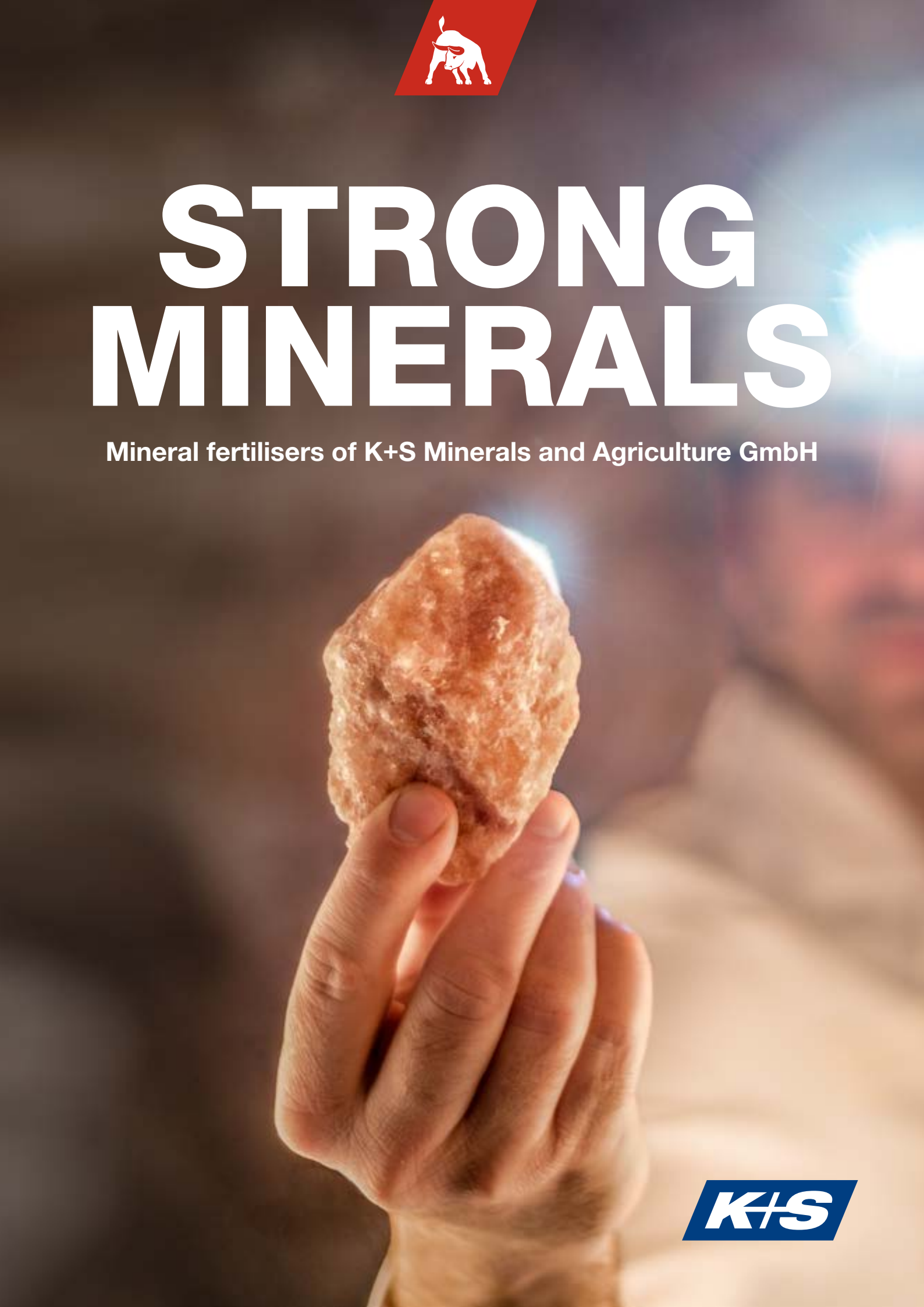
STRONG MINERALS

Mineral fertilisers of K+S Minerals and Agriculture GmbH



FOR EFFICIE
PLANT GROW

The minerals potassium, magnesium, sulphur and sodium are found widespread in nature. They are essential nutrients for plants, animals and humans. With the discovery of potash deposits in the middle of the 19th century and the processing of valuable potash fertilisers, it became possible to remedy the general deficiency of these nutrients in agriculture. Nowadays, the blessing of these minerals for food production is often called into question and the vital functions of these minerals for plants and humans are often neglected in the discussion concerning environmental impacts.

With this brochure, we seek to shed light on the potassium crude salt deposits in Germany as well as the production, function and application of potash and magnesium fertilisers and to highlight important functions of these natural products in the system of life.

Dr. Josef Wiebel
Managing Director
K+S Minerals and Agriculture GmbH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STRONG MINERALS

EVERYTHING AT A GLANCE

THE COMPANY K+S

FROM CRUDE SALT TO HIGH-GRADE PLANT NUTRIENTS

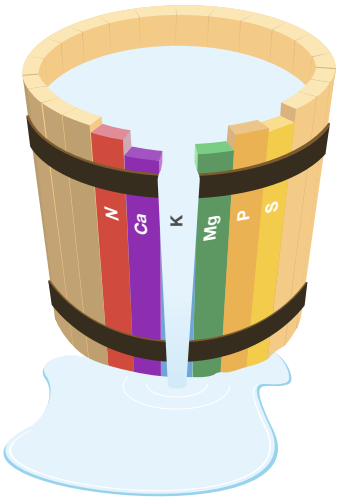
Essential Nutrients –
For Plants, Animals and People

Just a hundred years ago, bad harvests led to malnutrition and famines. For centuries, harvests removed nutrients from the soil that could only be partially replenished by means of natural fertilisers like farmyard manure. There was an open nutrient cycle that led to a continuous decrease in the soil fertility. In addition, a rapidly increasing population could no longer be fed sufficiently. The scientists Carl Sprengel and Justus von Liebig discovered in the first half of the 19th century that it is not the humus but the minerals that are essential for plant nutrition. Besides heat, light, water and air, the plant needs a series of minerals, above all the macro nutrients nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S). It does not matter for the plant, which source the nutrients come from and if they are applied in organic or mineral form. However, it is decisive that these nutrients are only available to the plants if they are in mineral form. Therefore, organic fertilisers first have to be mineralised in the soil before they can be absorbed. K+S mineral fertilisers contain the nutrients in fully water-soluble and therefore immediately plant-available form.

Liebig's findings coincided with the discovery of potassium salts along with the mining of common salt. Until then, only potassic wood ash was known as a source. Already in ancient times, it was leached in large pots, hence the name "potash". The amounts of potash that were extracted that way were by far not enough to meet the agricultural demand for potash fertilisers. The shortage of potassium was a key cause of the bad harvests throughout the world in the first half of the 19th century.

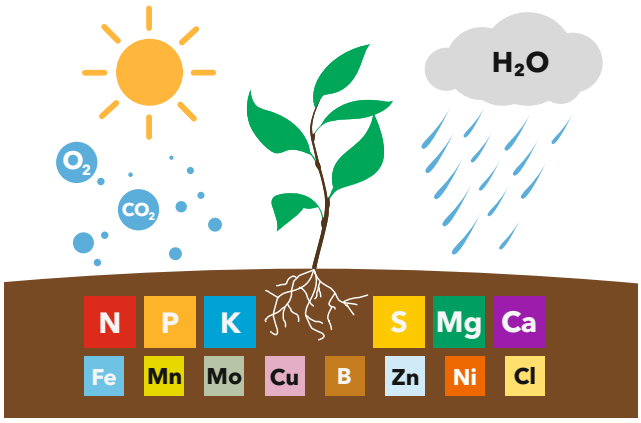
The Romans used potassic wood ash for vineyard fertilisation.

Law of the minimum (Justus von Liebig)



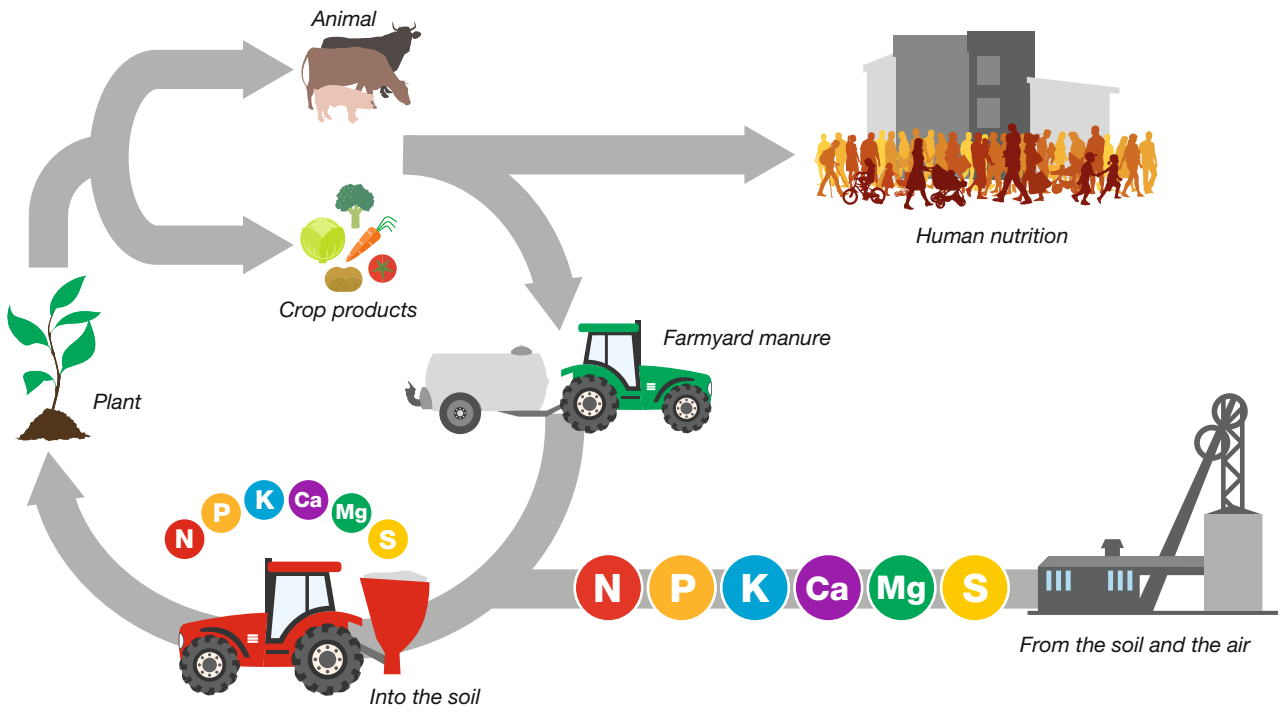
Just like this barrel cannot get completely filled due to the uneven height of the staves, plants cannot bring high yields if a growth factor – for example potassium – is lacking.

What does a plant need to live?



The plant absorbs all essential nutrients in dissolved form from the soil solution, regardless of whether organic or mineral fertiliser was applied.

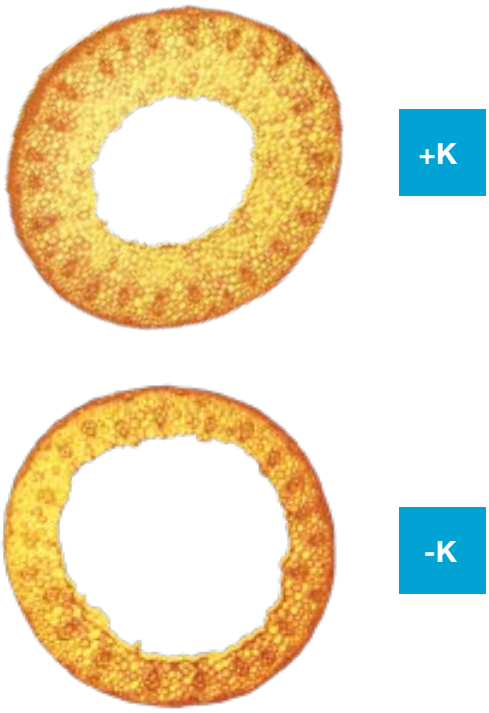
The circle of nutrients



Only mineral fertilisers allowed farmers to close the open nutrient cycle again.

Section of a historic illustration from the beginning of the 20th century. Even then, the indispensability of potassium for plant growth was a well known fact. For example, potassium ensures the transport and the storage of carbohydrates. Furthermore it increases the content of sugar and accelerates ripening.

Potassium for stronger stalks



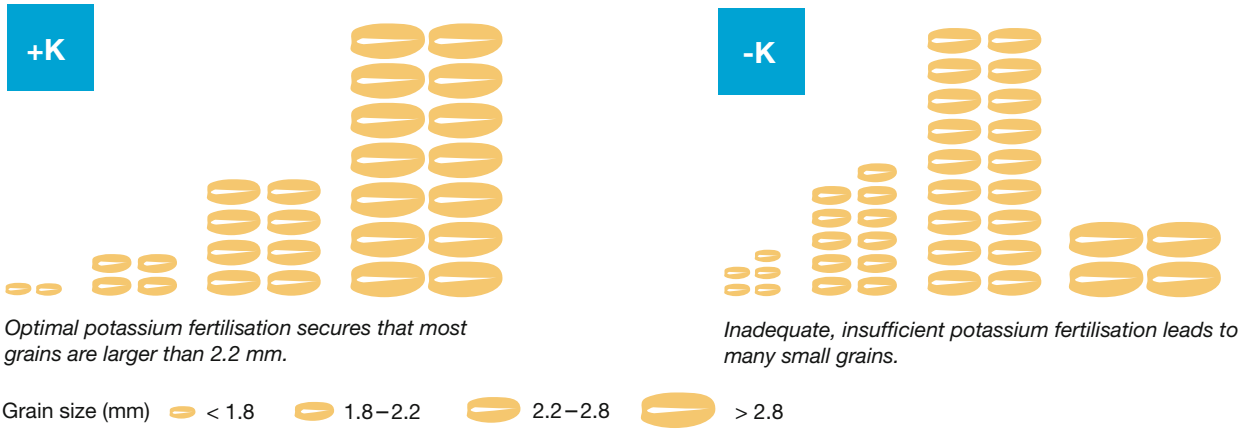
As the cross-sections of grain stalks show, potassium also strengthens the stalk tissue and thereby increases the stability of the grain.

The potash and magnesium minerals that were present in the salt deposits made it possible to solve the nutrient deficiency. Within only a few years, technical processes for the separation of potash from other salts were developed. The mining of potassium and magnesium began in 1861. This was the birth of the potash industry.

Regular mineral fertilisation made it possible to close the nutrient cycle. The fertility of the soil improved significantly in the 19th century. Where one haulm was growing before, ten are growing today. The wheat harvests increased from 0.8 t/ha in the year 1800 to more than 7.5 t/ha today with peak harvests of 12 t/ha.

As a result of a sufficient and balanced nutrient supply, cereal crops for example no longer produce shrivelled but rather fully developed grains, which have the desired protein and starch contents that are needed from the perspective of nutritional physiology as well as for good baking quality. Fruits and vegetables nowadays are not only characterised by a high vitamin and nutrient content but also by an increased shelf and storage life. The sustainable fertility of the soil and high yields with sufficient nutritional quality make it possible that since the time of Liebig, more and more people in the cities are fed by fewer and fewer farmers. For example, one farmer feeds 134 people in Germany today. Within the time of slightly more than one generation, the farmer has increased the number of consumers supplied by him many times (1950 = 10, 2006 = 134).

