



# Korn-Kali®

## Strong package

Perfect combination



100% solubility



More than just fertiliser



# Quality by nature

## Unique K+S KALI raw materials



### **Top quality potassium and magnesium fertilisers**

K+S KALI GmbH business is extraction, production and marketing of mineral fertilisers based on natural raw materials. Due to a unique composition of raw material deposits, K+S KALI GmbH offers – in addition to the basic potassium-based fertiliser – magnesium- and sulphur-based fertilisers, which are widely used in farming.

### **Origins of potassium and magnesium deposits**

A unique raw material used by K+S KALI GmbH is kieserite – extracted exclusively in German mines at the depth of 700 m and deeper.

Kieserite is used for the production of an original potassium- and magnesium-based fertiliser: Korn-Kali. This fertiliser is the natural source of potassium, magnesium and sulphur for plants. Korn-Kali also enhances the soil content of potassium and magnesium in a stable and safe manner, thus increasing soil fertility.

### **Strong package of nutrients**

The nutrients in Korn-Kali originate from raw salts mined in Germany. They were formed as a result of crystallisation of salt from a dried-out sea, which was on that territory over 250 million years ago.



The German deposits are the only ones in the world, where the minerals potassium and magnesium occur together. This allows for simultaneous extraction of vital nutrients for crops: potassium, magnesium and sulphur. As a result, the production of plants with the fertilisers based on natural raw materials guarantee fully developed yields of the highest quality.

#### **Extraction and processing of potassium salt deposits**

These raw materials are mined. The potassium and magnesium salts acquired in this manner are transported by means of self-propelled large-size loading machines to unloading points, where they are preliminarily crushed. The valuable material is

transported at the distance of many kilometres by means of band conveyors up to the lift shaft. From there, in a mine cage, it goes several hundred metres up to the ground surface, directly to the production plant, where it is further processed. The high quality of the fertilisers is acquired thanks to an advanced process chain, starting with the extraction through production and sales to the final client – the farmer.

# Korn-Kali®

## Strong package of nutrients



### Korn-Kali®

#### EC FERTILISER

Potassium chloride containing magnesium salts  
40 (+6+4+12.5)

- 40 %  $K_2O$  water-soluble potassium oxide (= 33.2 % K)
- 6 %  $MgO$  water-soluble magnesium oxide (= 3.6 % Mg)
- 4 %  $Na_2O$  water-soluble sodium oxide (= 3 % Na)
- 12.5 %  $SO_3$  water-soluble sulphur trioxide (= 5 % S)

#### Particle size distribution: typical

- > 5.0 mm 2 %
- 2.0–5.0 mm 94 %
- < 2.0 mm 4 %
- $d_{50}$  [mm] 3.4

#### Storage data:

- bulk density approx. 1,100 kg/m<sup>3</sup>
- tap density approx. 1,150 kg/m<sup>3</sup>
- dumping angle approx. 37°

#### Recommended doses of Korn-Kali® in the case of an average potassium content in the soil

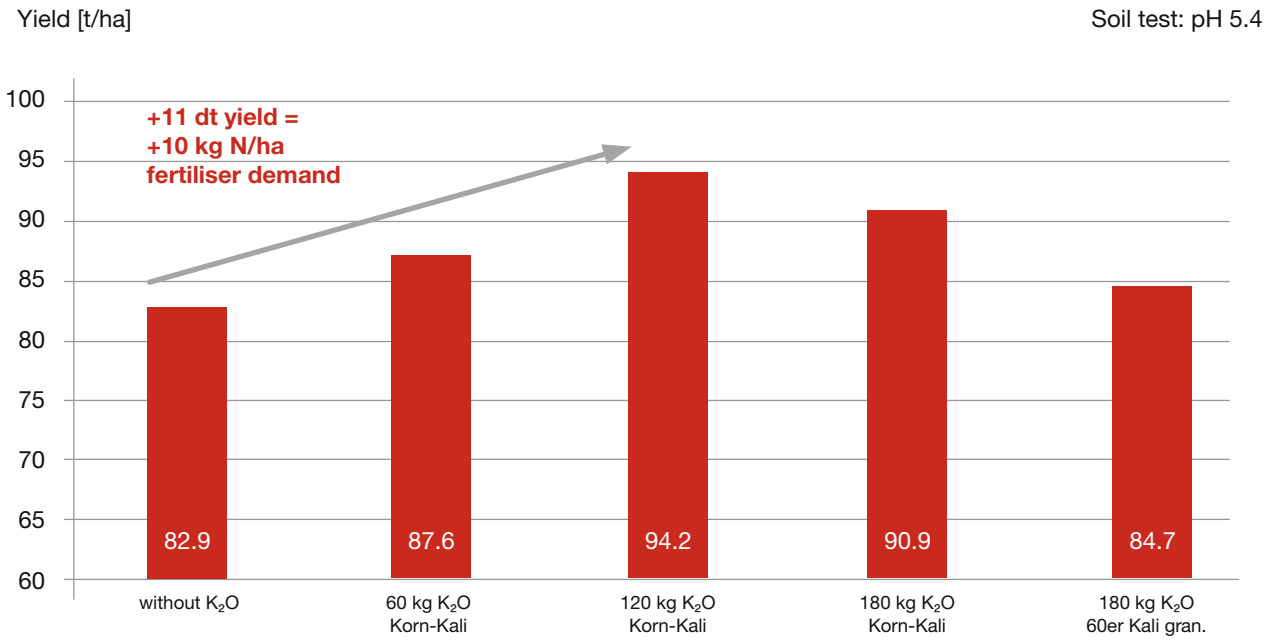
Crop	Yield (t/ha)	Korn-Kali (kg/ha)
Cereals	5–7	250–350
Rapeseed	3–4	400–500
Corn	8–10	500–650
Sugar beet	50–60	800–1,000
Grassland	10	600–700



