



The Authority in Potassium and Magnesium

K+S KALI GmbH
IFA/CPCIF/CBC China Seminar

Importance of magnesium, sulphur and
micronutrients for balanced fertilizer use on a
global scale

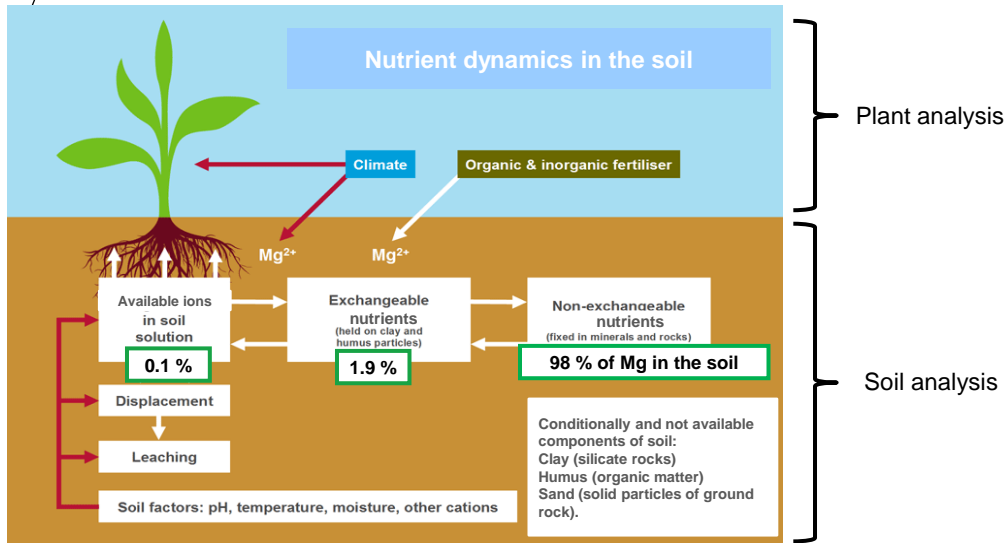
Andreas Gransee
Applied Research and Advisory Service Agro
K+S KALI GmbH, Germany

K+S Group



MAGNESIUM

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Nutrients in the soil
 Mainly fixed in minerals and rocks



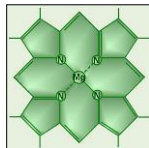
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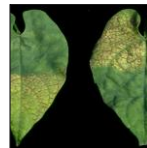
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Magnesium
 – crucial for metabolic processes



Magnesium is crucial for ...



... **photosynthesis** and thus for the transformation of light energy to yield. Mg is the central atom of the chlorophyll molecule.



... **stress tolerance**, such as heat/radiation stress.



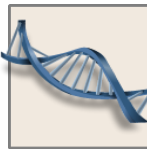
... for synthesis, transport and storage of important plant substances such as **carbohydrates, proteins and fats**.



... the function of numerous enzymes and thus for many **metabolic processes**.



... **root growth**. Mg thus increases water and nutrient uptake from the soil.



... **RNA synthesis** and therefore the translation of genetic information into proteins.

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K+S KALI GmbH Nutrient Deficiency Symptoms Magnesium (Mg)



- Mg is mobile in plants → Deficiency first visible in older leaves
- Interveinal chlorosis on older lower leaves with a marbling effect (leaf veins remain green).
- Later various shades of red/purple can appear as chlorophyll breaks down leading eventually to leaf necrosis.