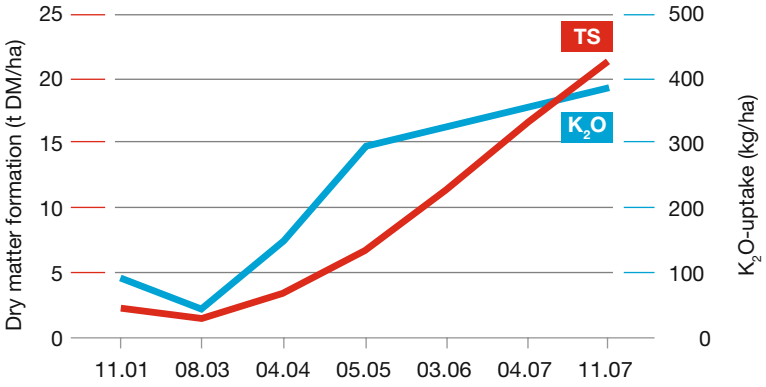
Grain size distribution from a long-term experiment on luvisol



Optimal potassium fertilisation secures that most grains are larger than 2.2 mm.

Inadequate, insufficient potassium fertilisation leads to many small grains.

Potassium uptake (kg K_2O/ha) and dry mater formation (t DM/ha) in oil seed rape

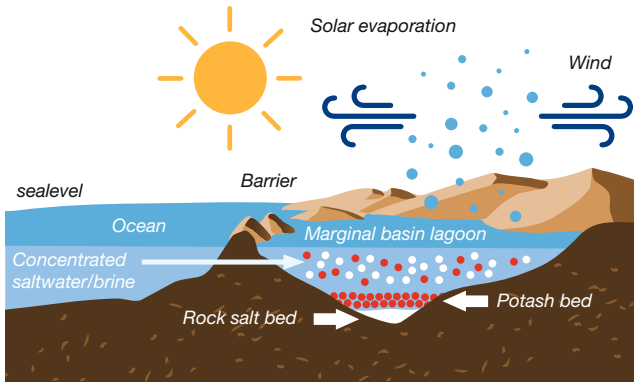


The graphic illustrates the potassium absorption in kg K_2O/ha and the dry matter formation in t/ha for oil seed rape. The potassium absorption precedes the dry matter formation and is a prerequisite for undisturbed growth.

Natural Resources –
The Potash Deposits in Germany

The potash deposits in Germany were formed more than 250 million years ago by the evaporation of the Zechstein Sea. According to the barrier theory as it is known, salty seawater flowed over shallow sea barriers into marginal shallow basins, where it evaporated due to extreme arid conditions. The salt concentration increased, and at last potassium, magnesium and sodium salts were crystallised and deposited in the order of their solubility. This process was repeated for hundredthousands of years, so that two or more potash deposits were formed at a depth of several hundred metres. In the course of the following geological history, the thick salt deposits were covered by triassic formations, vast series of shales, sandstones and limestones mostly of Bunter Sandstone, Muschelkalk and Keuper Ages and thus prevented from dissolution.

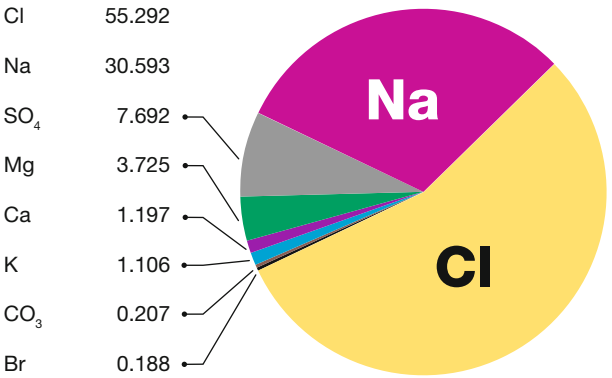
Formation of Potash Deposits



Composition of dissoluted salt in sea water

Sea water has average salt contents of 33–37 g/l. Amongst the dissolved salts, which consist of more than 30 elements, rock salt (or common salt) quantitatively accounts for the highest share. It is used as table salt and for various industrial purposes. Other main components are sulphur, magnesium, calcium, potassium and bromine. In hot and dry regions like Spain or Australia, the high salt contents of the sea is still utilised for table salt production via solar evaporation in open ponds.

Composition of dissoluted salt in sea water in %



Mining of Raw Potash Ore –
Deposits and Available Potash Salts

Bedded potash deposits with a thickness of ca. 3–8 metres can be found at a depth of about 500–2.500 metres.

Overlying water-impermeable clay layers and shales protect the deposits from groundwater.

High pressure of overlying rock and tectonic forces led to folding and updoming of the deposits. This is the reason that in salt domes the originally horizontal deposits are almost vertical today. The potash and magnesium deposits are mined at a depth of 400–1,500 metres. The depth is limited due to rock mechanic constriction.

Carnallitite

Carnallite ($KCl \times MgCl_2 \times 6H_2O$) and mainly halite (NaCl). Its components are present in the form of double salts of potassium chloride and magnesium chloride.

K_2O content: 8.0–15 %
MgO content: 7.5–15 %

Hard salt

Consists of sylvite (KCl), halite (NaCl) and kieserite ($MgSO_4 \times H_2O$) and or anhydrite, langbeinite, polyhalite.

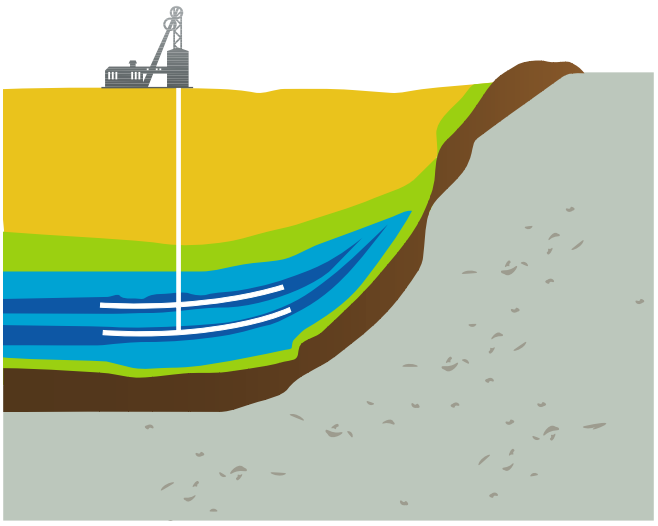
K_2O content: 10–15 %
MgO content: 3–12 %

Sylvinite

Consists of sylvite (KCl) and halite (NaCl).

K_2O content: 15–25 %

Bedded deposit



prevalent Sandstone; Triassic

Anhydrite, Claystone & carbonate; Upper Permian 1–7

Rock salt; Upper Permian 1

Potash seam; Upper Permian 1

Sandstone & psephite; Rotliegend

prevalent Slate, basal complex, Ordovician up to Lower Carboniferous

Using the Werra-Fulda deposit as an example, the schematic diagram gives an impression of the challenges in mining potassium and magnesium salts in Germany.

A True Success-Story –
The Kali-Producer Germany

In 1856, potash was discovered underground in Staßfurt near Magdeburg in Germany for the first time and mined since 1861.

Until 1918, Germany was the world‘s nearly only potash producer. Today, potash is also extracted in Canada, Russia, Belarus and at the Dead Sea.

The modern potash mines and plants in Germany have a total production capacity of about 10 million tonnes of potash and magnesium fertilisers. More than half is exported to upwards of 70 countries throughout the world. K+S accounts for about 10 % of global potash production.

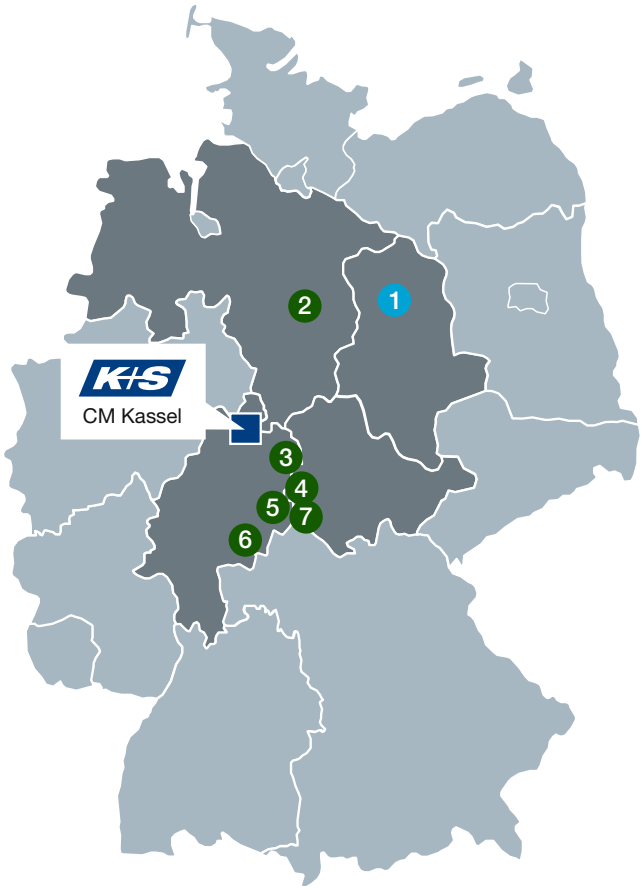
Kieserite – a valuable component

The German deposits are nearly the only ones in the world that also contain kieserite in addition to the potash salts due to special conditions caused during formation. This makes it possible to extract the important plant nutrients potassium, magnesium and sulphur at the same time and to process them into high-quality mineral fertilisers.

ESTA Kieserit gran. (left) and ESTA Kieserit fine (right) are high-grade magnesium sulphur fertilisers.

Zielitz plant, Lower Saxony

Regionally rooted –
The Mines of K+S Minerals and Agriculture GmbH



K+S Potash Plants

The K+S operates a total of six potash mines in Lower Saxony, Saxony-Anhalt and in the Hessian-Thuringian Werra-Fulda district.

Corporate management Kassel

1 Zielitz plant

2 Bergmannssegen-Hugo (Lehrte) (production only, no mining)

3 Werra works – Wintershall (Heringen)

4 Werra works – Unterbreizbach

5 Werra works – Hattorf (Philippsthal)

6 Neuhof-Ellers plant (Neuhof)

7 Merkers

Potash

Potash and Kieserite

Hattorf plant in Philippsthal, Hesse

The Somewhat Different Workplace – 1.000 Metres Below the Surface

Each potash mine has at least two shafts of which one is used for the transportation of miners and materials, while the other is mainly for the hoisting of crude salt. From the shaft, main drifts are driven for many kilometres on different levels to the extraction sites.

The transport systems reach lengths of 150–180 km, which corresponds to the road network of a big city. Depending on the depth and the fresh air supply (mine ventilation), the temperature underground is 20 to 40 °C.

The miners and the machines are transported by diesel-powered vehicles. The heavy machinery is also equipped with electric motors for the extraction work “on site” to keep exhaust fumes to a minimum.

First, seven meter deep large diameter (‘jumbo’) bore holes are created in the salt rock. Blast holes are drilled at the face around them and filled with a blasting agent. After the detonation, which is always initated in-between working shifts for safety reasons, large shovel loaders pick up the blasted ore and transport it to the crushing site plant. There it is crushed to lower size for transport. The crude salt is transported many kilometres via conveyor belts to the shaft, where it is hoisted to surface or placed into storage bunkers.

Underground repair shop for mining operations.

The crude salt that was loosened by the blast is transported to the crushing site using large LHDloaders.

Miners going underground

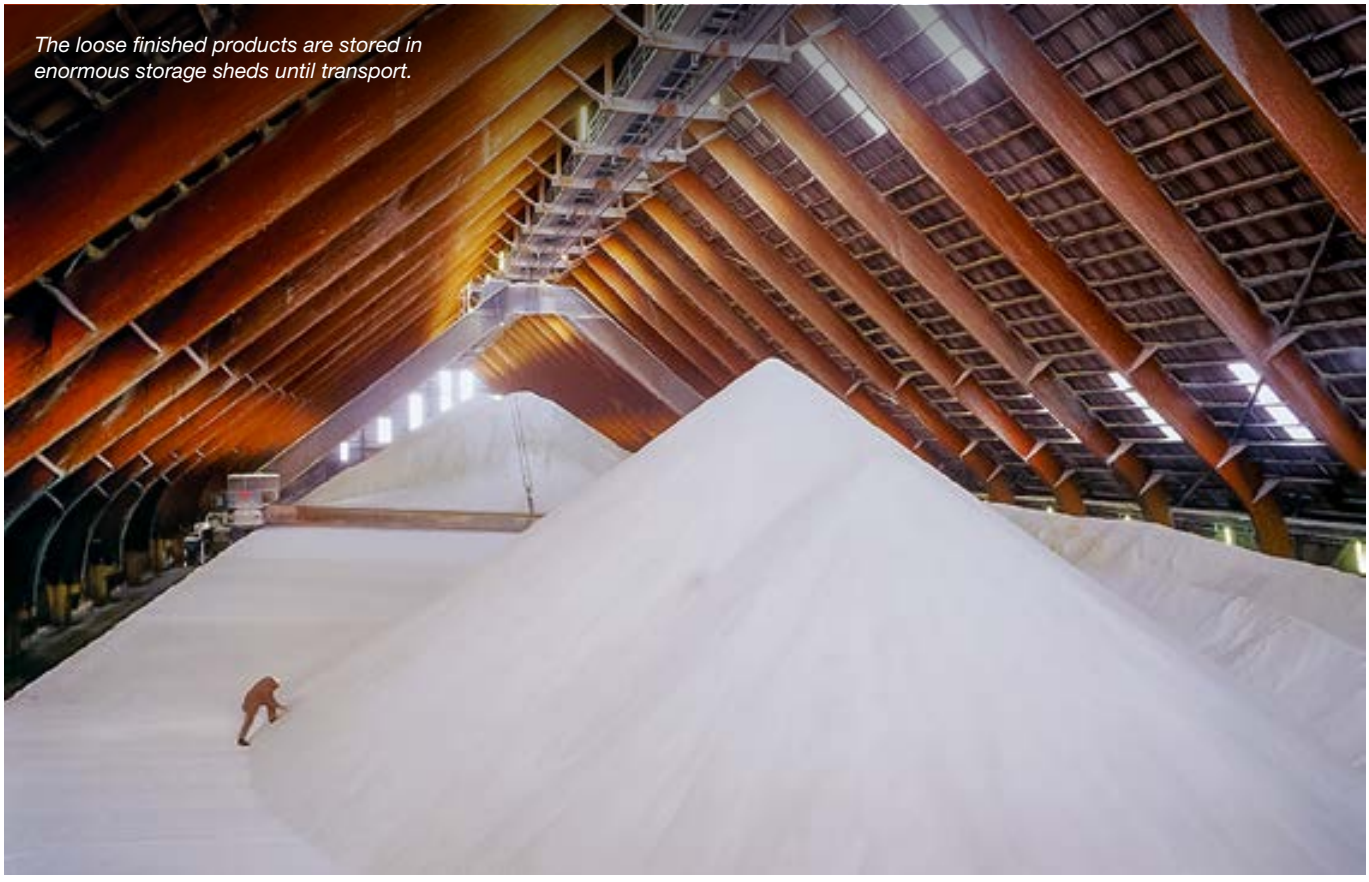
Salt- and other layers forming artistic structures caused by vulcanism

Drilling of large bore holes for blasting preparation

From Crude Salts to High-Grade Mineral Fertilisers – Processing Methods

Skips transport the crude salt aboveground with speeds of up to 24 metres per second.

The crude salt is transported to surface from underground in skips with speeds ranging from 15 to 24 metres per second. The next step aboveground is the fine grinding followed by the processing to fertilisers, depending on the potash salt type, via thermal dissolution, flotation or electrostatic separation. The selection of the separation process depends on the composition of the crude salt as well as the desired end product. These processes can also be combined.



The loose finished products are stored in enormous storage sheds until transport.