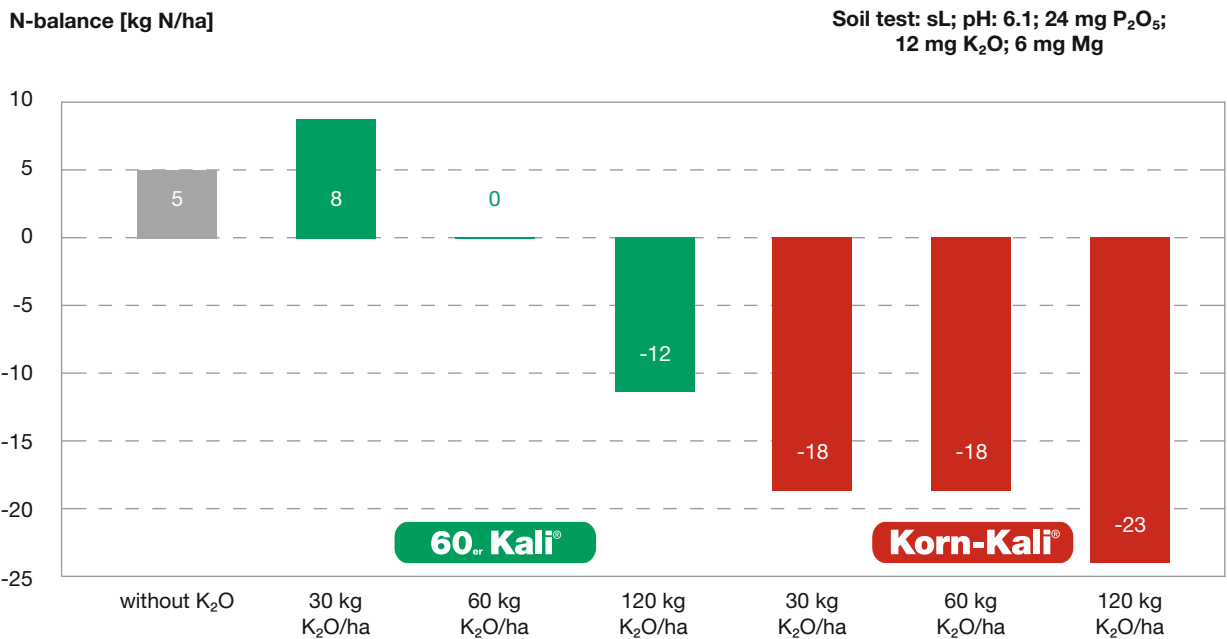
# Results

## Field research

Potash trial by the Agriculture Chamber of Lower Saxony Triticale in Holtland, Germany, 2014



N-balance for winter barley in the K fertiliser trial, FH Kiel – Ostenfeld, Germany, 2015



Previous crop: winter wheat; Crop: winter barley; Variety: KWS Meridian

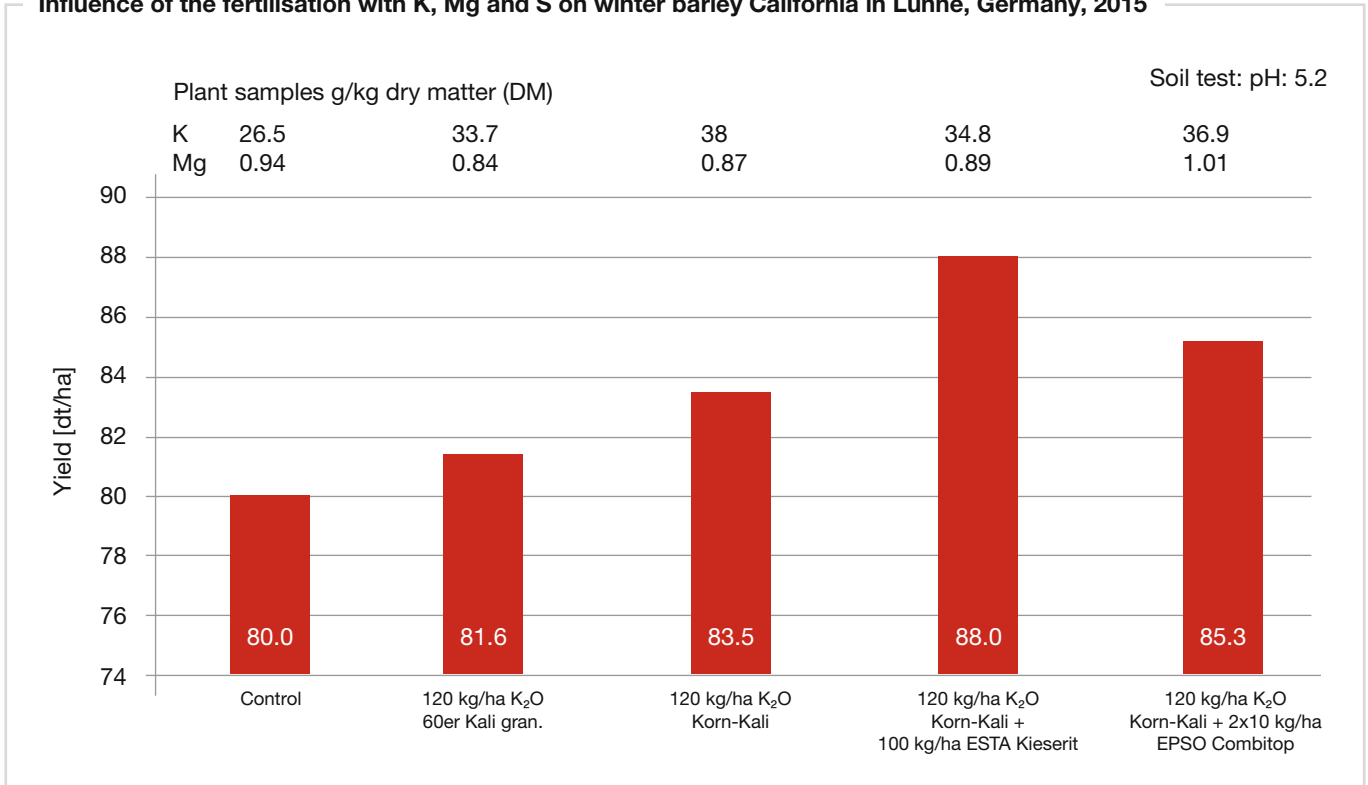
N<sub>min</sub>: 31 kg N ha<sup>-1</sup>; N-fertilisation: 190 kg N ha<sup>-1</sup>  
Total: 221 kg N ha<sup>-1</sup> Yield test 1,220 kg ha<sup>-1</sup>