Mg Deficiency Maize

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Mg Deficiency Potato



Mg Deficiency Cereals

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www.kali-gmbh.com/deficiency-symptoms

K+S KALI GmbH Leaching



- Mg is subject to leaching in considerably high amounts due to its high mobility in the soil
- Leaching can reach **20-30 kg ha⁻¹ a⁻¹** depending on:
 - Amount of leaching water / rainfall
 - Mg content in the soil and binding forms
 - **Cation Exchange Capacity (CEC)**
 - **pH in the soil**

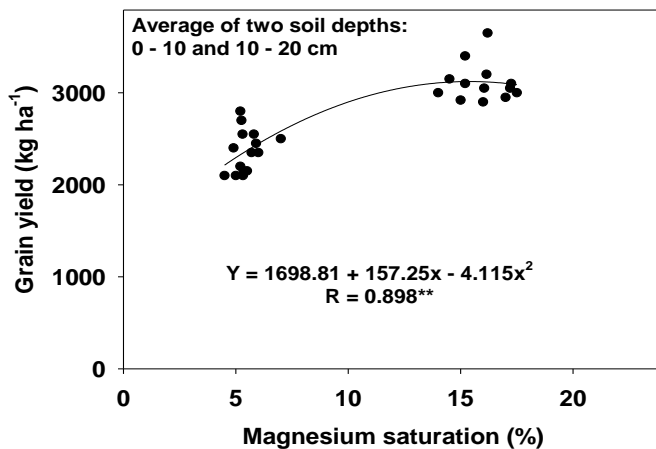
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**Magnesium saturation in the soil
 and grain yield, Brazil**



Grain yield of dry bean, Brazil, Oxisol



Fageria, 2009

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Cation Exchange Capacity (CEC)

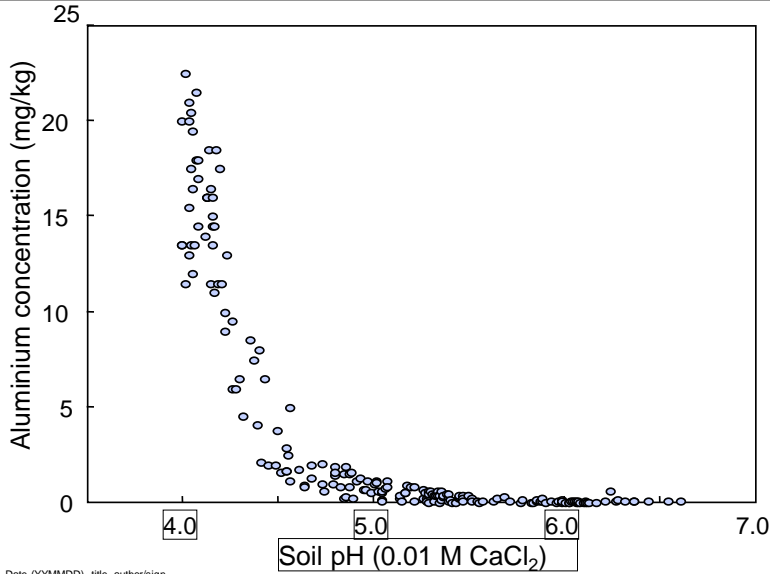


	pH	CEC _{pot}	CEC _{eff}	Saturation (% of CEC _{eff})		
	[CaCl ₂]	[mmol _c kg ⁻¹]		Ca	Mg	K
Soil under field (Germany)						
Luvisol	6.3	170	140	80	15	5
Chernosem	7.2	180	180	90	9	0.5
Fluvisol	5.1	370	250	50	42	3
Podzols	5.2	120	30	86	6	9
Soils of other climates						
Vertisol (Sudan)	6.8	452	470	71	25	0.4
Andisol (Hawaii)	4.5	531	133	71	20	3.8
Oxisol (Brazil)	3.5	130	26	2.7	3.5	3.1
Ultisol (Puerto Rico)	3.5	256	72	15	8.3	2.8
Aridisol (USA)	9.9	364	-	45	5.5	2.5

Based on Scheffer and Schachtschabel, 2002

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Aluminium concentration in soil increases with soil acidification