Dissolving station

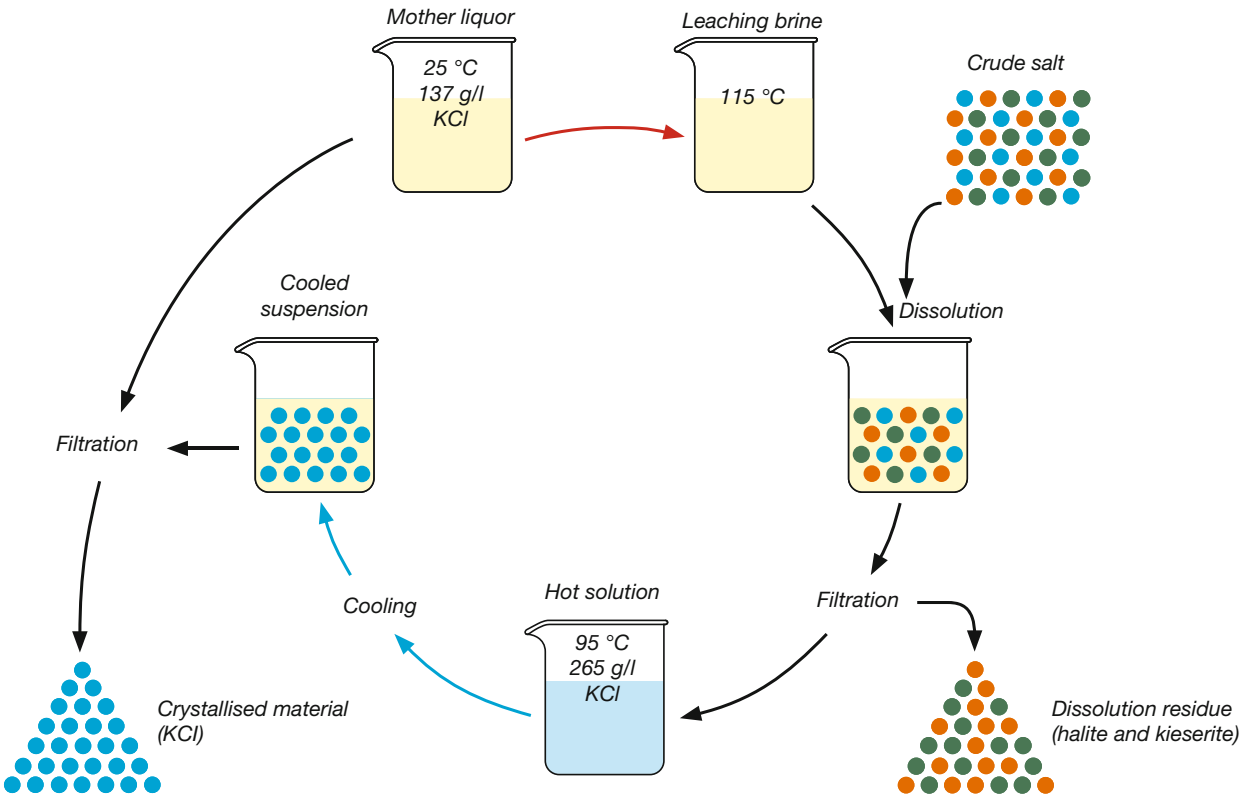
Thermal dissolution

The thermal dissolution method, which is used at several sites, is based on the temperaturedependant dissolution behaviour: While halite dissolves in water equally well nearly regardless of the temperature, the solubility of potassium chloride increases with the temperature. For example, only 137 grams of potassium chloride can be dissolved in one litre of brine at 25 °C, whereas 265 grams can be dissolved per litre at 95 °C.

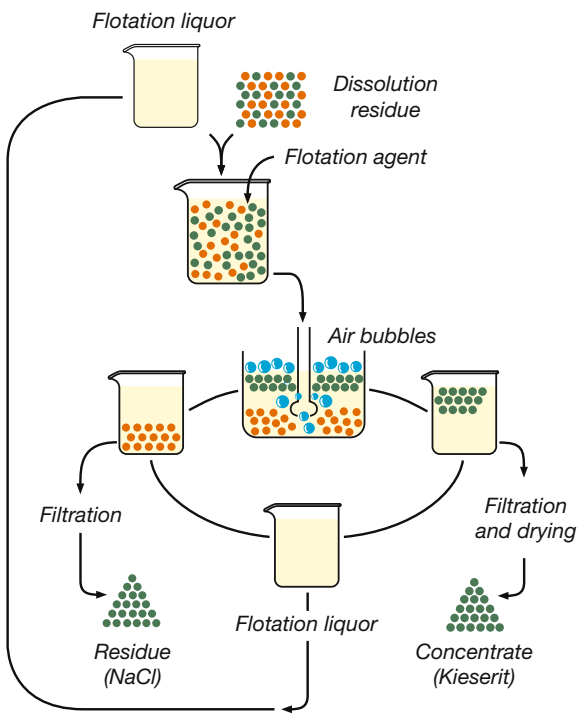
To extract potash from the crude salt, a saline solution which is saturated with halite and KCl is heated. After it has been heated, the solution continues to be saturated with halite but the solubility of sylvite increases with the rising temperature.

Crude salt is now added to the hot leaching brine, the potassium minerals dissolve, the halite and kieserite remain undissolved as solid material. The solid residue is separated by filtration or centrifugation and subsequent clarification. Potassium chloride is then extracted from the hot, clear solution with a purity of up to 97 % by cooling in a vacuum crystallisation system.

Thermal dissolution



Flotation



Flotation

The flotation process is used to separate halite and kieserite which form the dissolution residue from the thermal dissolution process. It allows for a large reduction of waste brine, which resulted from the previously common kieserite washing process and which had to be disposed of.

This process is based on the fact that the minerals that are to be separated are suspended in a saturated salt solution, into which air is then blown. To ensure that the air bubbles only latch onto specific types of minerals, they are treated with small amounts of special flotation agents, which make them water-repellent. The air bubbles then only stick to these particles, in this case kieserite. As a result, the kieserite risen to the top as foam and can be skimmed off.

The halite remains at the bottom of the flotation cell and, after it has been separated from the liquid, is piled up on surface or transported into large underground cavities as backfill.

It is essential for the success of this separating process that the minerals targeted for separation are not aggregated but were milled into fine powder beforehand. This process works with low amounts of waste brine that eventually have to be disposed of.

View at Kieserite flotation cells

View into a ESTA® station (Electrostatic separation unit)

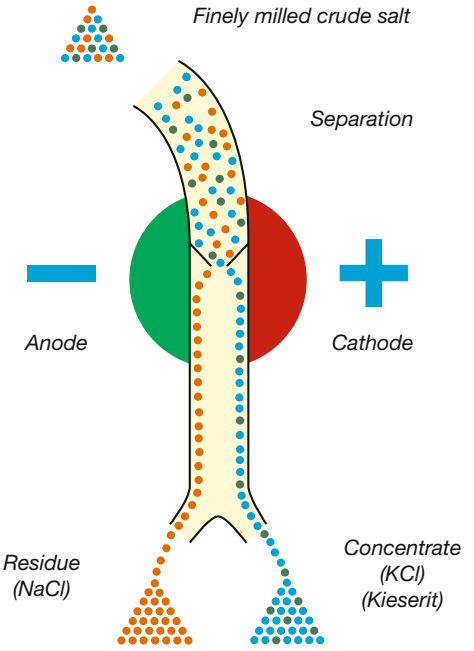
ESTA® process
(**E**lectro**STA**tic process)

This separation process, which is carried out dry without salt solutions or a high energy consumption for drying the products, is based on a phenomenon that can also be observed in everyday life: If two materials are rubbed against each other under certain physical conditions, they can become “electrically” charged.

Basically, the same effect occurs in the ESTA plant, a unique development of K+S. First, the crude salt is milled to a grain size of one millimetre so that the mineral conglomerate is broken down into its components. In the next step, the salts are treated with surface-active substances in a fluidised bed at a precisely defined temperature and humidity, so that they selectively charge each other either electrically positive or negative. The charged salt crystals trickle through a free-fall separator, which consists primarily of two electrodes with a high voltage field in-between.

Here, the differently charged crystals are diverted either to the anode or the cathode. The sorted minerals are then caught separately below the separator.

Electrostatic process

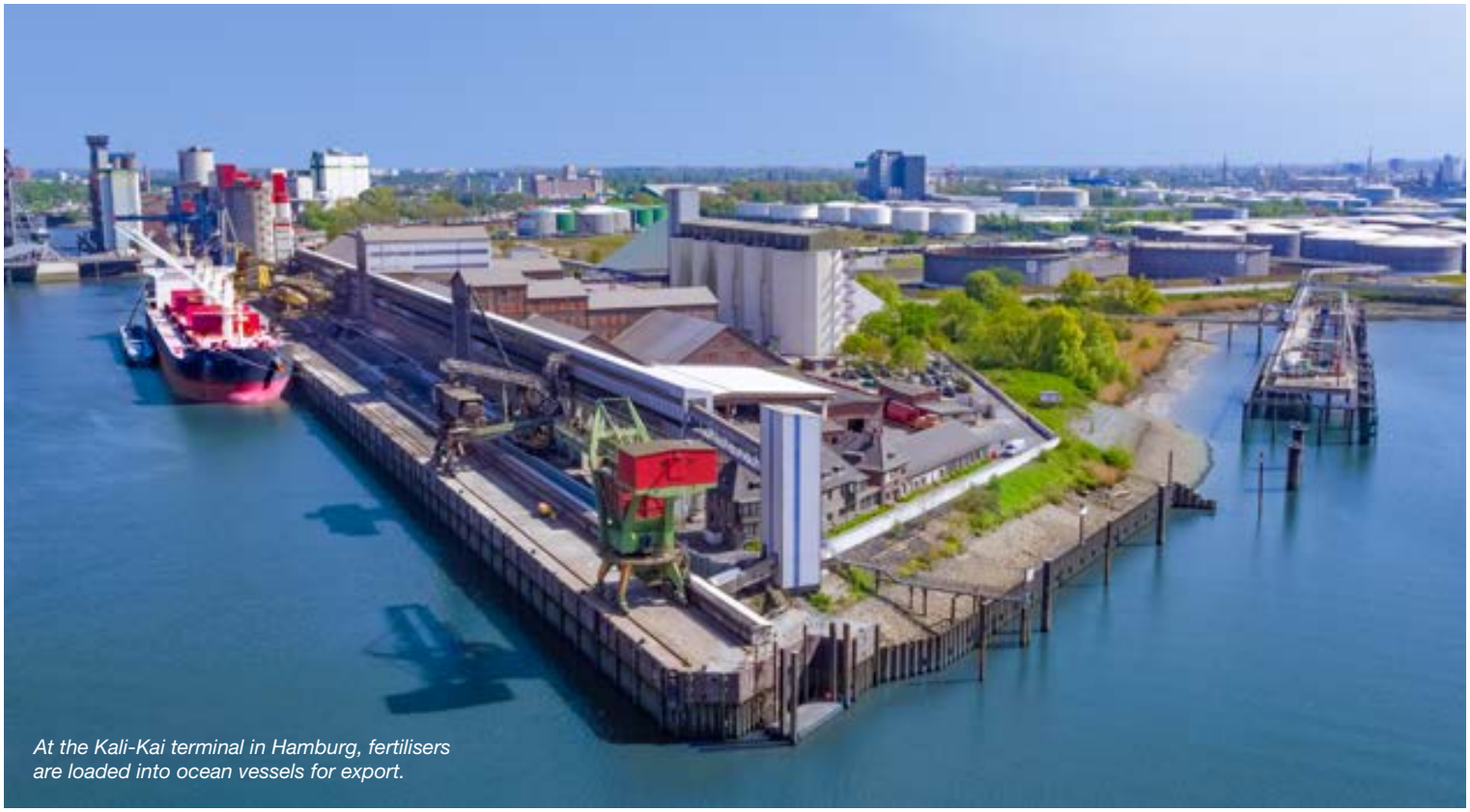


Competence Creates Security – Quality Control and Logistics

Automated control systems and constant control analyses ensure the adherence to the specified nutrient contents in the various potash and magnesium fertilisers.

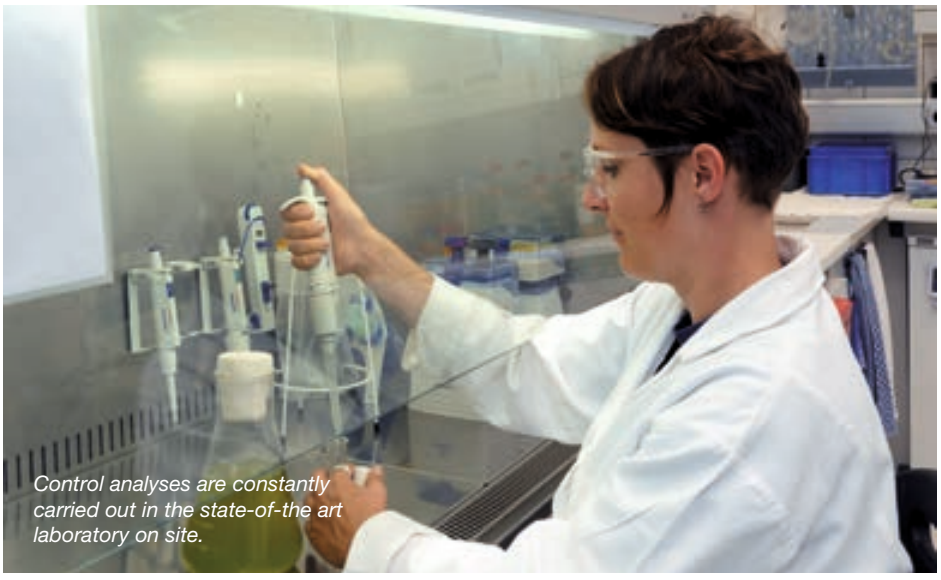
The deliveries are automatically tested and are analysed in laboratories on site, so that the declared nutrient content can be guaranteed on a lasting basis.

Production is monitored and controlled from central measuring stations.



At the Kali-Kai terminal in Hamburg, fertilisers are loaded into ocean vessels for export.

Rail is one of the most important means of transport for the high-quality K+S products.



Control analyses are constantly carried out in the state-of-the art laboratory on site.

Responsibility for the Environment – Foresighted Thinking, Sustainable Action

Sustainability in potash mining stands for economic activity in line with environmental requirements and social obligations. Therefore, we continuously invest in modern and environmentally-friendly technologies.

Our economic success highly depends on the efficient use of all substances and materials available in our value chain. Our constant goal is to optimise the use of our resources and to minimise the unavoidable environmental impact associated with the extraction and processing of crude salt.

K+S therefore employs modern exploration and extraction processes and is continuously improving the process technology used with intensive in-house research and development. We can proudly point out that we have continuously lowered raw material and energy consumption in the past years and decades.

Environmentally friendly resource separation

As the crude salt contains non-usable salts, these have to be separated from the resource and the residue has to be disposed of in an environmentally friendly manner. All potash producers worldwide face the necessity to dispose solid and liquid residues. Although K+S takes a leading role in the sector regarding environmental standards, a residuefree production is not entirely possible in our plants despite the use of best available technology. Depending on the site and composition of the crude salts, we employ the hot dissolution and the flotation process or – in combination with both – the electrostatic separation, the ESTA® process. While the first two processes include the use of water, the electrostatic separation is a dry separation process that K+S is employing as the only producer worldwide.

Solid residue is currently mostly non-usable rock salt with insoluble trace minerals, is either brought upon tailings pile or brought back into the mine, depending on geological conditions. In case of the tailings, the ground is prepared with suitable measures to largely prevent saline rainwater from seeping into the ground.

A comprehensive network of drainage systems in form of trenches and drainages ensures the collection and disposal in a controlled manner. This includes the saline waste water, which emerges as a consequence of precipitation on the tailings piles as well as production waste water. Under certain conditions it is possible to cover even large tailing piles with thin layers that can subsequently be planted. The vegetation layer can reduce waste water amounts significantly. This has been developed in longterm scientific experiments. We will nevertheless continue research in the area of tailing pile covering in the future.