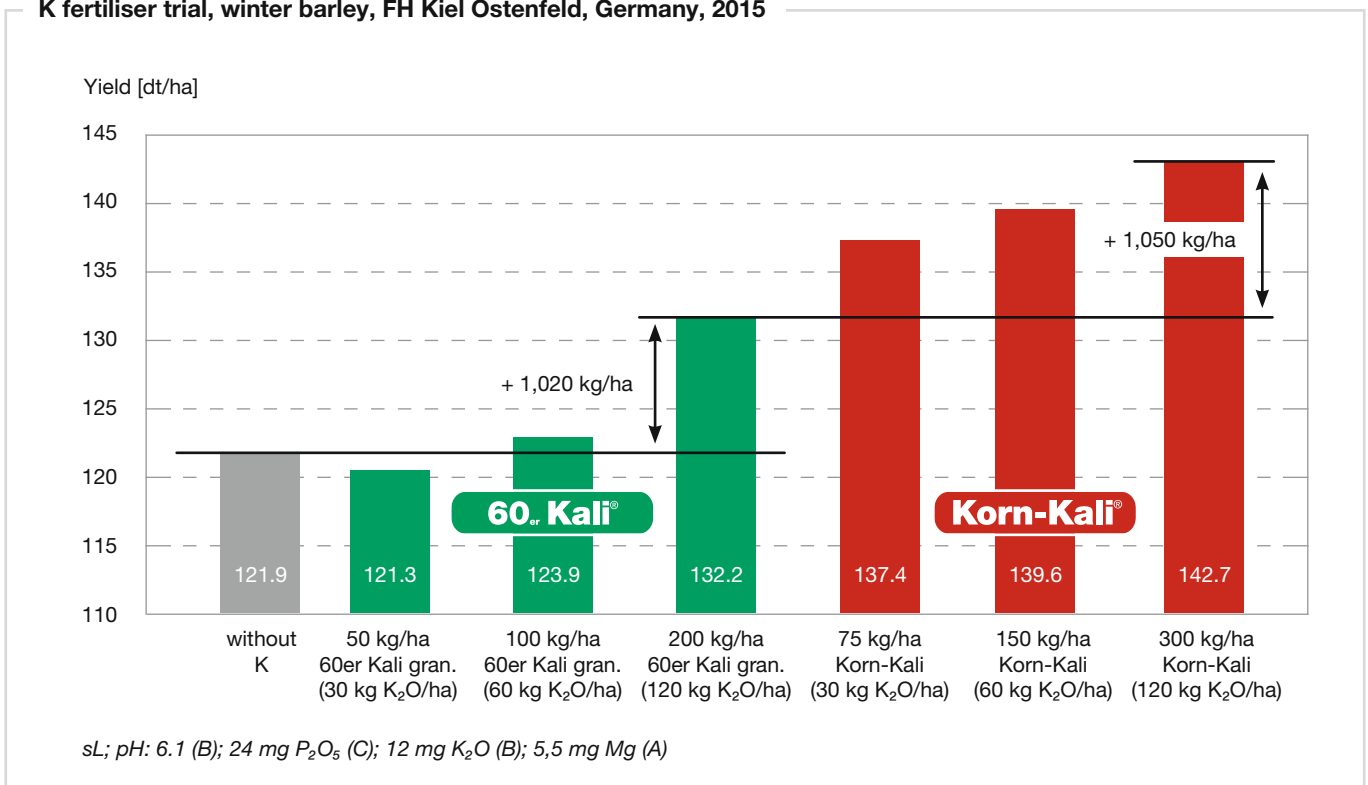
# Results

## Field research

**Influence of the fertilisation with K, Mg and S on winter barley California in Lünne, Germany, 2015**



**K fertiliser trial, winter barley, FH Kiel Ostenfeld, Germany, 2015**





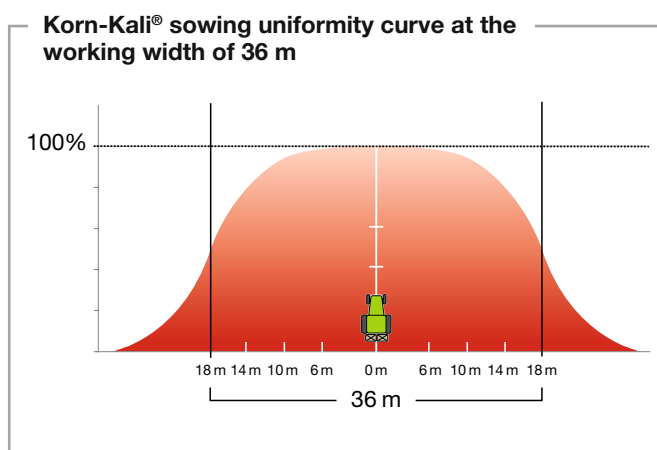
#### Company's business:

The K+S company has been working on the practical approach towards fertilisation for over 125 years now. A team of specialists works day in day out on the best solutions directed to the modern and safe farming. Only thanks to a close cooperation with research institutes and farmers, numerous field studies, quality control and experience exchange between companies are we able to produce high-quality fertilisers.

Our fertilisers are more than just nutrients. Let us take a closer look at what Korn-Kali granules are composed of:

1. Korn-Kali is a combination of potassium chloride, the unique mineral kieserite and sodium. Potassium combined with magnesium, sulphur and sodium in such a way form a fertiliser which meets the need of international agriculture.
2. The perfect granule – striving to meet the requirements of agricultural producers, we developed a granule of very high quality: it is hard, it does not crumble in the fertiliser distributor, is uniform (2–5 mm: 94 %) and dissolves fast after sowing. Thanks to all this, Korn-Kali can be very precisely applied at the width of even 36 metres with very good uniformity. It is a unique feature, which is sought by large farms in particular.

It has to be mentioned that only the original products of K+S KALI GmbH guarantee 100 % effectiveness and are a source of water-soluble nutrients, which are thus accessible to plants.





# Perfect combination

## The base of stable yields

### More than potassium

#### Potassium – the base of stable yields

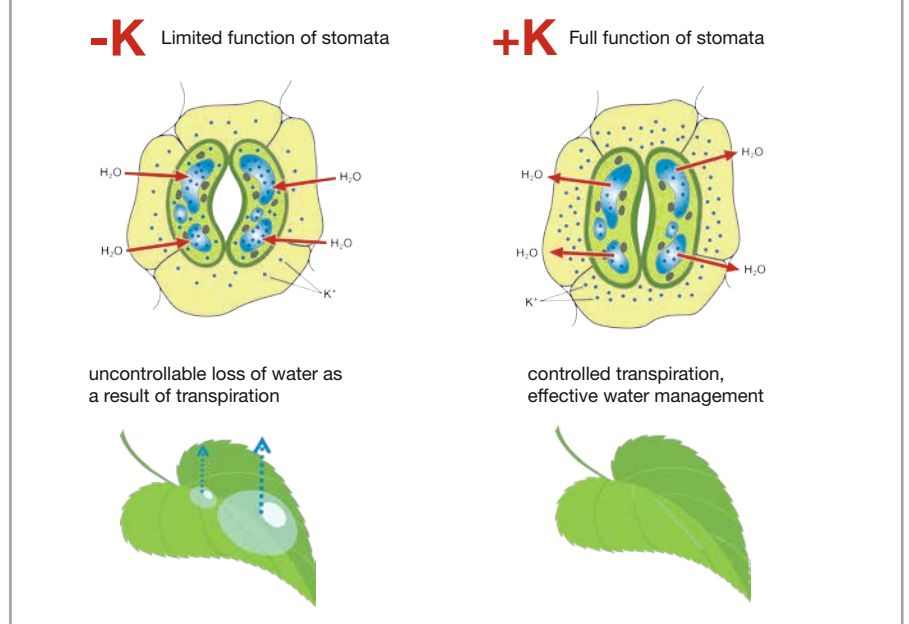
Potassium is one of the most important plant nutrients. The most significant processes in which potassium takes part are the following:

1. Transpiration	K	Effective water management
2. Significant influence on a crop's stress resistance	K	Better tolerance to drought, slight frost, crop lodging
3. Assimilate transport	K	Better development of the root system
4. Promotion of quality parameters	K	Increased amounts of e.g. protein, vitamins, starch, etc.
5. Increased water use efficiency	K	Efficient use of plant available water; better pore structure in the soil

