but can be used as a foliar spray. One application of a 1-1.5% solution may correct mild iron deficiency. Several applications, one to two weeks apart, may be needed for more severe cases.
- Zinc sulphate (36% Zn; 14% S) is the most commonly used dry zinc material. It is a relatively water-soluble inorganic compound and also effective in granular form. It is often applied to soil areas that are low in zinc or used for foliar application.
- Zinc ammonium sulphate is commonly used in liquid fertilizers. It is effective if properly applied in the soil (band application) and is less costly than organic forms of zinc.

Organic materials are either synthetic chelates, ring-type chemical structures formed around a polyvalent metal, or natural organic complexes. Chelated micronutrients tend to remain soluble longer when applied to the soil, giving more time for the plant to take up the desired nutrient.

Chelating agents are complex chemical structures such as EDTA, DTPA, EDDHA, NTA, and HEDTA and the compound initials are usually attached to the micro-nutrient.

- Fe-DTPA (10% Fe) is the most commonly used iron chelate and can be soil-applied if the soil pH does not exceed 7.5. It is also used as a foliar treatment.
- Zinc chelate (Zn-EDTA) is an effective material. Its main advantage is stability and mobility in the soil. When dry fertilizers are blended and applied as a row band, inclusion a granular zinc chelate is likely to be more effective than granular zinc sulphate.

When liquid fertilizers are used, a zinc chelate does not perform much differently to inorganic sources of zinc and is too expensive to be used at rates needed to increase zinc levels in the soil. The performance of most organic non-chelated zinc is similar to that of zinc sulphate.

Organic fertilizers

Crop residues, animal manures and slurries are the principal organic fertilizers. Although they have varying nutritional values, they are generally present on the farm and the nutrients they contain are recycled.

Animal manures and slurries cover a wide range of nutrient sources with different physical properties and nutrient contents. Furthermore, their nutrient contents vary regionally and depend on the type of livestock and the farm management system. Some typical values of nitrogen content are given below.

As the available nitrogen content of manures and slurries is mostly in the ammonium (NH_4^+) form, it can be susceptible to significant volatilization to ammonia, with a loss of nitrogen to the air. It is also one of the reasons why nitrogen from organic fertilizers is not as efficient as that from mineral sources, as the organic nitrogen needs to be transformed in the soil over time.

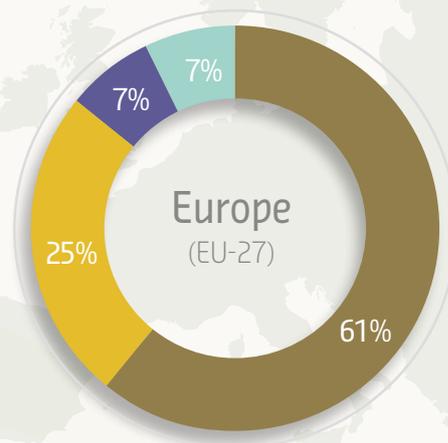
Available quantities on a farm are generally allocated to crops before other nutrient sources are considered. If the organic materials do not satisfy the nutrient needs of the crops, farmers use mineral fertilizers to make up the deficiency. Organic materials contribution to plant nutrition is highest in the year of application but is still measurable over ensuing cropping seasons.

In addition to manure and crop residues available on the farm, other bio-wastes form a further supply of organic materials. These include urban waste (e.g. sewage sludge, biological and waste from gardens and parks) and industrial waste (e.g. food processing waste, paper mill sludge, etc.).

These non-farm sources are known as 'Exogenous Organic Matter' as they are derived outside the agricultural context in

SOURCES OF ORGANIC MATERIALS

- Animal wastes
- Crop residues
- Industrial wastes
- Urban wastes



which they are often used. The majority of all organic waste materials in the EU are generated and used on farm, with 7% coming from industrial and 7% from urban wastes.

Due to their relatively low nutrient content, the main rationale for the incorporation of sewage sludge and other exogenous wastes is to build up organic matter in the soil and potentially improve its structure.

TYPICAL NITROGEN CONTENT OF VARIOUS ORGANIC SOURCES GENERATED ON FARM

Source	Total Nitrogen (N)	Ammonium (NH_4^+)
	g/kg dry matter	% total N
Cattle manure	13 - 29	10
Pig manure	22 - 33	10
Poultry manure	29 - 46	70
Cattle slurries	31 - 47	25 - 78
Pig slurries	55 - 103	56 - 65
Poultry slurries	28 - 74	21 - 70
Cereal straw	5 - 13	-

Source: Leclerc, 2001