The river Werra is a matter close to our heart

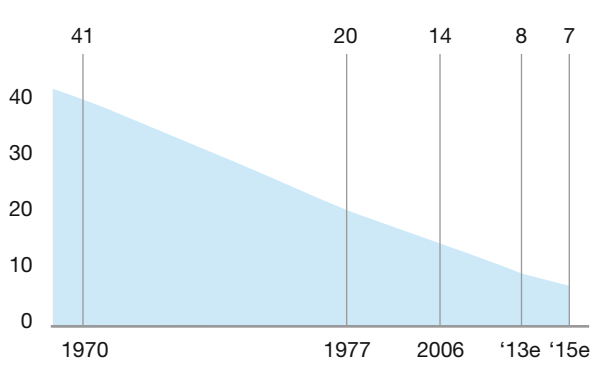
We will have invested up to € 360 million in the area of water protection at our production plants at the Werra by the end of 2015. In doing so, we can reduce half the saline waste water amounts and hence achieve a significant reduction in the salt concentration in the Werra. It is our goal to further strengthen the improvement that have been visible in the Werra for the past 10 years.

However, operational environmental protection not only concerns the disposal of solid and liquid residues. Responsible behavior for the environment is required in all production areas.

Some examples

In order to keep salt dust emissions to a minimum during crude salt processing in the various process steps and especially during milling, sieving and drying, our plants are equipped with highly effective dust removal systems. They clean the exhaust air from the plants according to the best available technology and meet all emission control requirements.

Significant reduction of the saline water content in the Werra



Decrease in salt water volume since 1970, forecast until 2015.

The waste water is run to collection tanks via sealed trenches.

Comprehensive measuring networks monitor the air quality in the area surrounding the plant.

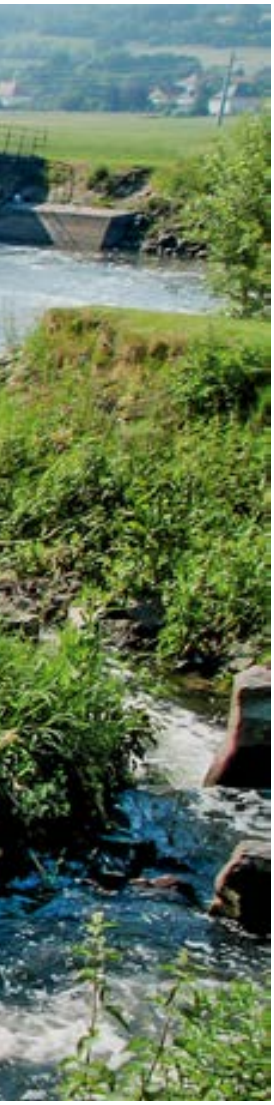
Species protection: A bat box is installed at a K+S production facility for use as daily quarters and as nursery.

The photo shows a fish ladder that was installed in line with the compensatory measures.

We implement extensive noise protection measures in order to contribute to further improvement of the quality of work and life of employees and residents. For example, we were able to significantly reduce the noise level in the area surrounding the plant by installing several silencers and by refitting noise-intensive systems.

Energy efficiency and climate protection are also important factors. We produce most of the energy necessary for production in the form of electricity and steam in our own lowemission natural gas power plants. We employ the best currently available power plant technology (cogeneration) at our sites with an energy efficiency of 90 %. The sites are therefore operating close to theoretically achievable energy efficiency, thus further investments would not lead to noticeable emission reductions. Another component in our programme to reduce carbon dioxide emissions and hence our contribution to climate protection is the optimisation of our production processes, the recovery and use of waste heat in our plants and power plants as well as the reduction of energy consumption in the entire value chain.

It cannot be completely avoided to make use of the landscape and nature for the extraction and processing of raw materials therefore these actions need to be compensated adequately. We take this obligation seriously. In connection with environmentally relevant large-scale projects, we are implementing numerous compensatory measures. Among them are not only measures for biotope improvements such as the construction of fish ladders but also the comprehensive planting of trees and shrubbery and renaturation measures that are planned in cooperation with the competent authorities. In many cases, local nature conservation organisations support us with their knowledge about the local fauna and flora.



The saline waste water is stored in pools before its disposal.

Merkers Adventure Mine –
The World of White Gold

Approachable mining

Deep below the ground and about 20 million years ago, the forces of volcanic activity in the Rhön region created a unique grotto almost completely covered by white gold. In Merkers Adventures mine fascinating salt crystals with unbelievalbe sizes up to one metre in length have grown. This grotto is a breathtaking sight for young and old. The first memorable experience for visitors is travelling down the mine in the shaft elevator an ideal introduction to the tour in 500 m depths to experience mining from previous times until today.

Acoustics and cuisine

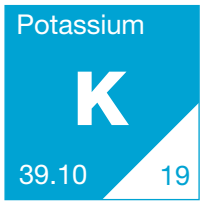
One stop on the underground tour is the bunker, which was once used as a holding facility for crude salt. Due to its excellent acoustics, it is also a suitable venue for concerts. In fact, it is the largest underground concert hall in the world. Its extraordinary ambience also makes it suitable for concerts, conferences and other events for up to 850 persons equipped with modern conference and concert technique. This unique sound is incomparable.


MERKERS ADVENTURE MINE

POTASSIUM, MAGNESIUM, SULPHUR AND SODIUM

ESSENTIAL PLANT NUTRIENTS OF NATURAL ORIGIN

Potassium –
Ensures Yield and Quality



The growing plant consists of up to 80 % water. If the dry matter is burned, potassium accounts for the largest content of all minerals at more than 40 %. In particular, young, metabolically active plants are rich in potassium, which can be attributed to its versatile function in the metabolism.

Potassium is crucial for photosynthesis

Numerous enzymes are involved in the photosynthesis or CO_2 assimilation that are activated by potassium. Therefore, the CO_2 assimilation is much higher in leaves with a good potassium supply than in leaves with a poor potassium supply.

Potassium promotes the assimilate transport

The faster the value-determining ingredients (for example sugar, starch) are transported from the leaves to the storage organs, the sooner new substances can be produced in the leaves. This transport depends on a good potassium supply.

Potassium ensures better grain filling

Potassium not only increases the number of grains per spike but also supports the grain formation and thus the thousand-seed weight.

Potassium increases sugar storage

A sufficiently high potassium content in the plant is essential for sugar production in the leaves, transport to the storage organ and sugar storage in the beets.

Improved water use through potassium

When a plant is malnourished, much of the water evaporates unproductively, which means it does not significantly contribute to production of dry matter. The plants regulate the release of water with the help of stomata on the underside of the leaf; a rapid opening and closing of stomata depends on a sufficient potassium supply of the cells in this area.

Improved nitrogen efficiency through potassium

High nitrogen dosages aid the development of green plant parts. An insufficient potassium supply can lead to the formation of loose tissue structure so that the stability of the plant and shelf life of the fruit are negatively affected and the invasion of pathogens is facilitated. This is prevented through good potassium nutrition by means of increased production and storage of cellulose and lignin.

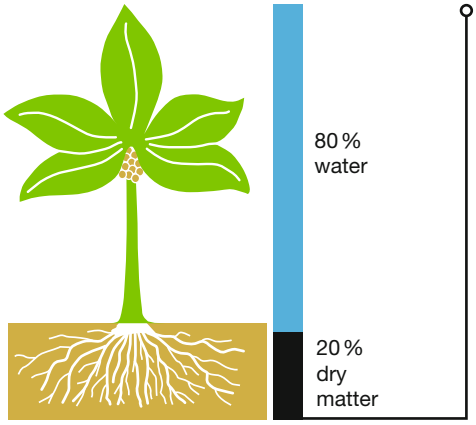
Potassium increases resistance to frost

When a plant receives an adequate amount of potassium, enough substances that lower the freezing point of the cell sap are stored inside the cell. Because potassium supports the formation of strong and dense root systems, there are no serious negative effects if alternating frosts and thaws cause heaving and parts of the roots are torn off.

Potassium increases resistance to diseases and pests

Potassium strengthens cell tissue. Therefore, an invasion is more difficult for fungi and pests.

Average composition of plants

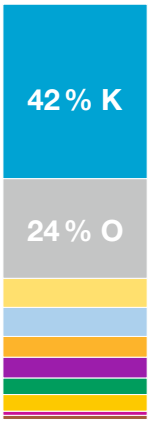


The dry matter consists of:

- 30 % crude fibre
- 12 % protein
- 48 % nitrogen-free extractives
- 4 % fat
- **6 % ash**

The ash consits of:

- 42 % potassium
- 24 % oxygen
- 7 % chloride
- 7 % silicon
- 5 % phosphorus
- 5 % calcium
- 4 % magnesium
- 4 % sulphur
- 1 % sodium
- 1 % trace elements for example iron, manganese, zinc, copper, boron et al.



A soil potassium content of only 10 mg K_2O/100 g soil (CAL) inhibited beet growth compared to 25 mg K_2O/100 g soil (right) at the same location and thus reduced sugar production. Korn-Kali with 40 % K_2O as well as its valuable supplementary nutrients MgO (6 %), Na (3 %) and SO_3 (12 %) is the ideal potash fertiliser for performance and quality in the cultivation of sugar beets.

Potassium supply and fertilisation has a direct effect on harvest yield and quality. Disappointing yields are the result of a suspended potassium fertilisation, as the experiment on the left clearly shows (in the front: No potassium fertilised, in the background: potassium fertilised with Korn-Kali).

Magnesium – Essential for Energy Supply and Assimilate Production

Magnesium
Mg
24.31 12

Magnesium is the essential component of chlorophyll. Chlorophyll performs the central function of plant growth, the conversion of the sun's energy into biological/chemical energy. Magnesium plays a key role on the total energy and metabolic performance of the plant.

- Up to 30 % of the total magnesium content of the plant are contained in the chlorophyll. Magnesium is the catalyst for the energy transformation with the help of ATP.
- Magnesium plays an important role in the protein and carbohydrate metabolism. The storage capacity for assimilates in the storage organs (grain, beet, tuber, etc.) is significantly affected by the magnesium content of the plant.
- Magnesium deficiency during the growing phase is directly associated with a reduced photosynthesis rate and thus reduced yield and quality of the plant.
- Magnesium improves root development and enables plants to get sufficient amounts of nutrients from the soil.

Ensuring Sufficient Magnesium Supply

- On soils derived from a parent rock with a low magnesium content, for example loess, granite and shell limestone.
- On light soils poor in humus with low magnesium content.
- On soils low in pH.
- After liming with magnesium-free lime.
- In case of considerable fluctuations in the water status of the soil.
- In case of ammonium-based nitrogen fertilisation, for example ammonium nitrate-urea solution, urea, diammonium phosphate, slurry.

The use of magnesium sulphate ($MgSO_4$) in the form of ESTA Kieserit or in the EPSO products has proven itself in practice.

Magnesium sulphate is completely watersoluble and therefore immediately available to the plant. The solubility of the magnesium products is marked on the packaging.

If the addition "water-soluble" is missing from the marking, then these are magnesium forms that are hardly soluble and will be plant available only to a very limited extent or not at all.

Magnesium deficiency in winter wheat.

Magnesium deficiency in oil seed rape.

Potatoes with optimal potassium and magnesium nutrition.

Sulphur –
Essential for the Metabolism of the Plant

Sulphur
S
32.07 16

Sulphur Fertilisation is Essential

Air pollution control measures have reduced average atmospheric sulphur deposition to only 5–10 kg S/ha/year in Germany and similarly in many other European countries. Therefore, sulphur fertilisation has become a necessary fact in all crops that has to be taken seriously.

In the soil, sulphur can only be stored in soil organic matter. It has to be mineralised first to make the sulphur available to the plant. This leads to the fact that sulphur supply is often insufficient, especially during periods of strong growth or at the beginning of vegetation.

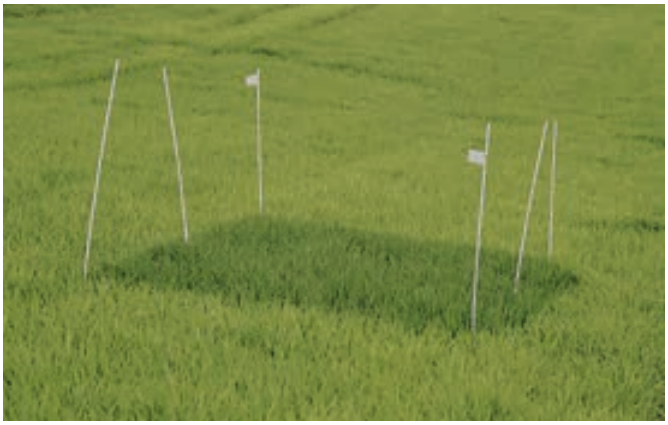
The only solution to have sufficiently sulphur available, is potassium or magnesium sulphate or also ammonium sulphate. All other sulphur fertilisers – generally containing elemental sulphur – have to be converted to sulphate first and therefore need a longer starting time and in addition they are associated with a decrease in soil pH.

K+S offers a series of fertilisers containing sulphur in the form of potassium or magnesium sulphate.

Potassium Sulphate and Magnesium Sulphate

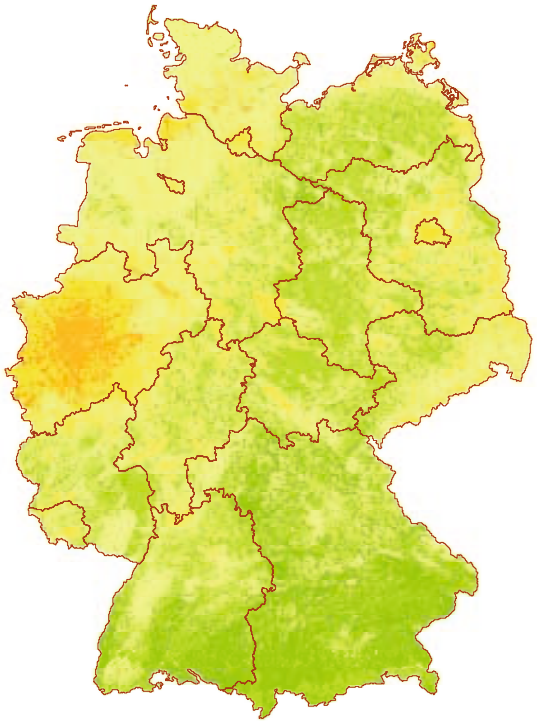
- make a targeted fertilisation possible.
- are fully water-soluble.
- offer the possibility of timely application.
- can be oriented on the need of the plants for sulphur.
- are pH-neutral.

Magnesium sulphate in form of EPSO Top is excellently suited for the use as foliar fertiliser.



Grain field turned green after sulphur fertilisation.

Sulphur Deposition from Rain and Air in Germany (kg S/ha)



0.3–6.0 | 6.0–9.0 | 9.0–15.0
15.0–24.0 | 24.0–49.3

In most regions, the sulphur deposit from rain and air is less than the amount that the plants need.

National Focal Center: German Federal Environmental Agency (UBA) BMU/UBA, FE-No. 204 63 252, GIS & Mapping 01/2008: Thomas Gauger

Sulphur deficiency is also provoked by various soil types.

Sulphur

- is absorbed by the plant in amounts similar to magnesium.
- in sulphate form, can be absorbed by the root as well as by the leaf.
- is an essential component for the production of amino acids and thus of protein.
- is involved in the synthesis of sugar, starch, vitamins and flavourings.
- is needed by oil plants for oil production.

Sulphur deficiency – a more and more frequently occurring symptom

In grains:
Low thriftiness, yellowing, rigidity of the plant (easy to mistake for nitrogen deficiency!)

In oil plants:
Marbled leaf surfaces between the leaf veins, red-violet anthocyan production, spoon-like deformations of the leaves, white petals.

In maize:
Young leaves become light green to yellow, low kernel formation at the cob.

Sulphur deficiency in maize

Sodium –
Important for Animal Health

Sodium
Na
22.99 11

The absorption of both sodium and chloride via the plant promotes the tastiness of the feed and the basic feed intake. This enables a higher milk yield from basic ration.