### Basic functions of potassium

1. Potassium, the main nutrient in Korn-Kali, allows the plant to use water economically. Thanks to a well-regulated transpiration, the available water is effectively used by the plant to produce biomass. Potassium considerably influences – as an osmotic factor – the opening and closing of the stomata of the leaf and therefore plays an important role in the water management of the plant. (Fig. 1)
2. Potassium protects plants against drought stress, which is occurring in our climatic zone more and more frequently. The plant can react on stress situations like drought by regulating its water management very diligently to minimise the unproductive loss of water. Potassium improves resistance to frost events thanks to the accumulation of assimilates reducing the freezing point of the plant cell. (Fig. 2)

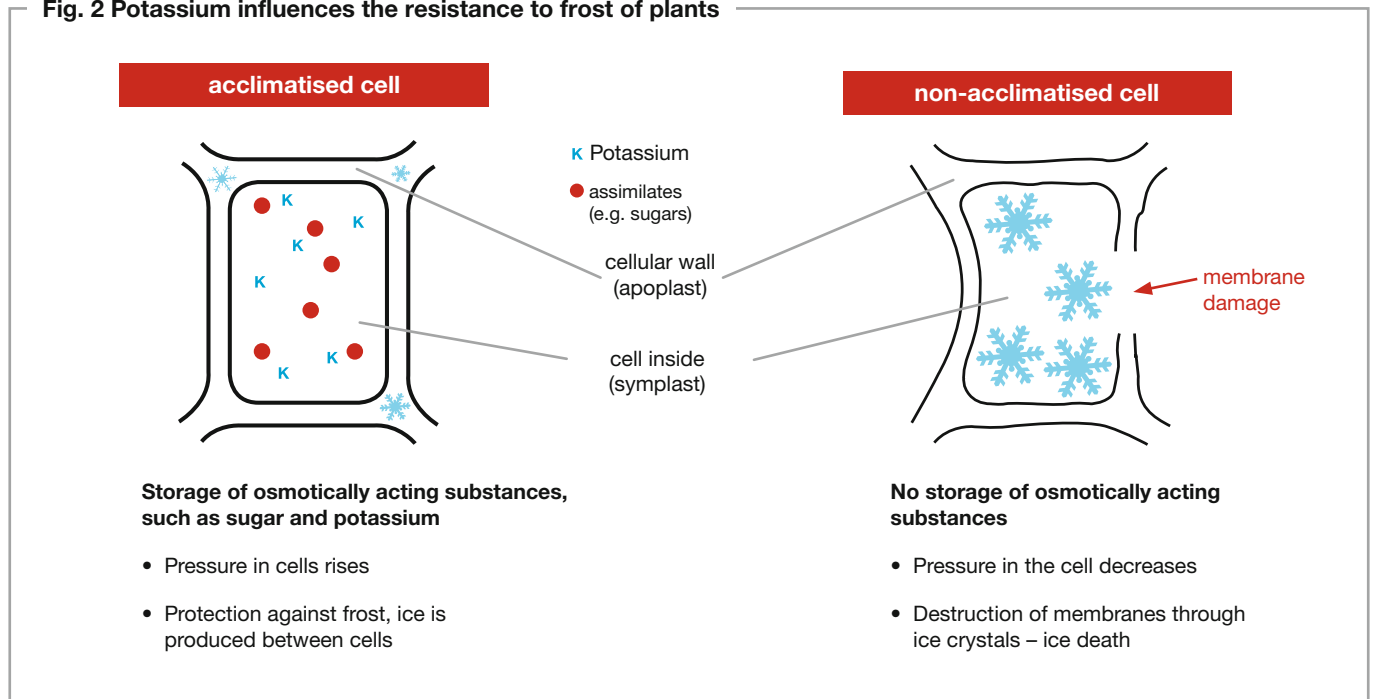
**Fig. 1 Good supply of potassium means effective water management**



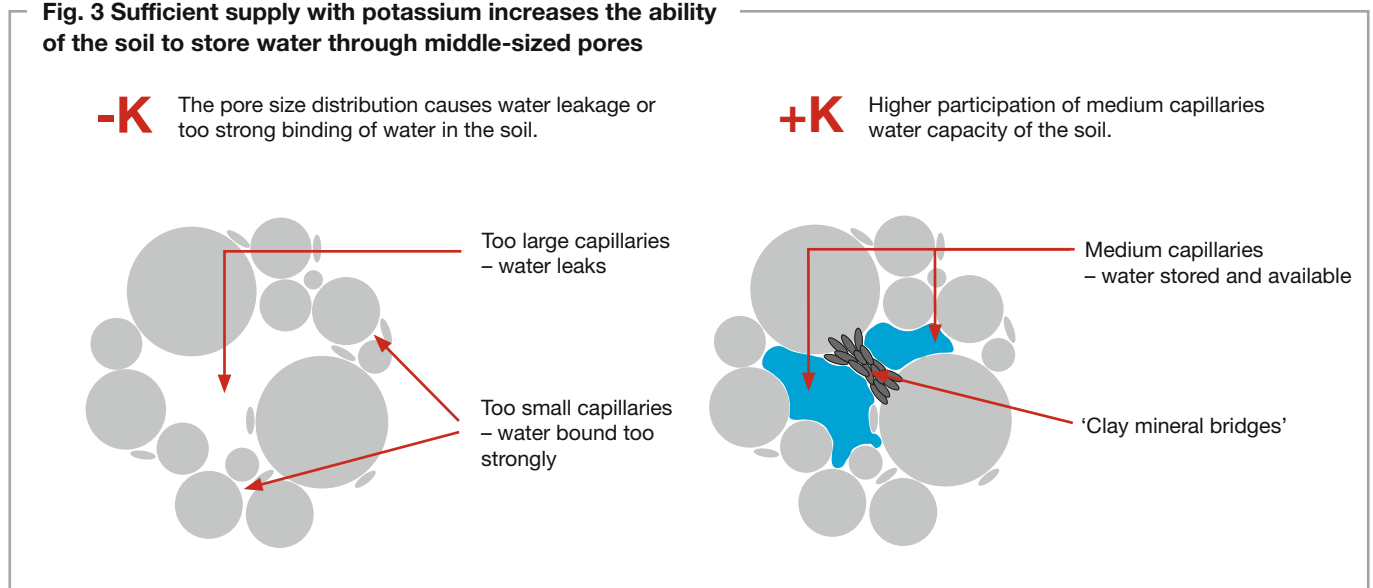


- Potassium effects photosynthesis and a good transport of photosynthesis assimilates. An effective nutrient flow between leaves and roots is thus secured even under difficult conditions.
- Better use of N – Yields and qualities are improved because of an increase of nitrogen use regulated by potassium supply through Korn-Kali.
- According to the latest studies, potassium can improve the ability of the soil to store water, which is substantially defined by soil capillaries. An adequate supply of potassium increases the water holding capacity of the soil through the forming of medium pores. This occurs by means of “clay mineral bridges”. (Fig. 3)