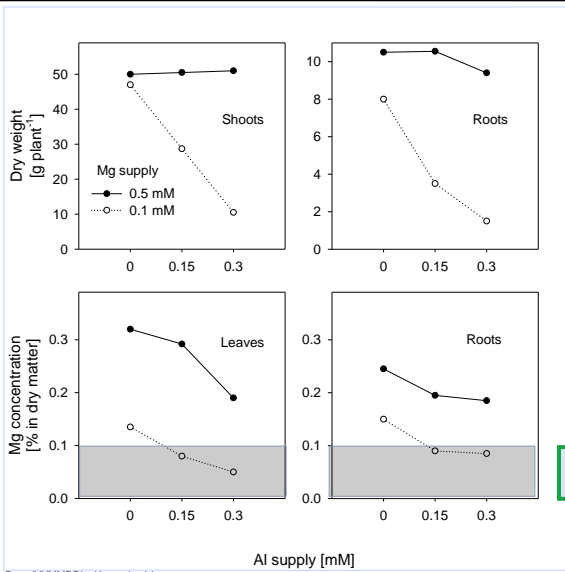


Rengel, 2012, presentation given on Mg symposium in Göttingen

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Magnesium supply increases tolerance towards Aluminium



Deficiency symptoms!

Based on Grimme, 1984, redrawn from Marschner, 2012

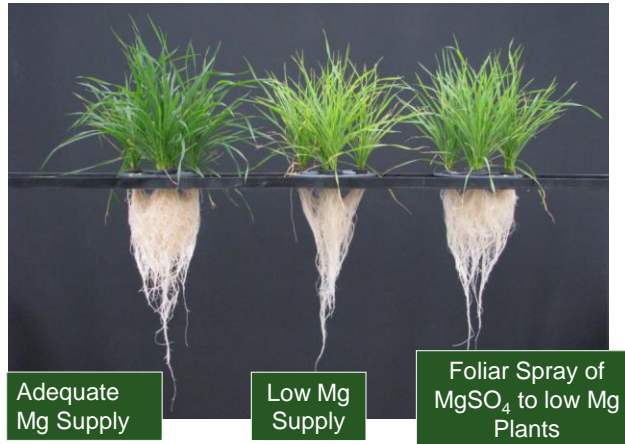
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Magnesium
Promotes Root Growth



Mg is necessary for Phloem loading of photo-assimilates and carbon partitioning between sink organs



Cakmak

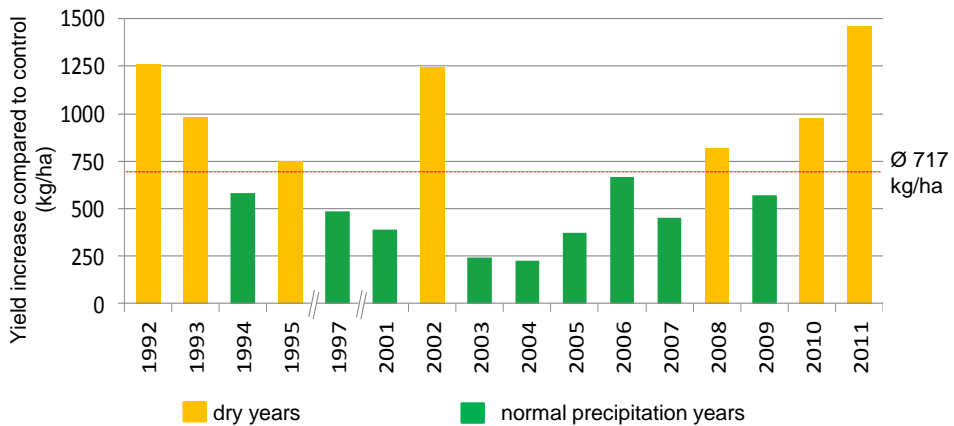
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Magnesium foliar fertilisation:
Risk reduction in dry years



Mg foliar application 25 kg ha⁻¹ EPSO Top® at BBCH 32, winter wheat on soil with high Mg content