The absorption capacity of sodium chloride from supplementary feeds like cattle salt, lickstones and mineral feed is physiologically limited. In order to prevent animals from diarrhoea, fertilisation of the plants is a better way to provide sodium to animals.

One-sided, sodium-free fertilisation leads to an extremely low sodium content in the feed. However, a close K:Na ratio of about 20:1 is an important requirement for a high performance. If that is not the case, the cow has to compensate with increased hormone production (aldosterone).

Aldosterone, which mainly controls fertility, is needed for maintaining the sodium balance of the cow in case of insufficient sodium supply and is therefore lacking as a reproductive hormone. Fertility problems are the result.

Potassium and Magnesium – Essential for Humans

Potassium is Vital

Potassium is present in every cell in the body and helps to maintain fluid balance.

Potassium is needed for protein production in the body and processing of carbohydrates and is essential for muscle function.

The symptoms of potassium deficiency are: Exhaustion, tiredness, muscle weakness and constipation. In serious cases it can even lead to impaired consciousness and cardiac arrhythmia.

Some causes for potassium deficiency are:

- poor nutrition
- frequent intake of laxatives
- chronic kidney and gastrointestinal diseases

Potassium concentration in the human body per kg fresh weight

blood	4.4 g
flexed muscle	3.6 g
heart muscle	2.6 g
liver	3.0 g
skin	0.8 g

Magnesium works preventatively

- against depression
- against learning disorders of children
- against headaches caused by tensed muscles in the back of the head, neck and shoulders
- against circulatory disorders
- against tendency to thrombosis
- against calcification
- against angina pectoris
- against circulatory problems and heart attack
- against menstrual cramps, pregnancy discomfort and premature births
- against stomach and intestinal cramps
- against the formation of kidney stones

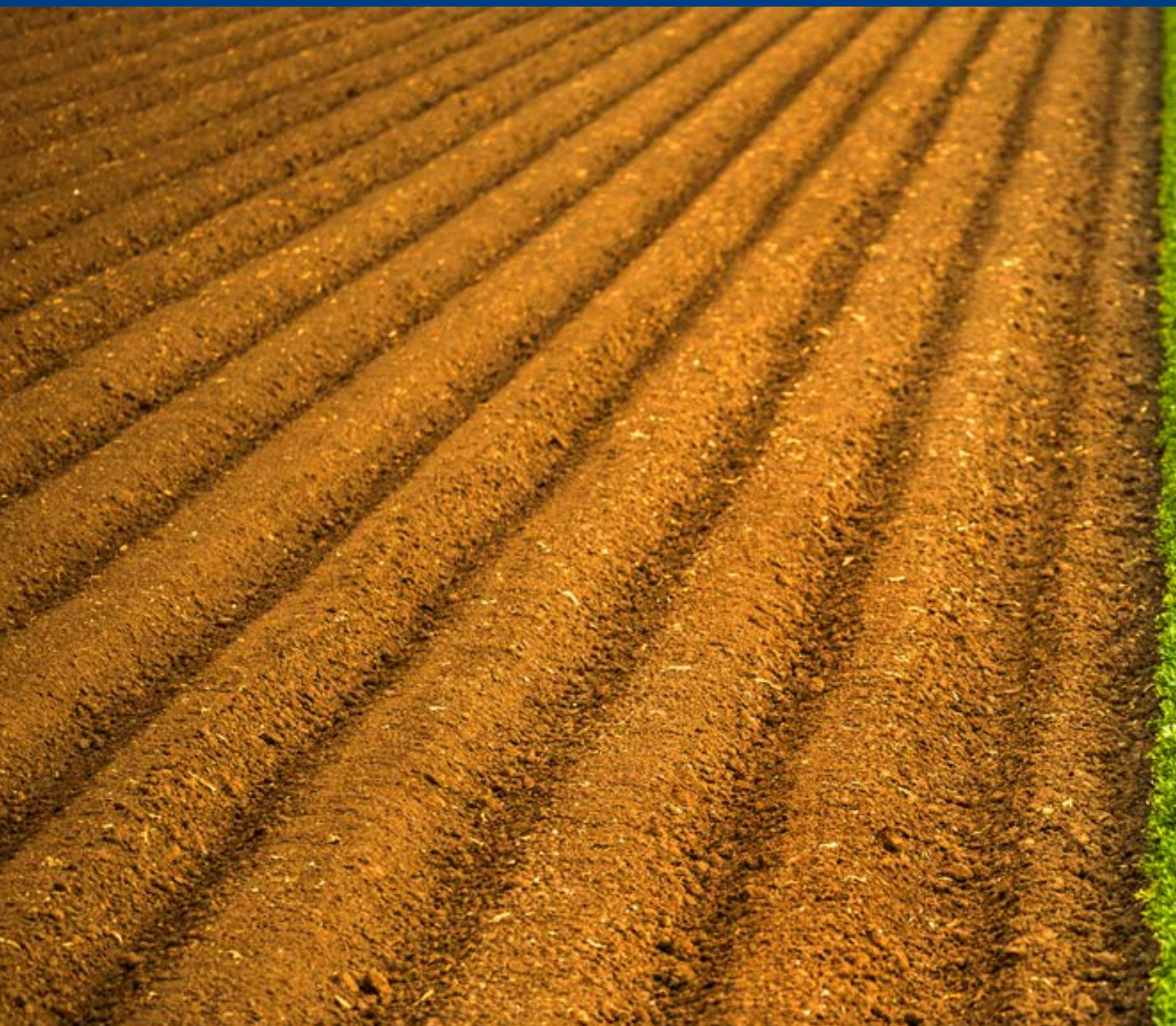
Potassium and Magnesium for Humans

Potassium and magnesium are not only important for plants and animals but also play an important role in the human metabolism.

Potassium requirement per day ca. 2,500 mg Potassium content of some foods (mg/100 g edible part)	
Beans, white	1,310
White mushrooms, fresh	418
Potatoes (cooked)	400
Milk chocolate	400
Muscle meat	385
Banana, raw	382
Tomato, raw	270
Rye bread	291
Milk	157
Quality wine	110

The market not only requires fruits and vegetables to have a high vitamin and nutrient content but also an improved storage life and a longer shelf life – plants with a good nutrient supply are the prerequisite for this.

Magnesium requirement per day ca. 500 mg Magnesium content in food (mg/100 g edible part)	
Hazelnuts	156
Peas	125
Spinach	58
Cheese	40
Bananas	36
Fish (average)	30
Pork	26
Carrots	21
Apples	4



PRODUCTS OF K+S

PLANT NUTRIENTS OF HIGH QUALITY FOR AGRICULTURE

Diverse and High Quality –
Our Products at a Glance

Soil fertiliser	FOR ORGANIC FARMING *	(in %) K_2O	MgO	Na	S
60er Kali®		60	-	-	-
Korn-Kali®		40	6	3	5
Magnesia-Kainit®	✓	9	4	26	3.6
KALISOP® gran.	✓	50	-	-	17,6
Patentkali®	✓	30	10	-	17
ESTA® Kieserit fine	✓	-	27	-	22
ESTA® Kieserit gran.	✓	-	25	-	20

Foliar and liquid fertilisers		K_2O	MgO	Na	S
EPSOTop®	✓	-	16	-	13
EPSOMicrotop® 0.9 % B, 1 % Mn	✓	-	15	-	12.4
EPSOCombitop® 4 % Mn, 1 % Zn	✓	-	13	-	13.6

**approved for organic farming pursuant to EC regulation 834/2007 and 889/2008.*

60er Kali®

Potassium Chloride – Fine and Granulated

60er Kali® fine and gran.

EC FERTILISER
Potassium chloride 60

60 % K_2O water-soluble potassium oxide

60er Kali®

- is a universal potash fertiliser suitable for all chloride tolerant crops and soils to supply the plant with the nutrient potassium.
- is usually spread onto medium and heavy soils onto the stubble in autumn or prior to sowing and is incorporated into the topsoil layer during tilling.
- is easy to apply in granulated form with high spreading quality with all modern fertiliser spreaders.

The potassium can also be successfully applied to winter crops and perennial crops, especially on lighter soils, as top-dressing in early spring.

Deposit fertilisation (crop rotation fertilisation) for crops in need is also possible on medium to heavy soils.

Use of 60er Kali®

- 60er Kali fine is mainly used for the manufacture of compound fertilisers.
- 60er Kali gran. is a highly concentrated potash fertiliser. It is suitable for all chloride tolerant crops, whereby an additional supply with magnesium, sodium and sulphur has to be ensured in the fertilisation plan.

Korn-Kali®

The All-rounder –
Extremely Versatile

Korn-Kali®

EC FERTILISER
Potassium chloride with magnesium 40 (+6+4+12.5)

40 % K_2O	water-soluble potassium oxide
6 % MgO	water-soluble magnesium oxide
4 % Na_2O	water-soluble sodium oxide (= 3 % Na)
12.5 % SO_3	water-soluble sulphur trioxide (= 5 % S)

Korn-Kali®

- is a combined potash and magnesium fertiliser with 40 % K_2O in the form of potassium chloride and 6 % MgO in the form of magnesium sulphate (Kieserite). Further important constituents are 4 % Sodium as sodium chloride (Na_2O) and 12.5 % Sulphur as sulphate (SO_3).
- contains all nutrients in fully water-soluble form. They can therefore be directly absorbed by the plant.
- ensures the basic supply of the crops amongst others during the autumn application with a sulphur content of 5 %.
- has a narrow particle size spectrum ensuring a high spreading quality and enabling a constant distribution at large spreading widths.
- is effective regardless of the soil pH and is therefore suitable for all sites.
- is a valuable partner even in bulk blending.

Korn-Kali increases the sugar-content.

Korn-Kali® has many benefits

Significant amounts of potassium and magnesium are taken from the soil with each harvest. They have to be replenished with adequate fertilisation. Korn-Kali contains both nutrients in a ratio favourable for the plant.

Regularly used in the crop rotation, Korn-Kali meets the specific nutrient requirements of agricultural crops for potassium, magnesium, sulphur and sodium.

Sugar beets are particularly sensitive to potassium deficiency with losses in yield and quality. Korn-Kali promotes the favourable sugar content and the sugar yield even if the soil is adequately supplied with nutrients.

Due to a reduced atmospheric deposition and the use of low-sulphur fertilisers, symptoms of sulphur deficiency can be observed in many regions. The regular use of Korn-Kali forms the basis for the sufficient sulphur nutrition of the plant.

Korn-Kali is the ideal potash fertiliser for stubble and autumn fertilisation and ensures an application in a soil-conserving manner and a good nutrient distribution in the topsoil.

Korn-Kali®: All-round Potassium Fertiliser – Application in Crops

Fields of application for Korn-Kali®

Due to its optimal nutrient composition, Korn-Kali is the most used single-nutrient potash fertiliser in Germany and very common in many other countries of Europe and the world as well. An economic application is possible on all soil types and for almost all crops (plants sensitive to chloride require sulphate-based fertilisers).

Within crop rotation, Korn-Kali should be applied to crops that have high demands on a good potassium supply (for example sugar beets, rape, maize) and that have special requirements regarding specific macronutrients (for example sulphur requirement of rape, magnesium or sodium requirement of sugar beets).

Fertilisation with Korn-Kali is recommended for soils with optimal magnesium contents in order to maintain magnesium levels and to prevent deficiencies (maintenance fertilisation).

Fertilisation with Korn-Kali is especially important for the magnesium supply of the plants, if nitrogen fertilisation occurs in form of amide (urea) or ammonium (for example liquid manure).

Fertilisation recommendations

The amount of Korn-Kali that has to be applied depends on

- the potassium requirement of the crop or the crop rotation,
- the potassium or magnesium supply and dynamic of the soil (site conditions),
- the various requirements of different crops regarding the macronutrients like magnesium, sulphur and sodium,
- the nutrients provided by organic fertilisation.

Autumn fertilisation with Korn-Kali®

Korn-Kali is applied to medium and heavy soils in autumn (stubble fertilisation) and is incorporated into the topsoil layer during tilling. That way, the nutrients are unrestrictedly available at the beginning of the vegetation period.

On light soils, Korn-Kali should be applied in early spring to prevent nutrient loss at these locations.

Korn-Kali is the ideal partner for fertilisation systems with single-nutrient or NP fertilisers and also serves as supplement for the application of compound fertilisers.

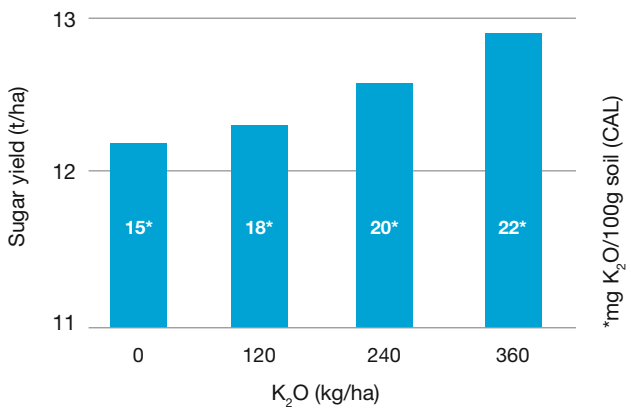
© Amazone.de

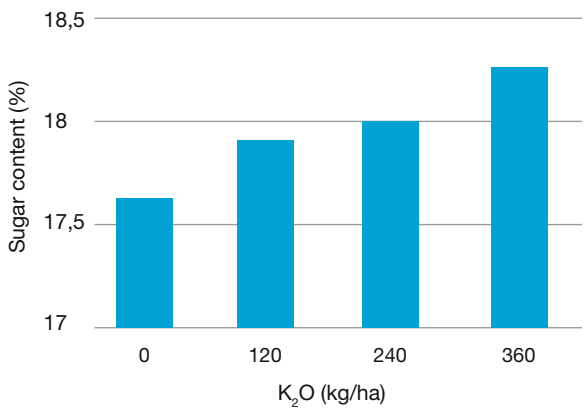
For some crops, the specifications in the table below serve as reference for the fertilisation of soils with medium potassium content, regardless of the organic fertilisation.

Potassium requirement of several crops (in kg K_2O/ha)

Crop	Yield level medium	high
Cereals	100–140	140–180
Oil seed rape	200–240	240–280
Sugar beets	360–400	400–480
Forage/grain maize	200–240	240–280
Forage crops	180–240	240–340

Impact of a different K-supply of sugar beets on sugar yield and content
K+S Minerals and Agriculture GmbH – experiments, 1985–1997





Magnesia-Kainit®

The Specialist –
For Healthy Forage

Magnesia-Kainit®

EC FERTILISER
Kainit 9 (+4+35+9)

9 % K_2O	water-soluble potassium oxide
4 % MgO	water-soluble magnesium oxide
35 % Na_2O	water-soluble sodium oxide (= 26 % Na)
9 % SO_3	water-soluble sulphur trioxide (= 3.6 % S)
47 % Cl	chloride

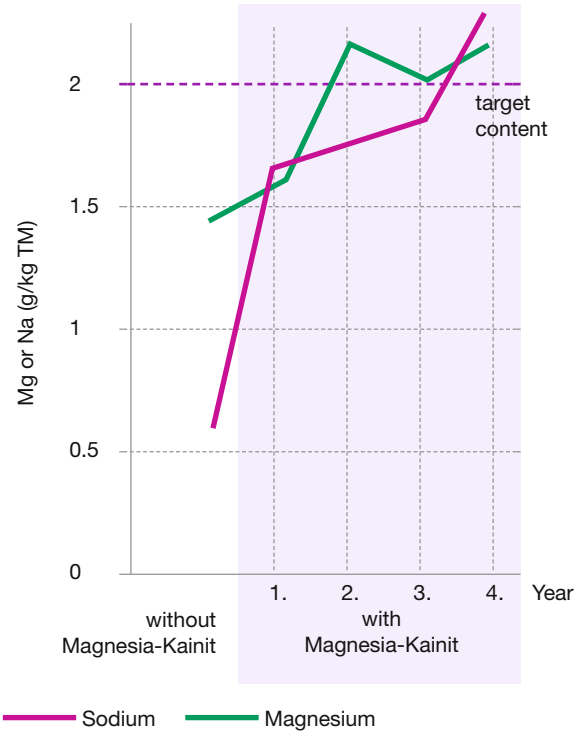
Magnesia-Kainit®

- is with 9 % K_2O a special fertiliser for grassland and forage cropping. This fertiliser is characterised by its magnesium and sulphur content (4 % MgO, 9 % SO_3) and sodium (35 % Na_2O) which is essential for animal feed. Magnesia-Kainit is an ideal supplementary fertiliser, if large amounts of liquid manure are applied.
- is a mined crude potash salt, containing the valuable mineral kieserite. All nutrients are water-soluble and are therefore immediately available to crops.
- is effective regardless of the pH value of the soil and is therefore suitable for any location.
- is a granulated fertiliser. Its particle size spectrum ensures a high spreading quality and enables constant distribution.
- contains 9 % SO_3 and thus contributes to an efficient utilisation of nitrogen fertilisation.
- is certified for organic farming according to the regulations (EU) 2018/848 and (EC) No. 889/2008.