**Fig. 2 Potassium influences the resistance to frost of plants**



**Fig. 3 Sufficient supply with potassium increases the ability of the soil to store water through middle-sized pores**

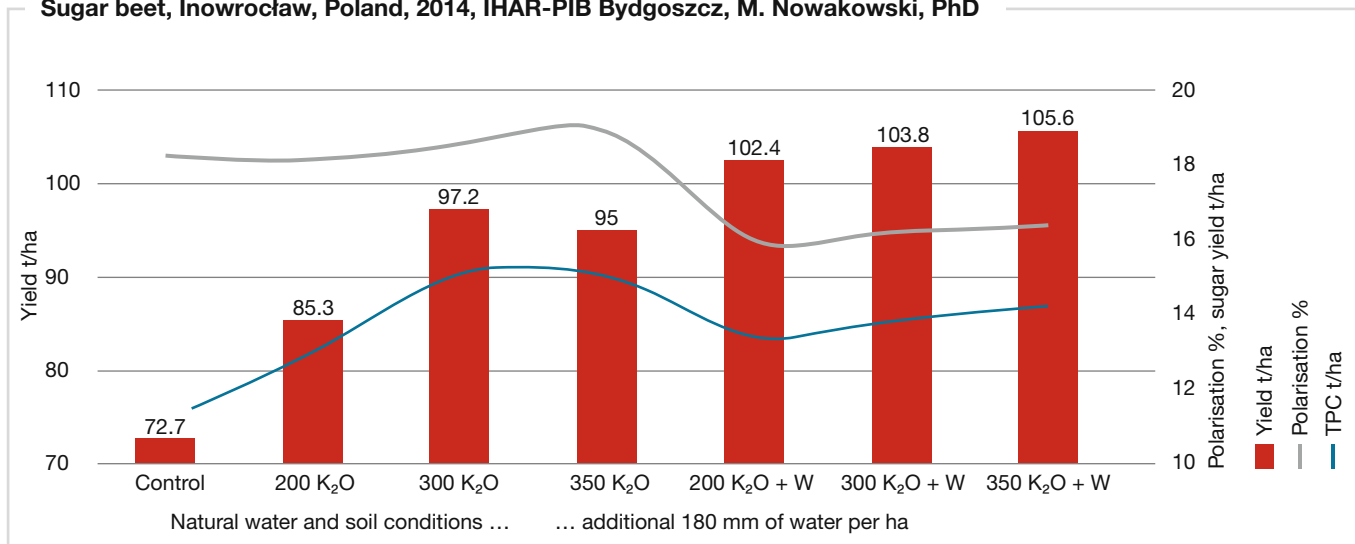




# The basis for stable yield

## Potassium, magnesium, sulphur and sodium

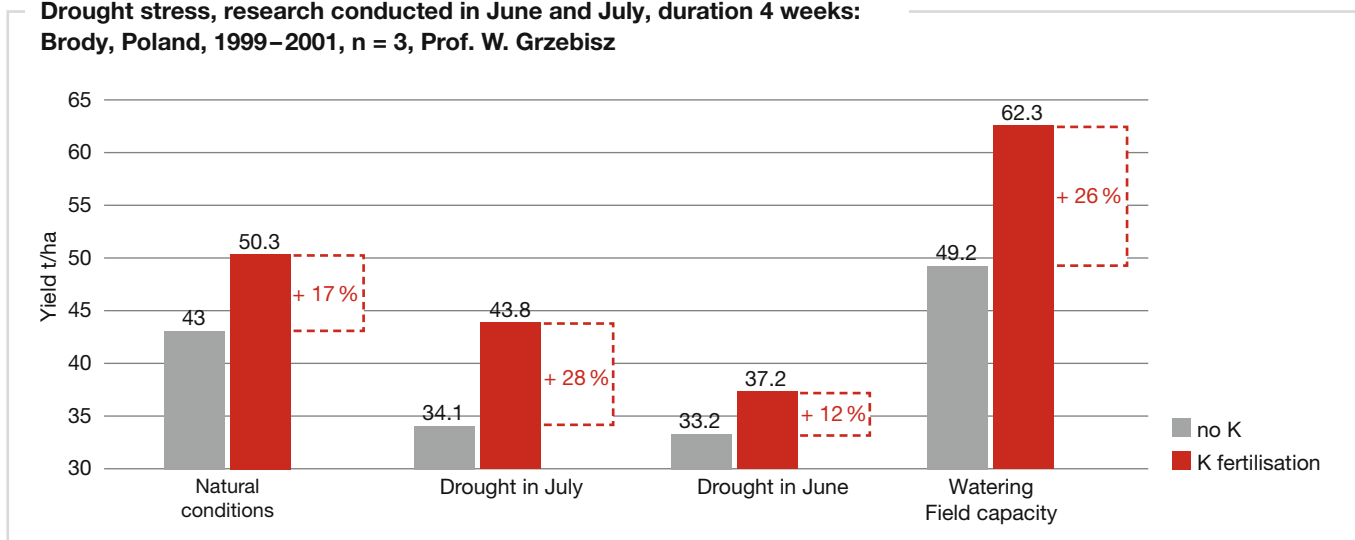
**Sugar beet, Inowrocław, Poland, 2014, IHAR-PIB Bydgoszcz, M. Nowakowski, PhD**



Use of potassium influences the stabilisation of the yield, which is particularly visible in dry years. Many years of farming experience – e.g. in the case of sugar beets – show that both higher doses of potassium (potassium in Korn-Kali 40 % K<sub>2</sub>O, 6 % MgO, 12.5 % SO<sub>3</sub> and 4 % Na<sub>2</sub>O) and optimal precipitation (in this case by means of watering) positively affect the growth of yield and its quality. If water cannot be supplied artificially, high level of yield can be achieved through proper potassium-based fertilisation. Therefore, potassium – in proper combination with magnesium and sulphur (as in Korn-Kali) – allows for achieving larger yields with natural precipitation. Practice shows that well-balanced potassium fertilisation is more efficient and cheaper than watering in the case of basic farming plants such as sugar beets or cereal crops. On the other hand, counting on the optimal distribution of precipitation under the conditions of ever more frequent long-lasting droughts is unreliable as well.

Use of Korn-Kali stabilises the size of the yield by allowing the plant to manage the water from precipitation in the most efficient manner. It protects the plantation against excessive yield loss under the conditions of drought. In the case of optimal precipitation or in watered fields, Korn-Kali guarantees that the largest amount of water is managed in the plant for yield generation instead of unproductive losses as a result of excessive evapotranspiration from plants. The chart below shows that regardless of the conditions in a given month, adding potassium resulted in pronounced yield increase. Hence, potassium should be seen as the basic and indispensable nutrients of plants.

**Drought stress, research conducted in June and July, duration 4 weeks: Brody, Poland, 1999–2001, n = 3, Prof. W. Grzebisz**



If water is not efficiently used in a dry year ...



... it leads to stress caused by drought and in consequence to yield loss ...

... we have to water.



And this is always expensive!

- Drought cannot be prevented, but its unfavorable effect can be reduced.
- Stress caused by a periodical water deficiency can be partially controlled.
- Fertilisation with potassium is the easiest and cheapest way to reduce yield losses.
- An optimal plant nutrition with potassium increases the resistance of crops to survive stress periods longer and to reduce the risk of yield loss.