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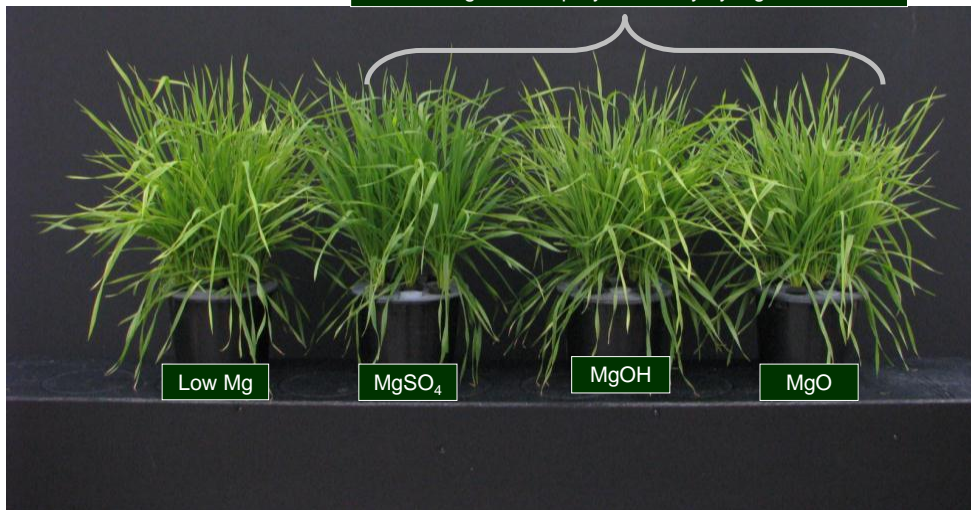
The significance of Magnesium supply for oil yield

Treatment	Year 5	Years 1-5 combined	Oil to bunch ratio
	(t ha ⁻¹)	(t ha ⁻¹)	
N+P+SOP	4.35 b	6.00	27.90
N+P+SOP+1.5 Mg	5.92 a	6.54	28.49
N+P+SOP+3.0 Mg			29.27

- Magnesium (ESTA Kieserit) significantly increased FFB yield, oil content (O/B) and oil yield
- An extra 0.57 t ha⁻¹ year⁻¹ oil was obtained by application of 1.5 kg Mg palm⁻¹ year⁻¹ as ESTA Kieserit

K+S KALI GmbH Form of Mg Foliar Fertilisation

Low-Mg Plants Sprayed Foliarly by Mg fertilizers





The solubility of Mg sources other than Mg sulphate is very low!

SULPHUR

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Sulphur
 – for oil and protein synthesis



Sulphur is crucial for ...



... activating important enzymes for the **metabolism of energy and fatty acids.**



... synthesis of sulphur-containing amino acids and thus for **protein synthesis.**



... an increased **nitrogen use efficiency.**



... the production of **innate plant defence substances** (phytoalexines, glutathione).



... synthesis of sulphur-containing, **secondary plant substances** such as aromatic oils and compounds (leek oil, mustard seed oil...).

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Nutrient Deficiency Symptoms
Sulphur (S)



- Sulphur is immobile in plants → Symptoms on youngest leaves first
- Diffuse yellowing, sometimes marbled.
- Leaves form spoon shapes, curl upwards and may become brittle.
- Later, flowers are reduced in number and are markedly pale.