Magnesia-Kainit increases the nutrient content of the base feed

Fertilisation	Mg content in the growth (g/kg dry matter)	Na_2O content in the growth (g/kg dry matter)
120 kg K_2O (sodium-free)	2.1	0.57
130 kg K_2O + 20 kg Na	2.1	0.87
120 kg K_2O + 55 kg MgO + 220 kg Na (as “Magnesia-Kainit”)	2.3	2.24

Result of years of application



Multi-annual application of Magnesia-Kainit leads to sufficient magnesium and sodium contents in forage plants.

Magnesia-Kainit® – For Improving Feed Quality

- The lack of magnesium in the feed ration can lead to the dreaded grass tetany and an unsatisfactory milk yield. The magnesium supply of plants and animals has to be ensured with the appropriate magnesium fertilisation with Magnesia-Kainit.
- Fertility problems lead to lack of appetite, weight loss and a decreasing milk yield. Symptoms are a shaggy hide and excessive licking. Regular fertilisation with Magnesia Kainit increases the magnesium and sodium content in the base feed and thus significantly contributes to the mineral supply of the animals.
- The administration of sodium-containing supplementary feed or the placement of animal lickstones alone does not ensure sufficient and regular sodium supply. Only a mineral supply stemming from the base feed can lead to the desired results.
- About 2 g Mg and 2 g Na per kg dry matter are necessary in the base feed to meet the daily magnesium and sodium requirements of dairy cows. According to analyses in the practice, the average magnesium and sodium content of grassland crops is about 1.3 to 1.5g Mg/kg dry matter and 0.1 to 1.0 g Na/kg dry matter. Accordingly they are insufficient.
- Experiments and observations have shown that animals grazing in differently fertilised areas always prefer the feed fertilised with Magnesia-Kainit; horses graze evenly.
- Sodium increases the palatability of the growth (forage, hay, silage), the animals consume more basic feed and are more productive. They eat more and have an improved mineral supply.
- A higher feed intake of cows leads to an additional milk yield of up to 2 l/day without the additional use of concentrates („Milk more milk from the basic feed!“)
- Sufficiently high magnesium and sodium contents are especially important for the first grassland growth, as they are generally very low. Fertilisation with Magnesia-Kainit prior to the first growth is therefore essential.

Outdoor storage of Magnesia-Kainit®

- Magnesia-Kainit maintains its spreading quality even when properly stored outdoors.
- The outdoor storage of Magnesia-Kainit is possible without any problems, if the following requirements are met:
  - resistant and water-impermeable floor area under all operating and weather conditions,
  - careful covering with an at least 0.2 mm thick foil that is secured with ballast and edge fasteners against wind and mechanical influences.

Time of application

Magnesia-Kainit is preferably applied to slightly frozen and thus well trafficable soil in early spring. Magnesia-Kainit is especially effective at that time.

However, Magnesia-Kainit can also be successfully applied to the young, green grass (ensure dry condition!) as well as after the first use.

Fertilisation recommendations

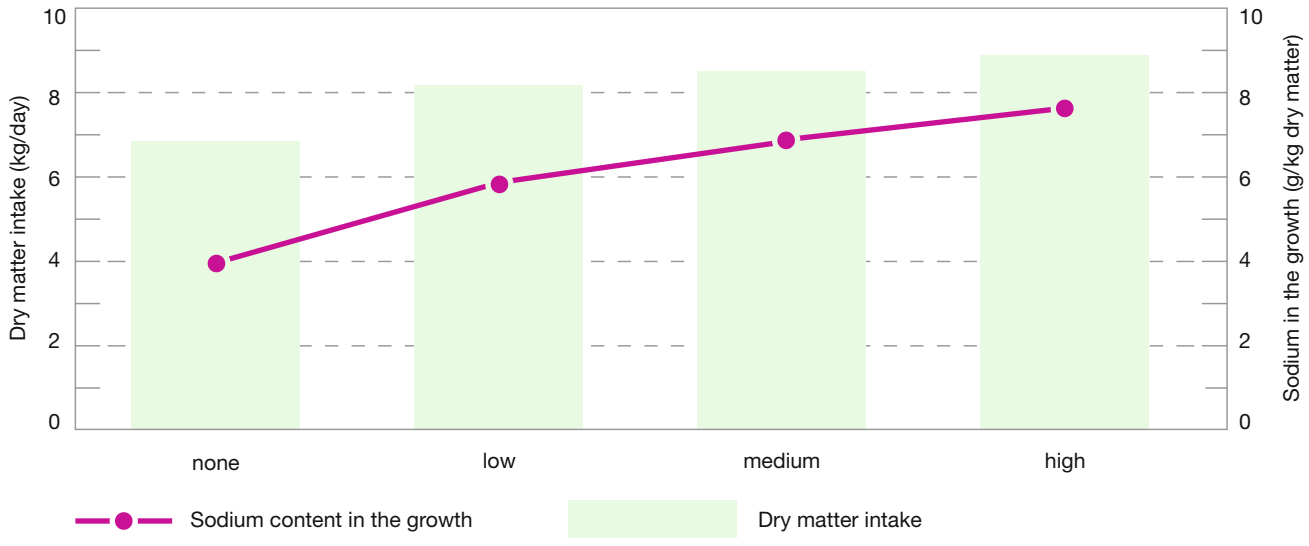
The Magnesia-Kainit amount that should be applied depends on

- mineral requirements due to cultivation,
- potassium, magnesium and sodium contents in the soil,
- the nutrient amount supplied by organic fertilisation.

Soil and feed analysis on the magnesium and sodium content are the best way to determine the necessary fertiliser amount.

Generally, 500–800 kg/ha Magnesia-Kainit are recommended.

Impact of different sodium fertilisation on the sodium content in the growth and feed intake



Source: Chiy et al. 1993 · University of Wales, Bangor

KALISOP®

Premium Quality –
For all Special Crops

FOR ORGANIC FARMING acc. to (EU) 2018/848 (EC) No 889/2008

KALISOP®

EC FERTILISER
Potassium sulphate 50 (+44) gran.

50 % K_2O water-soluble potassium oxide
44% SO_3 water-soluble sulphur trioxide (= 17,6 % S)

KALISOP®

- is a highly concentrated potassium sulphate fertiliser with 50 % K_2O and 44 % SO_3 in sulphate form.
- is water-soluble, so that the nutrients potassium and sulphur are immediately available to the plant.
- is nearly chloride-free and is therefore the ideal potassium source for chloride-sensitive crops.
- has, in compared to other potash fertilisers, a lower salt index and is therefore especially suited for the fertilisation of valuable special crops in intensive cultivation systems.
- is the ideal fertiliser for crops with a high sulphur requirement. Sulphur improves the efficiency of the nitrogen fertilisation and has a positive impact on yield and quality.
- is not hygroscopic and therefore has a good storage stability.
- is certified for organic farming according to the regulations (EU) 2018/848 and (EC) No. 889/2008.

KALISOP® for top quality in the cultivation of fruits, vegetables and tobacco.

The nutrients potassium and sulphur contained in KALISOP are decisive quality-enhancing factors. They play a key role in plant metabolism such as sugar and starch synthesis, protein production, transport of assimilates and activation of enzymes.

Improved appearance and taste

With KALISOP, fruits and vegetables have a more beautiful colouring. Sugar and acid content is increased and aroma intensified. Cash crops thus become more attractive to the consumer.

Increased storage and processing quality

KALISOP increases the firmness of plant tissue in fruits and vegetables, thus improving the storage life and transportability of the harvested products as well as their suitability for processing and preservation.

Top quality in tobacco cultivation

KALISOP improves the external properties like leaf size, specific leaf weight, leaf colour and increases disease resistance. The low chloride content ensures a long burn time in tobacco. In addition, KALISOP enables the optimal adjustment of potassium and nitrogen supplies in combination with singenutrient nitrogen fertilisers.

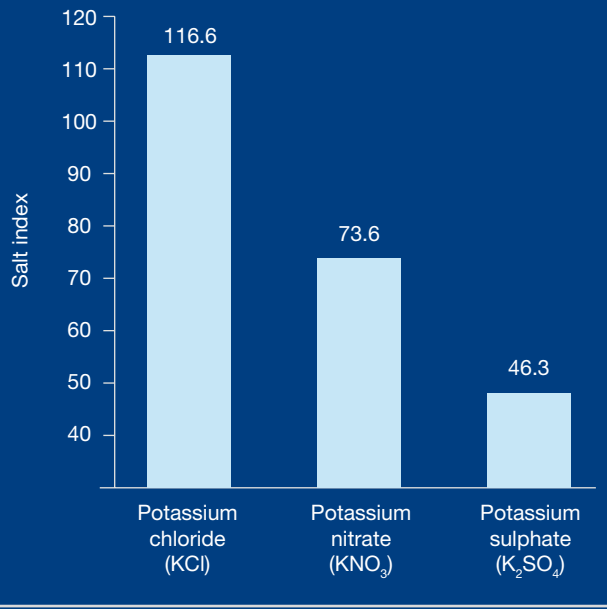
KALISOP® as sulphur fertiliser

- Reduced sulphur emissions from the atmosphere and the continued use of highly concentrated fertilisers with a low sulphur content lead in many regions to a sulphur deficiency in plants.
- Sulphur deficiency causes symptoms, mainly pale leaves, which are very similar to those with nitrogen deficiency. Depending on the nitrogen supply, chlorosis increasingly occurs in older leaves (in case of an inadequate nitrogen supply) or in younger leaves (in case of good nitrogen supply).
- Due to its high sulphur content (44 % SO_3), KALISOP is especially suited for plants with a higher sulphur requirement (oil seed rape, sunflowers, different kinds of cabbage, onions, leeks, etc.). In addition, good sulphur supply increases the utilisation of nitrogen in plants.
- KALISOP contains sulphur in the watersoluble and immediately plant available sulphate form. The soil pH is not altered by KALISOP application.

KALISOP® –
For Crops Sensitive to Chloride and Salt

- Most fruit and vegetable crops are sensitive to chloride and are particularly sensitive to a high chloride supply during germination and early growth. The most important chloridesensitive crops include: Tobacco, soft fruits, stone fruits, grape vines, beans, potatoes, cucumbers, melons, onions, lettuce, early vegetables, greenhouse crops, conifers, flowers and ornamental plants. KALISOP is in principle chloride-free.
- KALISOP has been particularly successful in starch potato cultivation. The assimilate transport from the leaves to the tubers can take place undisturbed, because KALISOP has only a very low chloride content. Therefore, the yield potential of the potato can be fully exploited with concurrent high starch contents.
- The salt concentrations in the soil solution in intensive cultivation systems under glass and in the field can vary depending on the water balance. Growth disorders and lower yields are often the result. Under these conditions, KALISOP is the ideal potash fertiliser due to its low salt index.

Salt index of different potash fertilisers



Potato crisps made from potatoes fertilised without KALISOP: dark spots reduce quality

Potato crisps made from potatoes fertilised with KALISOP: perfect quality

Fertilisation recommendations

- KALISOP enables a precise automatic application with the fertiliser spreader and is also suited for mechanical mixes (bulk blends).
- KALISOP is suitable for basic fertilisation as well as the top dressing of the crops. Potassium sulphate should be applied in spring to soils that are at risk for leaching to prevent losses.
- The optimal fertiliser amount depends on the potassium content in the soil, cultivation intensity and yield expectations. The following recommendations serve as general guidelines for the calculation of the fertilisation of soils with a good potassium supply and medium to high yield expectations. Regional experiences should always be considered when calculating the fertiliser application.

Crop	K_2O (kg/ha)	KALISOP (kg/ha)
Potatoes	100–300	200–400
Oil plants	100–200	200–400
Tobacco	100–200	200–400
Vegetables	100–300	200–600
Tomatoes	150–300	300–600
Paprika	100–150	200–300
Cucumbers/Melons	100–200	200–400
Cabbage	200–400	400–800
Hop	100–150	200–300
Fruit, Soft fruits	150–250	300–500
Vines	50–150	100–300

Patentkali®

The Formula for Success –
For Highest Quality

FOR ORGANIC FARMING acc. to (EU) 2018/848 (EC) No 889/2008

Patentkali®

EC FERTILISER
Potassium sulphate with magnesium 30 (+10+42.5)

30 % K_2O water-soluble potassium oxide
10 % MgO water-soluble magnesium oxide
42.5 % SO_3 water-soluble sulphur trioxide (= 17 % S)

Patentkali®

- is a special potash fertiliser with a high content of magnesium and sulphur. The nutrients are present in the form of sulphate, are water-soluble and therefore immediately available to the plants. In contrast to many other magnesium fertilisers, the magnesium content in Patentkali is 100 % derived from the natural mineral kieserite ($MgSO_4 \times H_2O$).
- is effective regardless of the soil pH and can therefore be used at all locations.
- ensures good spreading quality. The uniform particle size spectrum enables precise distribution even at wide spreading widths.
- is especially suited for plants with a high sulphur requirement (rape, sunflowers, different kinds of cabbage, onions, leeks, etc.) due to its high sulphur content (42.5 % SO_3). A good sulphur supply also improves nitrogen utilisation in plants.
- is certified for organic farming according to the regulations (EU) 2018/848 and (EC) No. 889/2008.

Harvest quality with Patentkali®

- The nutrients potassium, magnesium and sulphur have a significant effect on the quality of the harvested crops. They control important enzyme functions and especially aid protein synthesis and production of carbohydrates and vitamin A.
- The sufficient supply with these nutrients ensures high yields and is at the same time an essential requirement for achieving product qualities fit for the market.
- Drastically reduced sulphur emissions from the atmosphere have already led to sulphur deficiency symptoms in several crops that can only be prevented by relevant sulphur fertilisation. Patentkali with a guaranteed sulphur content of 17 % in immediately plant-available form prevents this deficiency.
- Due to the extremely low chloride content of max. 3 % Cl and the low salt index, Patentkali is especially suitable for the nutrient supply of chloride-sensitive crops in agriculture, horticulture and forestry.

Usage of Patentkali®

- Patentkali is especially suitable for the fertilisation of starch potatoes, potatoes for processing, vegetables, fruits, vines, sunflowers and other special purpose crops.
- The use for processing potatoes and table potatoes leads to improved quality (low blackspot bruising, good storage properties, good taste) and for starch potatoes to an increase in the economically crucial starch yield.
- The quality-enhancing effect of Patenkali is preferably used in the cultivation of fruits and vegetables (many vegetable plants are chloride-sensitive) as well as in viniculture.
- Patenkali is well suitable for the revitalisation of damaged forests with proven K and Mg deficiency.
- The application of Patentkali significantly improves the green colouring of Christmas tree crops and greenery.
- In viniculture to ensure a sufficient potassium and magnesium supply.