Drought stress in Germany



# The basis for stable yield

## Potassium, magnesium, sulphur and sodium

### Magnesium – the forgotten macro nutrient

Magnesium plays a key role in plant nutrition. It is frequently referred to as an element of life due to its participation in numerous significant processes necessary for the proper functioning of the human body. Under certain soil conditions, on many fields, especially in the case of light soils and those

used intensely, magnesium deficiency is occurring more and more often. It is therefore worth remembering the functions of this macro nutrient as well as to include magnesium in the fertilisation balance.

<b>1. Chlorophyll</b>	<b>Mg</b>	Increase of photosynthesis efficiency
<b>2. Transport</b>	<b>Mg</b>	Proper metabolic processes
<b>3. N management</b>	<b>Mg</b>	Better N efficiency
<b>4. Root growth</b>	<b>Mg</b>	Deeper root system
<b>5. Al<sup>3+</sup> tolerance and less sunburns</b>	<b>Mg</b>	Tolerance to low soil pH, metabolism

#### Basic functions of magnesium

1. Chlorophyll and photosynthesis – magnesium is the central atom of the molecule chlorophyll and participates in the transformation of the light energy into biomass. Therefore, it plays a significant role in proper development of all plants. As much as 30–35 % of the total plant magnesium is found in the chlorophyll. (Fig. 4)
2. Transport in the plant – magnesium is necessary for the transport of sugars and proteins in the plant and to activate many enzymatic processes. (Fig. 5)

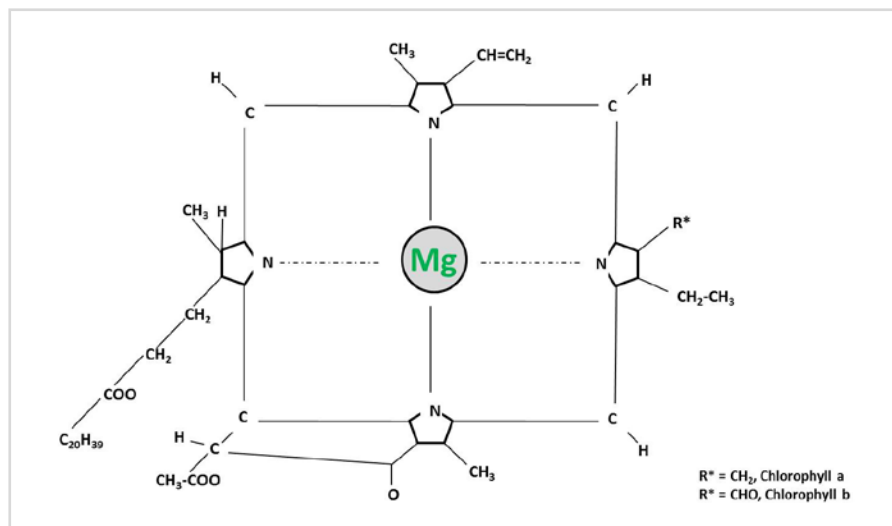


Fig. 4 Magnesium – the central atom of the chlorophyll molecule

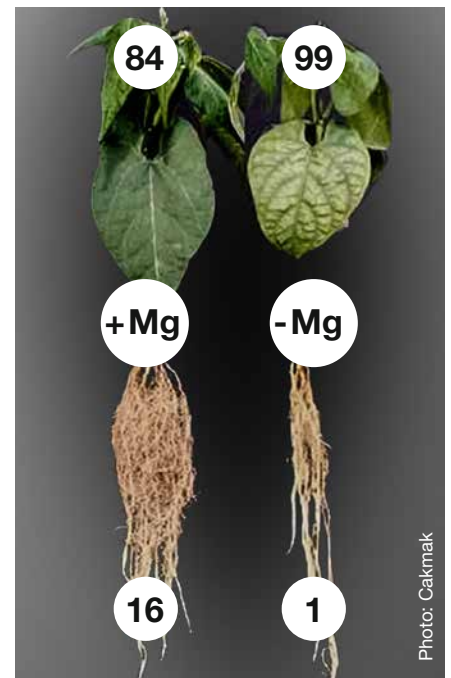


Fig. 5 Magnesium facilitates transport in the plant. On the left 84 % of carbohydrates in leaves and 16 % in roots – no visible symptoms of deficiency. On the right – as much as 99 % of carbohydrates in leaves, inhibited transport to roots resulting from magnesium deficiency.

Photo: Cakmak

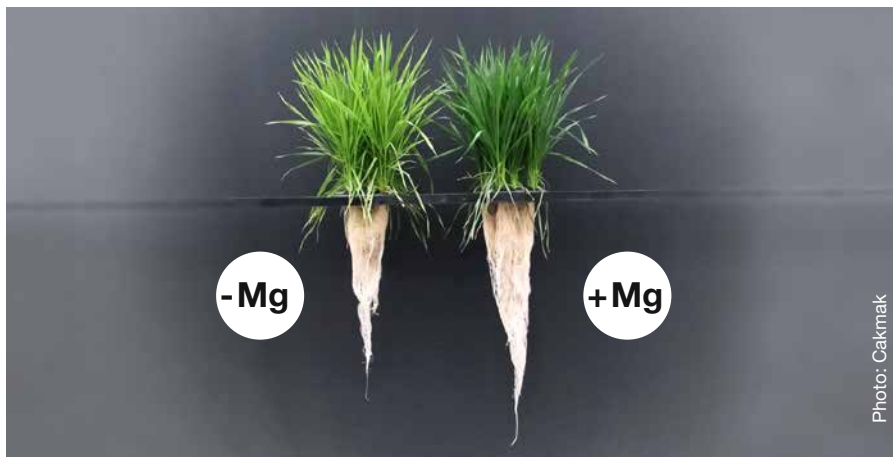


Fig. 6 Influence of magnesium on root growth of wheat

3. Better use of nutrients – An optimal magnesium nutrition is needed to receive optimal yields and it is necessary for an optimal use efficiency of other nutrients e.g nitrogen and phosphorus.
4. Development of the root system – magnesium effects better transport of carbohydrates to the root, which ensures the supply of energy for the growth of the root system. (Fig. 6)
5. Counteracting the toxicity of aluminium – good nutrition inhibits aluminium toxicity in soils with low pH.
6. Resistance against sunburns – plants deficient in magnesium show higher susceptibility to high radiation, which results in sunburns. (Fig. 7)