S Deficiency Oilseed Rape



S Deficiency Oilseed Rape



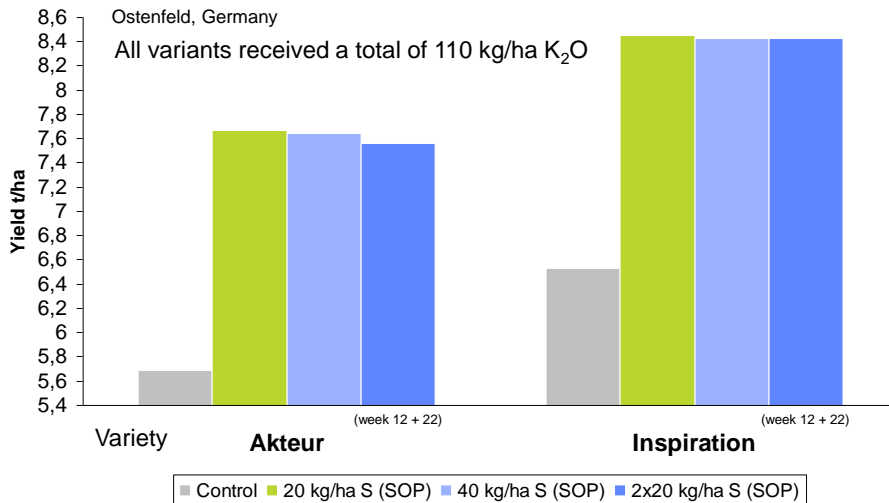
S Deficiency Cereals

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**Effect of Sulphur Fertilisation on the Yield
of Winter Wheat**



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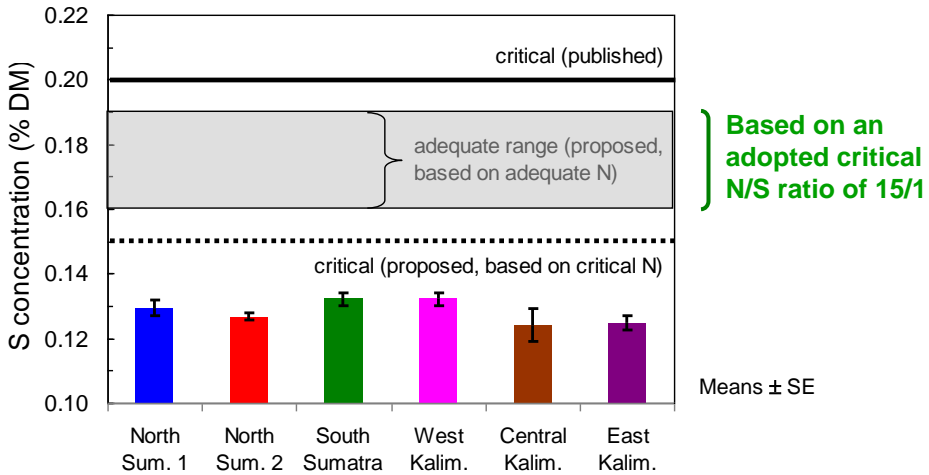
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**Effect of Sulphur Fertilisation
Field Trial Ostenfeld, Germany**



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**The S status of oil palm in Indonesia:
 Leaf status S at BMP project sites in 2009**



Based on an adopted critical N/S ratio of 15/1

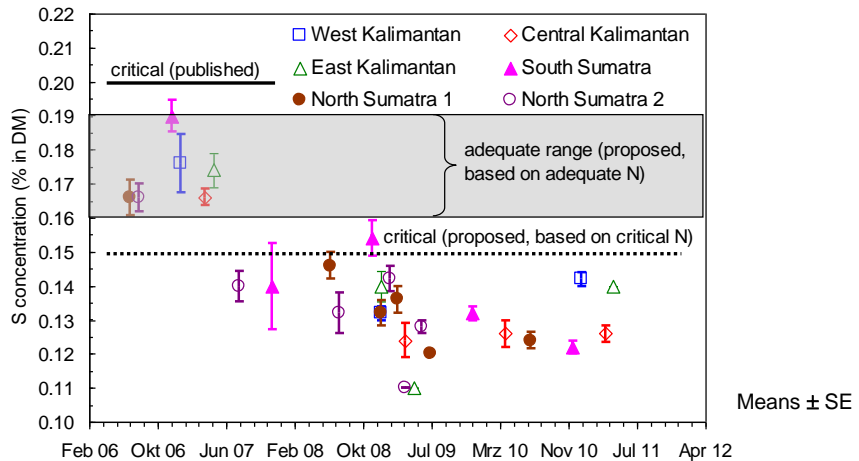
→ S status of oil palm is very low in Indonesia

06/2012 – JG, MA

Source: Gerendás, Donough & Oberthür, PIPOC 2011

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**Time course of leaf S status monitored
 in BMP project sites in Indonesia**



→ The S status of oil palm in Indonesia is declining!