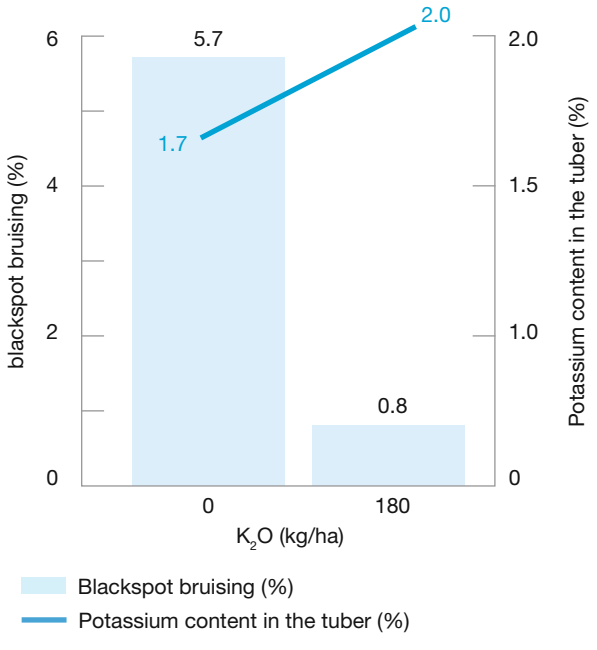
The potassium fertilisation via Patentkali® increases the tuber and starch yield of potatoes.

Potassium fertilisation K_2O (kg/ha)	Tuber yield (t/ha)	Starch yield (t/ha)
0	29.6	6.8
100	41.0	8.4
200	44.5	9.0
300	47.0	9.1

without Patentkali *with Patentkali*

A demand-oriented potassium fertilisation significantly reduces blackspot bruising.

Blackspot bruising drastically decreases with increasing potassium content in the tuber



Time of application

- Patentkali can be applied to all crops until shortly prior to sowing or planting. Top dressing is also possible without any problem.
- On light soils, Patentkali should be applied in spring.

Fertilisation recommendations

The following factors have to be considered when calculating the amount of Patenkali that should be applied:

- the potassium and magnesium requirement of the crop or the crop rotation,
- the potassium and magnesium supply and dynamic of the soil,
- the requirements of different crops regarding the macronutrients (for example magnesium requirement for potatoes, sulphur requirement for different kinds cabbage),
- the amounts of nutrients supplied by organic fertilisation.

The following recommendations serve as general guidelines for the fertilisation of soils with medium potassium contents, not taking organic fertilisation into account.

With Patentkali® the tuber and starch yield of potatoes is much higher because of the nutrients potassium, magnesium and sulphur

Crop	Patentkali (kg/ha)
Potatoes	600–1200
Cabbage and root vegetables	800–1200
Orchards	400–600
Vines	300–400
Soft fruits	600–800
Leafy vegetables	600–800
Forestry	300–500

ESTA® Kieserit

Fine and Granulated –
Magnesium-Sulphur-Power

FOR ORGANIC FARMING acc. to (EU) 2018/848 (EC) No 889/2008

ESTA® Kieserit

EC FERTILISER
Kieserit fine 27+55

27 % MgO water-soluble magnesium oxide
55 % SO_3 water-soluble sulphur trioxide (= 22 % S)

Kieserit gran. 25+50

25 % MgO water-soluble magnesium oxide
50 % SO_3 water-soluble sulphur trioxide (= 20 % S)

ESTA® Kieserit fine und gran.

- is a sulphate based magnesium and sulphur fertiliser with 27 % MgO and 55 % SO_3 (ESTA® Kieserit fine) or 25 % MgO and 50 % SO_3 (ESTA Kieserit gran.).
- contains the nutrients magnesium and sulphur in fully water-soluble and therefore immediately plant-available form.
- is effective regardless of the soil pH and can therefore be used at all sites.
- is certified for organic farming according to the regulations (EU) 2018/848 and (EC) No. 889/2008.

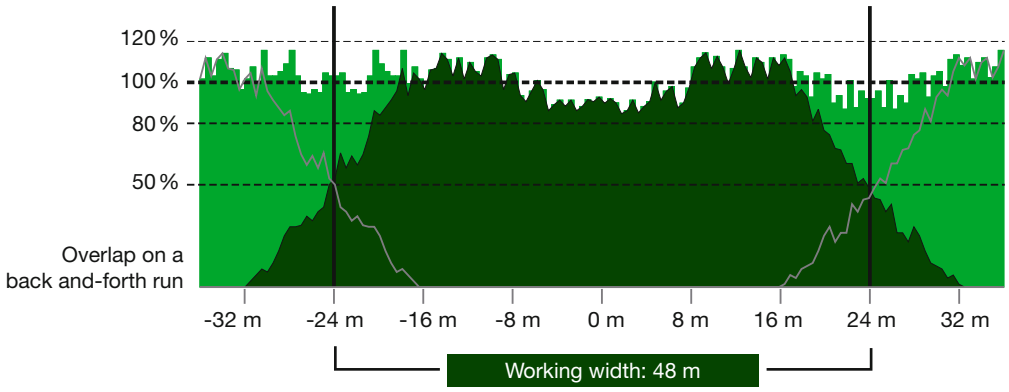
ESTA® Kieserit gran.

- has an excellent ideal particle size distribution, granule hardness and excellent spreading properties and it can be applied precisely and properly with all modern fertiliser spreaders.
- is well-suited for use in fertiliser blends.

ESTA® Kieserit:
The valuable magnesium and sulphur fertiliser

- The effectiveness of magnesium fertilisers largely depends on their solubility. The superior effectiveness of ESTA Kieserit ($MgSO_4 \cdot H_2O$) is based on the full watersolubility and therefore immediate plant- availability.
- Many soils have an inherently low magnesium content, especially light and acidic soils. In soils with high pH values and free lime, the high calcium concentrations in the soil solution negatively affect magnesium availability. Under these conditions in particular, the pH-independent solubility of the kieserite ensures optimum magnesium supply for the plants.
- The significant reduction of atmospheric sulphur depositions and the continued use of low-sulphur fertilisers lead in many regions to sulphur-deficiencies in plants. ESTA Kieserit with 20–22 % sulphur content can effectively prevent this deficiency. Additionally, a sufficient sulphur supply improves nitrogen utilisation in plants and therefore leads to a more efficient fertiliser input.

Spread pattern at working width 48 m



Excellent spreading properties of ESTA Kieserit gran.

Magnesium deficiency in vines

Magnesium deficiency in oil seed rape

Magnesium deficiency in maize

ESTA® Kieserit – The Fields of Application

- The superior properties of ESTA Kieserit – for example a quick and sustainable plant availability and a pH-independent effectiveness – give the possibility for a variety of applications in agriculture, horticulture, for special crops and forestry.
- Due to its good granular quality properties, ESTA Kieserit is especially suitable for use as a single-nutrient fertiliser and as a component in bulk blending processes (compound fertiliser).
- In case of soils with low magnesium content, the fertiliser should be applied to the stubble in autumn and subsequently incorporated into the soil. Light soils have to be treated with ESTA Kieserit in the spring (300–500 kg/ha).
- ESTA Kieserit gran. can be used as top dressing to counteract acute magnesium or sulphur deficiency and can be spread into the crops (200–300 kg/ha) in the spring without any problem.
- ESTA Kieserit gran. is applied in combination with NP fertilisers for the subsoil fertilisation of maize crops.
- To improve the magnesium supply of vineyard soils.

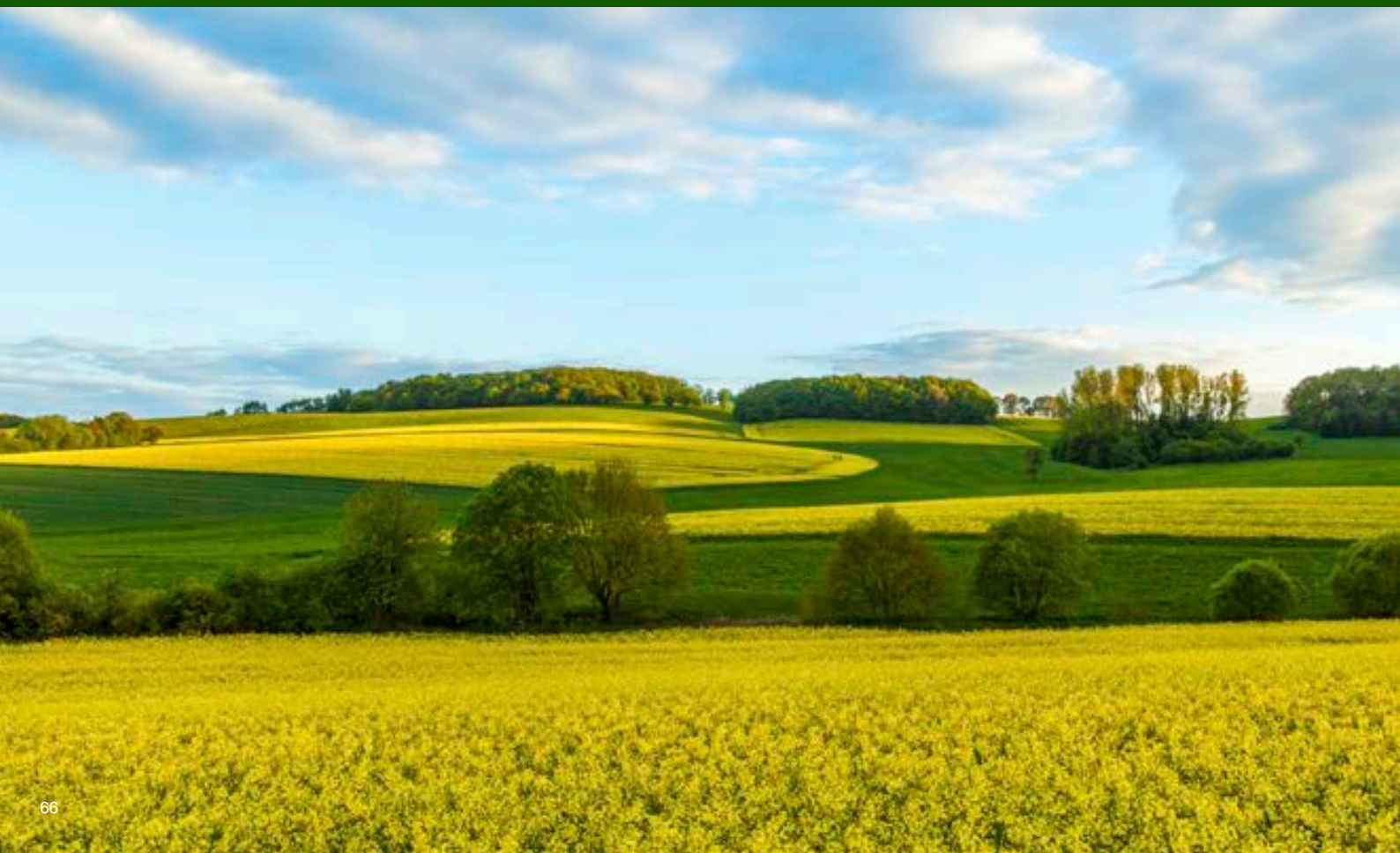
Fertilisation recommendations

The following factors have to be considered when calculating the amount of ESTA Kieserit that should be applied:

- the magnesium and sulphur requirement of the crop or the crop rotation
- the magnesium and sulphur supply and dynamic of the soil (site conditions)

ESTA Kieserit is used for the melioration of soils with low magnesium contents as well as for the regular, targeted magnesium and sulphur fertilisation depending on the requirements of the crops.

Note: Various fertilisers, for example the potash fertilisers Korn-Kali, Patentkali and Magnesia-Kainit contain magnesium and sulphur in kieserite form. The special properties of the kieserite are already exploited in these fertilisers. Therefore, watch out for fertilisers with kieserite.



Magnesium deficiency in pine trees

Reforestation and Christmas tree crops

- Agricultural and forestry land (especially sandy soils) which are subject to reforestation should be treated with 200–300 kg ESTA Kieserit/ha during the year after planting to ensure rapid early growth. This must then be repeated after 2–3 years.
- To achieve high-quality Christmas trees and fir greenery (intensive green or blue colouring of the needles), an application of 300–400 kg ESTA Kieserit/ha prior to planting is recommended. In the following years, soils with low magnesium content should be annually treated with 100 kg ESTA Kieserit/ha to ensure the economic success of these crops.
- In forests, kieserite should be applied in late autumn.

Magnesium and sulphur removal by agricultural crops

Crop	Yield (t/ha)	MgO (kg/ha)	ESTA Kieserit (kg/ha)
Cereals	7	14–35	50–120
Grain maize	7	42–70	150–240
Silage maize	50	40–50	140–180
Sugar beets	50	45–55	180–350
Fodder beets	100	50–100	270–400
Potatoes	40	35–60	120–200
Rape	3	30–40	100–150
Field beans	4	20–40	70–140
Peas	3	12–24	40–80
Sunflowers	3	50–100	180–350
Meadows	10	60–80	200–280
Pastures	450.0 kStE	45–65	160–220
Vegetables	depending on crop	10–65	30–230

Magnesium deficiency in hops

EPSOTop®

Magnesium & Sulphur – to Close Nutrient Gaps

FOR ORGANIC FARMING acc. to (EU) 2018/848 (EC) No 889/2008

EPSOTop®

EC FERTILISER
Magnesium sulphate 16+32.5

16 % MgO water-soluble magnesium oxide
32.5 % SO_3 water-soluble sulphur trioxide (= 13 % S)

EPSO Top

- is an immediately effective magnesium and sulphur fertiliser for foliar fertilisation. The nutrients are fully water-soluble and are present in sulphate form ($MgSO_4 \times 7\ H_2O$).
- dissolves immediately in water without any residues and is therefore especially suitable for the application as foliar fertiliser via crop protection sprayers or it can be injected into irrigation systems (fertigation).
- can be used as a supplement to soil applications in particular in case of magnesium deficiency and to meet peak requirements. There is no risk of damage to the plant, as long as it is properly used and the recommended concentrations are complied with.
- can be mixed with most plant protection products and liquid fertilisers. However, manufacturer information must be followed.
- is very effective, as it is common for foliar fertilisation, due to the loss-free magnesium and sulphur absorption via the leaf.
- is certified for organic farming according to the regulations (EU) 2018/848 and (EC) No. 889/2008.

Magnesium deficiency in winter wheat

Sulphur deficiency in oil seed rape

Magnesium deficiency in sugar beets

Sulphur deficiency in oil seed rape

Magnesium deficiency in potatoes

Magnesium

- plays an important role in the yield and quality formation of the plants,
- is involved in the efficiency of photosynthesis as the central atom in chlorophyll,
- plays an important role in the energy, protein and carbohydrate metabolism for the growth and storage of assimilates,
- deficiency often occurs during the intensive growth period of the crops. This temporary magnesium deficiency will be quickly and successfully remedied with EPSO Top foliar fertilisation.

Sulphur

- must be increasingly considered in fertilisation, as emissions have been significantly reduced,
- is directly absorbed as sulphate via the leaf,
- is of importance especially for the protein metabolism and increases the nitrogen efficiency during the yield formation.

EPSO Top®: Versatile Foliar Fertiliser – Suitable for all Crops

Cereals

Two critical phases during cereal growth determine the application period of EPSO Top. Visible magnesium deficiency symptoms often occur at the start of stem elongation. The ripening and grain formation period is also critical. A high magnesium and sulphur content is essential to keeping the flag leaf long in the green phase and thus to ensure photosynthesis.

Oil seed rape

The cruciferous plants react most severely and visibly to magnesium and also sulphur deficiency. EPSO Top should be applied as foliar fertiliser repeatedly during stem elongation until the flowering phase to meet the magnesium and sulphur requirement of the rape plants.

Sugar beets

Foliar fertilisation with EPSO Top during row closure has a significant effect on the yield formation as well as the quality of the beets. This leads to an optimised nitrogen metabolism and thus to an improved quality of the sugar beets.