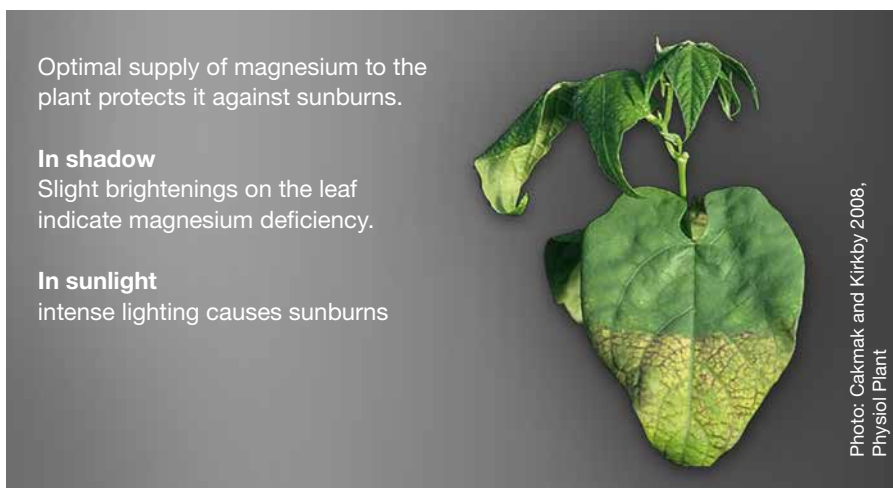


Fig. 7 Magnesium deficiency leads to light sensitivity

**Grain formation of wheat at different levels of magnesium-supply**



Seeds from Low Mg Plants

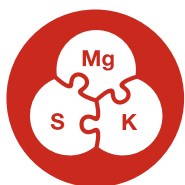


EPSTop  
Seeds from Low Mg Plants +  
Foliar  $MgSO_4 \cdot 7H_2O$  Spray



ESTA Kieserit  
Seeds from Mg-Adequate Plants

Photos: Ceylan et al., 2016, Plant and Soil



# The basis for stable yield

## Potassium, magnesium, sulphur and sodium

### Sulphur – to be more efficient

Air pollution control measures have reduced average atmospheric sulphur deposition radically. Therefore, sulphur fertilisation has become a necessary fact in all cultures 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.

### Main functions of sulphur:

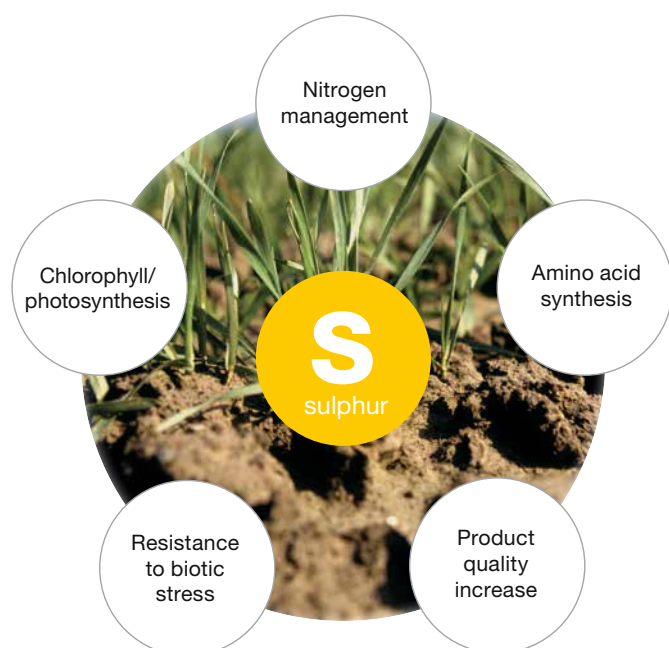
1. Effects chlorophyll formation – increases the efficiency of photosynthesis
2. Is indispensable in controlling the nitrogen management
3. Participates in the synthesis of amino acids of cysteine, cystine and methionine, which are crucial for the quality of forage and nutrition products – building material of proteins
4. Effects a decrease of non-protein forms of nitrogen in the plant – nitrite reductase
5. Participates in the reduction of nitrites to ammonia
6. Participates in enzymatic reactions responsible for biological binding of the atmospheric nitrogen by rhizobia
7. Influences increase in flavour and aroma of some plant products (onion or garlic)
8. Increases the resistance of plants to diseases and pests – bactericidal and fungicidal properties



*Sulphur-induced cereal greening*



*Upper picture: young leaves with S deficiency  
Lower picture: optimal S nutrient in wheat*



### Sodium – a beneficial element?

Sodium ranks among the beneficial elements and positively influences the course of many physiological processes. That sodium is indispensable has been proven in some plant species belonging to the C4 class, where sodium stimulates synthesis of chlorophyll or the activity of nitrate reductase. Sodium plays an important role in the fertilisation of grasslands. The proper sodium content in bulky feed acquired from grasslands increases its flavour: as a result, animals prefer it and the milk production is on high level. This allows for increase in milk supply from the bulky feed. In order to maintain the health of the cattle, it is of necessity to maintain the K-to-Na ratio at the level of approx. 20:1, respectively.

Otherwise, cows will have to compensate it with increased production of the hormone of aldosterone, which is responsible for fertility. However, in the case of sodium deficiency in animals, sodium reabsorption increases, which results in less fertility.

Korn-Kali contains a small amount of sodium combined with potassium, magnesium and sulphur in an optimal ratio as fully available for plants.

Through well-balanced fertilisation with potassium and magnesium, a more stabilised and reliable level of yielding can be acquired over the years.