Potatoes

The magnesium and sulphur requirement of the potato plant peaks during tuber initiation and the tuberisation phase – parallel to the flowering phase. The supply via the leaf keeps the photosynthesis rate stable so that deficiencies are prevented during tuberisation.

Hops

EPSO Top is applied shortly prior to or directly during flowering in combination with crop protection treatments. The application is repeated during the cone development (3–4 weeks after flowering), because the magnesium and sulphur requirements then reach their peak.

Asparagus

The green asparagus leaves produce the reserve substances for the coming spring and thus determine the yield the following year. Magnesium deficiency quickly leads to yellow and consequently dead asparagus leaves and thus to a shortened storage phase. A single or multiple EPSO Top application can counteract this effect. Application rate: 50 kg EPSO Top per hectare and year.

Due to the small green mass of asparagus leaves, the EPSO Top concentration can be increased up to 10 % (10 kg EPSO Top per 100 l water) for small spraying volumes.

Conifers

Conifers – firs, spruces, etc. – often exhibit discoloured needles. These discolorations – magnesium deficiency – change from light green to yellow and brown. A repeated treatment with EPSO Top can quickly and successfully counteract this phenomenon.

EPSO Top® foliar fertilisation method

- A single or multiple application with 25 kg/ha in 5 % concentration (5 kg/100 l water) is recommended to meet the peak requirement and to counteract latent deficiency. In case of severe deficiency and/or visible deficiency symptoms, up to 50 kg/ha, split into two to four partial applications should be applied.
- EPSO Top can be mixed with most insecticides and fungicides as well as with growth regulators and herbicides so that combined use is possible. However, the manufacturer's recommendation for mixtures should be followed. EPSO Top should be dissolved before the plant protection product is added.
- Miscibility can be tested by mixing and dissolving a sample of EPSO Top with the respective plant protection product in a test vessel. If the mix fully dissolves, then the products can be safely applied together.
- EPSO Top can also be applied in an aqueous solution in combination with other liquid fertilisers, ammonium nitrate-urea solutions as well as NP and urea solutions. Therefore EPSO Top has to be dissolved in water first.

Crops	Application time	BBCH state	Concentration (in %)
Cereals	from the end of tillering until the fruit development	29–71	5*
Rape	rosette stage until flowering	30–57	5
Peas, beans	prior to flowering	up to 59	5
Potatoes	prior to and during flowering	51–69	3–5
Beets	at row closure	31–39	5
Maize	with corn borer treatment	up to 59	5
Fruit	at fruit formation, with scab treatment, repeatedly	71–79	2–3
Hops	one to two times until flowering	60–69	2–5
Vine	until early August at the latest, one to two times	9–17 and 25	3–5
Asparagus	with sufficient leaf mass		3–10
Vegetables	with fungicide / insecticide treatment	up to 59	2–3
Conifers	repeatedly in case of yellowing or browning		3–5
Greenhouse crops	drip irrigation	up to 59	2–3

**equivalent to 5 kg EPSO Top/100 l water*

EPSO Microtop®

The Special Foliar Fertiliser –
Extra Boron and Manganese

FOR ORGANIC FARMING acc. to (EU) 2018/848 (EC) No 889/2008

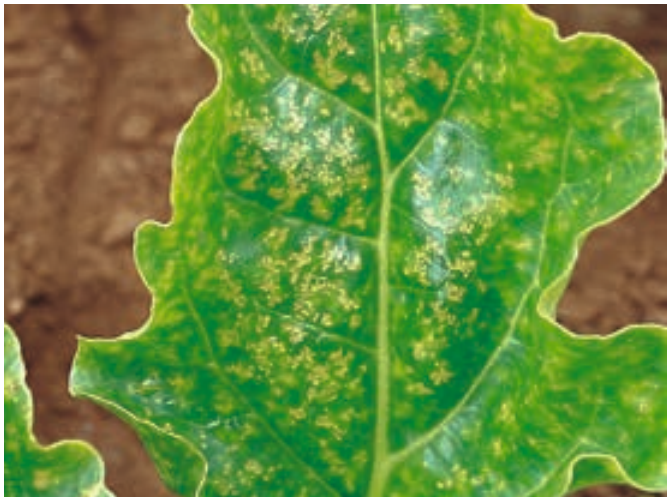
EPSO Microtop®

EC FERTILISER
Magnesium sulphate with micronutrients 15+31

15 % MgO	water-soluble magnesium oxide
31 % SO_3	water-soluble sulphur trioxide (= 12.4 % S)
0.9 % B	water-soluble boron
1 % Mn	water-soluble manganese

EPSO Microtop®

- is an immediately effective foliar fertiliser with the nutrients magnesium and sulphur as well as boron and manganese. All nutrients are in water-soluble form.
- meets the increasing requirement for micronutrients.
- can be immediately and completely absorbed via the leaf and is quickly effective.
- prevents magnesium, sulphur, boron, and manganese deficiencies during the growth phase quickly and reliably.
- is especially suitable as cost-effective prophylactic measure for the prevention of deficiencies.
- its effectiveness does not depend on the soil pH, because the nutrients are directly absorbed via the leaf.
- allows for a quick, targeted and precise application of boron and manganese in combination with magnesium and sulphur.
- should only then be applied to boron-sensitive crops like cereals, strawberries, etc., if the boron content of the soil or the plants is known.
- is certified for organic farming according to the regulations (EU) 2018/848 and (EC) No. 889/2008.



Manganese deficiency in sugar beets

Boron deficiency in sugar beets

Magnesium deficiency in maize

EPSO Microtop® combines four important nutrients

Magnesium

- is an essential nutrient for the yield and quality formation of the plants.
- is involved in the efficiency of the photosynthesis as the central atom in the chlorophyll.
- plays an important role in the energy, protein and carbohydrate metabolism for the growth and storage of assimilates.
- deficiency often occurs during the intensive growth period of the crops as well as during periods of cold, drought or in soils with insufficient magnesium availability

Sulphur

- is a vital nutrient, especially for protein synthesis therefore increasing nitrogen efficiency.
- is absorbed as sulphate (SO_4^{2-}) via the root and the leaf.
- is becoming increasingly important, as sulphur emissions have significantly decreased due to air pollution control measures.

Boron

- is important for cell wall formation, water balance as well as the production of energyrich assimilates such as sugar and starch.
- has a narrow effective range between remedying deficiencies, an optimum supply and toxicity. A precise boron fertilisation tailored to the boron requirement of the plant is therefore essential.
- deficiency symptoms often occur after periods of drought and include death at the growing points, deformation and death of the youngest leaves, stunted growth, thickened stems, cracked tissues and shortened leaf lamina.

Manganese

- activates a variety of enzymes and therefore plays an important role in the metabolism of the plant.
- is essential for chlorophyll as well as photosynthesis, for nitrate reduction and the production of amino acids.
- increases the disease-resistance of the plants.
- availability significantly decreases with increasing soil pH. Drought or good soil aeration increases manganese fixation. Therefore, foliar fertilisation is the only immediate and reliable solution.

Manganese deficiency in potatoes

Manganese deficiency in rape

Application recommendations

EPSO Microtop®

- 25 kg EPSO Microtop per hectare supply the plants via the leaf with 3.75 kg MgO, 7.5 kg SO_3, 225 g boron and 250 g manganese. One or two treatments meet the peak requirement of the crops for magnesium and sulphur as well as their total maintenance requirement for boron and manganese.
- dissolves without any residue (no clogged nozzles) and is very well plant compatible.
- can be mixed with most plant protection products and liquid fertilisers. Manufacturer's instructions must be followed.
- is delivered in handy 25 kg bags.
- is good storable and therefore easy to handle.
- is efficient: EPSO Microtop enables a costeffective nutrient supply of magnesium, sulphur, boron and manganese without any additional costs for the application, if this measure is combined with plant protection treatments.
- eliminates magnesium, sulphur, boron, and manganese deficiency symptoms quickly and reliably.

Note

A single or multiple treatment with 25 kg/ha in 5 % concentration (5 kg/100 l water) is recommended to meet the peak requirement and to counteract latent deficiency. In case of severe deficiency and/or visible deficiency symptoms, the application rate should be increased to up to 50 kg/ha, split into two to four partial applications.

Crops	Application time	BBCH state	Concentration (in %)
Sugar beets	from row closure	31–39	5
Oil seed rape	from rosette stage until flowering	30–57	5
Cabbages	from 6 leaf stage until half head size	16–45	5
Potatoes	with potato blight treatment	from 21	3–5
Sunflowers	from 8 leaf stage until flowering	18–53	5
Maize	until 10 leaf stage	from 59	5
Vine	from 3 leaf stage until prior to flowering and post-flowering until early August	9–17 25	3–5

EPSO Combitop®

The Foliar Fertiliser –
Ideal for Cereals

FOR ORGANIC FARMING acc. to (EU) 2018/848 (EC) No 889/2008

EPSO Combitop®

EC FERTILISER
Magnesium sulphate with micronutrients 13+34

13 % MgO water-soluble magnesium oxide
34 % SO_3 water-soluble sulphur trioxide (= 13.6 % S)
4 % Mn water-soluble manganese
1 % Zn water-soluble zinc

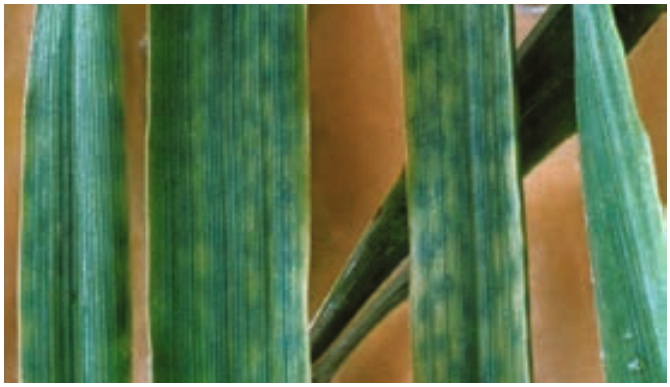
EPSO Combitop®

- is especially formulated for the micronutrient requirement of cereals in an ideal combination with magnesium and sulphur.
- is an immediately effective foliar fertiliser with the nutrients magnesium and sulphur and additionally manganese and zinc. All nutrients are in water-soluble form.
- meets the increasing requirement for micronutrients.
- can be immediately and completely absorbed via the leaf and is thus quickly effective.
- prevents magnesium, sulphur, manganese and zinc deficiencies during the growth phase quickly and reliably.
- is especially suitable as cost-effective preventative measure for the prevention of deficiencies.
- effectiveness does not depend on soil pH, because the nutrients are directly absorbed via the leaf.
- allows for a quick, targeted and precise application of manganese and zinc in combination with magnesium and sulphur.
- iis certified for organic farming according to the regulations (EU) 2018/848 and (EC) No. 889/2008.

Sulphur deficiency in barley

Manganese deficiency in wheat

Without micronutrient fertilisation in autumn, significant crop failure occurs.



Magnesium deficiency in rye

Zinc deficiency in maize

Aside from magnesium and sulphur, manganese and zinc are of special importance for cereals.

Manganese

- Manganese activates a variety of enzymes and therefore plays an important role in the metabolism of the plant.
- is essential for chlorophyll synthesis and photosynthesis as well as for nitrate reduction and the production of amino acids.
- increases the disease resistance of the plants.
- availability significantly decreases with increasing soil pH. Drought or good soil aeration increases manganese fixation. Therefore, foliar fertilisation is the only immediate and reliable solution.

Zinc

- is a nutrient essential for protein synthesis, which is inhibited in case of zinc defiency.
- is necessary for the stability of the ribosomes.
- is important for the longitudinal growth of plants. Typical symptoms of zinc deficiency are stunted growth, small-sized leaves and rosette formation. Wheat shows yellow-white spots, which can change into stripes along the whole leaf.

EPSO Combitop® – Application Recommendations

EPSO Combitop®

- serves as foliar fertiliser for effective prevention as well as treatment of acute deficiency. All nutrients are fully water-soluble, absorbed via the leaf within a short time and are therefore fast-acting.
- 25 kg EPSO Combitop per hectare supply the plants via the leaf with 3.25 kg MgO, 8.10 kg SO_3, 1000 g manganese and 250 g zinc. One or two treatments meet the peak requirement of the crops for magnesium and sulphur as well as their total maintenance requirement for manganese and zinc.
- dissolves without any residue and is very well plant compatible.
- can be used in mixtures with most plant protection products and liquid fertilisers. The technical mixability for the production of residue-free solutions has to be tested prior to the application. The information of the manufacturer has to be followed.
- is delivered in handy 25 kg bags, is good storable and easy to handle.
- is usually applied as 5 % EPSO Combitop solution (5 kg/100 l water). This concentration can also be used in mixtures with plant protection products. After mixability with the plant protection product has been tested, a combination is possible in the following order: Fill plant protection sprayer with 1/3–1/2 water > EPSO Combitop > plant protection product.
- for cereals, is usually used in combination with crop protection measures in spring. The recommended rate is 2 x 10 kg EPSO Combitop per hectare from the onset of vegetation. An immediate treatment is recommended, if deficiency symptoms are already visible. Soils known for deficiencies should be additionally treated in autumn with 10 kg /ha from BBCH 15 on, which is costeffective even if a separate pass with the sprayer is needed.

Crops	Application time	BBCH state	Concentration (in %)
Cereals	from the end of tillering until the fruit development	29–71	5*
Maize	with corn borer treatment	up to 59	5
Potatoes	prior to and during flowering	51–69	3–5
Fruit	at fruit formation, with scab treatment, repeatedly	71–79	2–3
Vegetables	with fungicide / insecticide treatment	up to 59	2–3

**equivalent to 5 kg EPSO Top/100 l water*

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FROM A FOR APP TO Z FOR ZESTFUL CUSTOMERS

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Deficiency Symptoms ABC –
Quick and Reliable

Nutrient requirements vary from crop to crop. Our K+S agronomists are prepared to support you by providing essential information on optimal crop nutrition.

If your plants show acute deficiency symptoms, you may use our Nutrient Deficiency ABC on our website www.kpluss.com or within our App “KALI-TOOLBOX” to identify what is missing. Here you will see right where you are, in the field, which nutrients your plants are lacking.

As soon as you have identified the problem, K+S products with their high nutrient availablity will fix it immediately.

Additionally, KALI-TOOLBOX contains a nutrient converter that helps to calculate different forms of nutrients.

Our App is for free!

Search for “KALI-TOOLBOX” in your store:

Download on the App Store

GET IT ON Google Play

Visit www.kpluss.com

Strong Know-how –
Research & Advisory of K+S

K+S supports agricultural practice all over the world by providing expert knowledge on fertilisation, in order to achieve high yields and excellent quality, and to maintain these even under adverse climatic conditions. The foundation of the advice provided is our extensive research activity.

For more than 100 years, K+S has been involved in agricultural research, always looking for solutions to agronomical challenges, such as how to increase productivity, how to improve soil fertility and how to efficiently use resources.

Together with Georg-August-University of Goettingen K+S today runs the Institute of Applied Plant Nutrition (IAPN). As an intersection between science and practice, the IAPN picks up on topical issues, pools existing knowledge and transfers new findings to agricultural practitioners.

K+S supports IMI, International Magnesium Institute, in China to understand and strengthen the growing importance of magnesium nutrition, especially in high value crops.

The advisory service of K+S as well aims at transferring existing and new research findings in the field of plant nutrition to agricultural practice. Farmers all over the world benefit from this know-how, which enables them to implement new and promising methods in their fertilisation practice, and to thereby improve yields and quality of their harvests. Our commitment and our expertise represent a significant contribution to securing global food supply and to protect the livelihoods of farmers.

Benefit from our agronomists' expertise and get more information on www.ks-minerals-and-agriculture.com/uken/fertiliser. Here you will find useful technical information, brochures and also our app, KALI-TOOLBOX.

For personal advice, call our agronomists in Kassel. They might as well provide local contacts.

How to contact us

Detailed information on all K+S fields of expertise can be found at: www.kpluss.com

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