Schematic yield curves

**Korn-Kali®**  
**ESTA Kieserit**

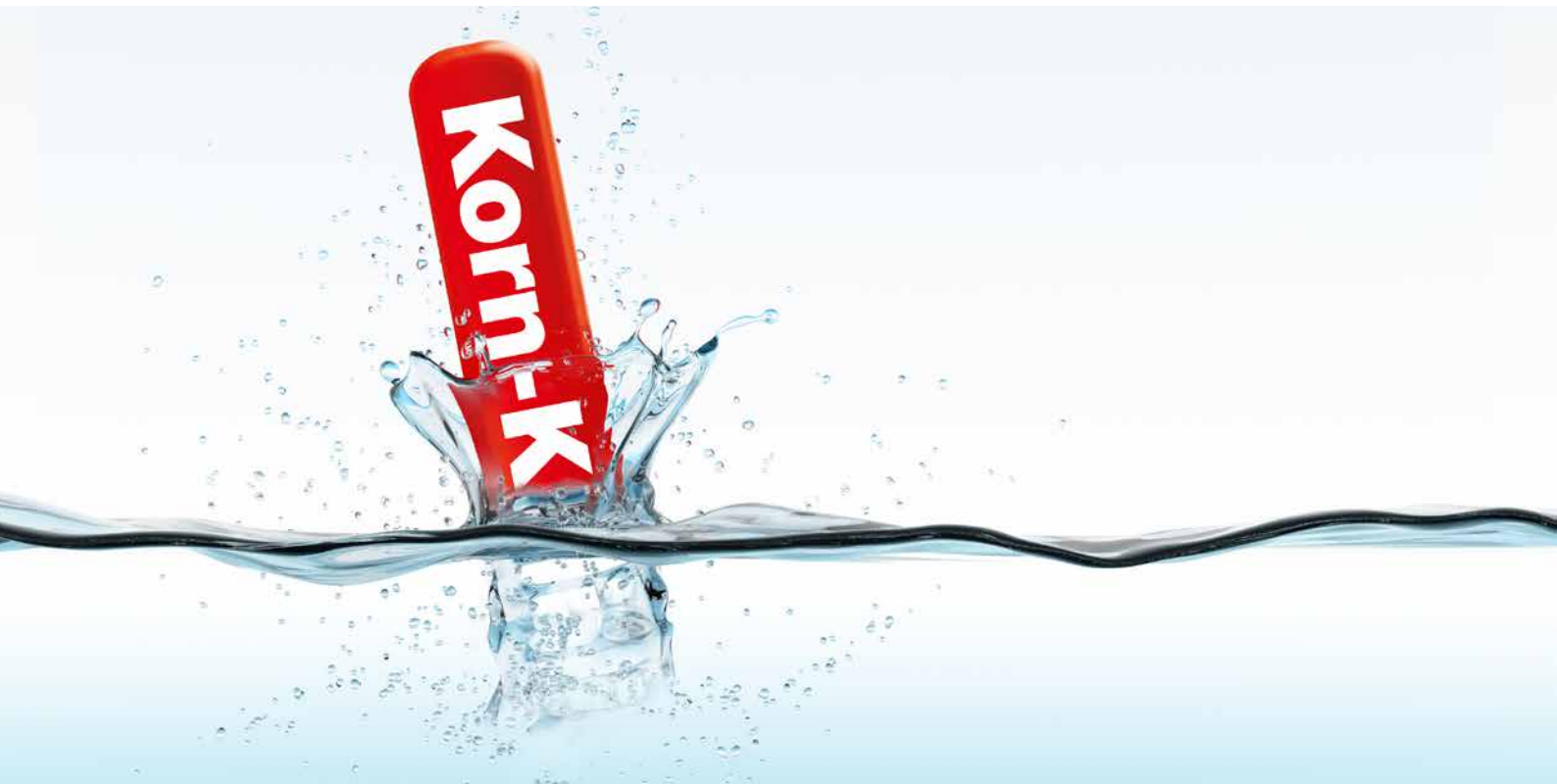
-K -Mg

2001 – 2002 – 2003 – 2004 – 2005 – 2006 – 2007 – 2008 – 2009 – 2010 – 2011 – 2012 – 2013 – 2014 – 2015 – 2016



## 100 % solubility

Original potassium, magnesium and sulphur



### Korn-Kali® – strong, original package of nutrients

Korn-Kali is a well-balanced fertiliser which fulfils its role in the fertilisation of most arable crops. In places with high needs for potassium and magnesium, it is necessary to use fast and easily accessible nutrients, which prevents deficiencies and secures high yields.

Korn-Kali is a package with a well balanced ration of nutrients for the plant. It contains potassium, magnesium and sulphur in proper proportion as regards the needs of the plant.

### The average absorption by plants and content of the nutrients in Korn-Kali®:

	$K_2O : MgO$
Average absorption by the plant	6 : 1
$K_2O : MgO$ in Korn-Kali	40 : 6 (6.67 : 1)

	$K_2O : S$
Average absorption by the plant	about 5 : 1
$K_2O : S$ in Korn-Kali	40 : 5 (8 : 1)

### Natural strength – Kieserite

250 million years ago kieserite was built by evaporation. Discovered in potassium deposits in Germany in the 19th century, it is still the only natural source of magnesium sulphate. The extracted natural mineral is used as the highest quality raw material for the production of high quality products e.g. Korn-Kali and ESTA Kieserit. Only kieserite guarantees that the magnesium and sulphur included in the products:

- are fully water-soluble,
- are fast plant-available,
- provide the optimal dose of nutrients as regards the needs of plants,
- are of natural origin.





## Original package of nutrients

### A guaranteed efficiency

#### Korn-Kali® with fully water soluble nutrients (K, Mg, S, Na)

The K+S KALI mineral fertilisers contain the nutrients in fully water-soluble and therefore plant available form. Therefore, Korn-Kali guarantees the 100 % availability of the nutrients to the plant and is a unique source of magnesium and sulphur in the agriculture in demand.

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 % Sulphur as sulphate ( $SO_3$ ).

The main advantage of kieserite is in comparison with other magnesium-based fertilisers, e.g. of oxide ( $MgO$ ) or carbonate (dolomite-based) type, the nutrients are released much faster (table below). Hence, Korn-Kali is the excellent fertiliser which supplies the soil with potassium combined with magnesium and sulphur adequately to the needs of the plant. This is a strong package of nutrients easily available for the plant.

#### Safe quality – no heavy metals

The natural source of potassium, magnesium, sulphur and sodium, i.e. the raw materials from German deposits, guarantee no harmful additions, e.g. heavy metals, which could come from chemical production processes. The entire chain of processes is supervised by the entire research and development department. This guarantees products of highest quality.



*Kieserite – the natural, original mineral, which provides plants with soluble magnesium and sulphur.*

#### The solubility of various forms of magnesium in fertilisers

The form of fertiliser		Solubility (g/l)
Kieserite	$MgSO_4 \cdot H_2O$	471
Dolomite	$CaCO_3 \cdot MgCO_3$	0.034
Magnesium oxide	$MgO$	0.0062
Magnesium hydroxide	$Mg(OH)_2$	0.009
Magnesium silicate	$2 Mg \cdot SiO_2$	Non-soluble in $H_2O$

Source: Taschenbuch für Chemiker u. Physiker; UEIC 2012/Ullmann's Encyclopedia of Industrial Chemistry; P. Benezeth et al.: Experimental Determination of the Solubility of Magnesite; H.C. Helgeson: Thermodynamics of Hydrothermal Systems at Elevated Temperature; M. Bhuiyan et al.: A Solubility and Thermodynamic Study of Struvite



## More than fertiliser

### Know how – a success built for years

Korn-Kali is produced with many years of experience of farmers, agricultural advisors and specialists from the K+S KALI GmbH. The research institute “Institute of Applied Plant Nutrition – IAPN” working on modern agriculture, was built by K+S KALI together with the University of Göttingen. The main issue of IAPN is the configuration of fertilisation systems which perform well even under adverse conditions.

We want to satisfy our clients to yield interest throughout the production process. The strength of Korn-Kali is the necessary package of strength for healthy plants. The fertilisers produced from natural deposits guarantee quality and are 100 % safe for people. What guarantees the production of healthy and wholesome food is the use of fertilisers based on natural raw materials.



#### Extraction

We extract approx. 100 thousand tons of raw potassium and magnesium salts in our mines every day. The unique mineral – kieserite – can be found only in the potassium salt deposits located in Germany.



#### Production

The extracted raw materials are processed in 6 production plants build up next to the mines. Modern technologies and one-of-its-kind production method – ESTA – make us to the leader among the producers of high-quality fertilisers.



#### Quality control

Still underground, the content of e.g. kieserite in raw salt is analysed with modern equipment. Constant quality control from the extraction to the end of the production eliminates the risk of raw material contamination.



#### Distribution and service

The partners of our company in the scope of product sale to the final client are fertiliser distributors. Many years of fruitful cooperation with farmers is a guarantee for availability of fertilisers to the final clients – farming households.



#### A farmer

Numerous farming households cooperate with distributors and they regularly get in stock of the fertilisers offered by K+S. Along with the guaranteed high quality of fertilisers, we also offer the service of fertilisation advisory.



**More than just fertilisers –  
potassium and magnesium for your risk management**



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