06/2012 – JG, MA

Source: Gerendás, Donough & Oberthür, PIPOC 2011

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ZINC

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K+S KALI GmbH Zinc – for protein synthesis



Zinc is crucial for ...



... the activation of several enzymes and therefore affects many **metabolic processes** in the plant.



... **protein formation**, which is drastically inhibited if the nutrient is insufficiently supplied due to the role of Zn in RNA synthesis.



... the synthesis of fructose-6-phosphate, an important metabolite in glycolysis and therefore **photosynthesis**.



... indole-3-acidic acid content which is important for regulation of **plant growth**.

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Nutrient Deficiency Symptoms
Zinc (Zn)



- Zinc is immobile in plants → Symptoms on youngest leaves first
- Chlorotic and necrotic streaks develop on either side of the leaf mid-rib whilst the margins often remain green.
- In cases of severe deficiency, the plants are stunted due to shortened internodes.



Zn Deficiency Cereals

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Zn Deficiency Maize

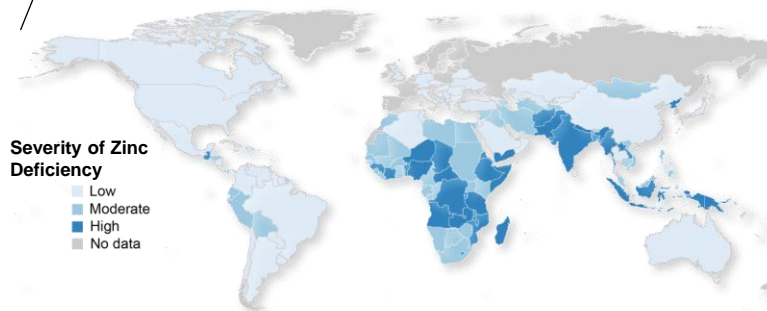


Zn Deficiency Maize

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Zinc Deficiency – a severe problem



One-third of the world's population live in countries where the risk of zinc deficiency is high.

More than 400,000 children die each year due to zinc deficiency.

Micronutrient malnutrition / hidden hunger is the result of a diet mainly based on inexpensive staple foods, as the poor can no afford fruit, vegetables or animal products.

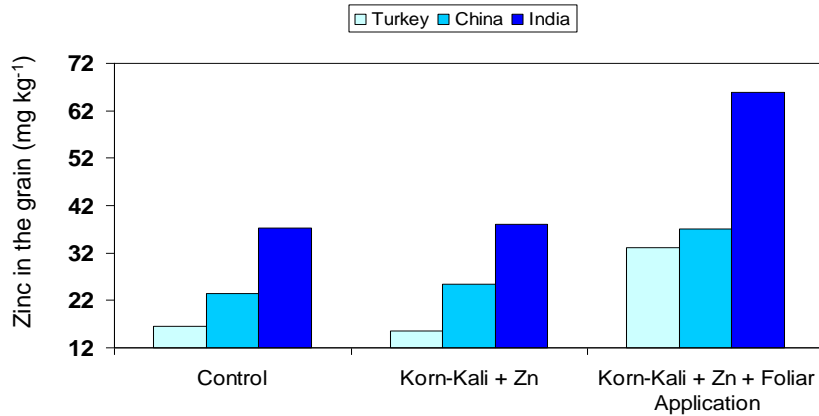
Harvest Plus focuses on the biofortification of staple foods such as rice, maize, wheat or cassava → breeding, fertilisation

Source: www.harvestplus.org, data based on World Health Organization, Global Health Observatory Database

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 HarvestPlus: Effect of Zn-fertilization on the grain zinc content of winter wheat



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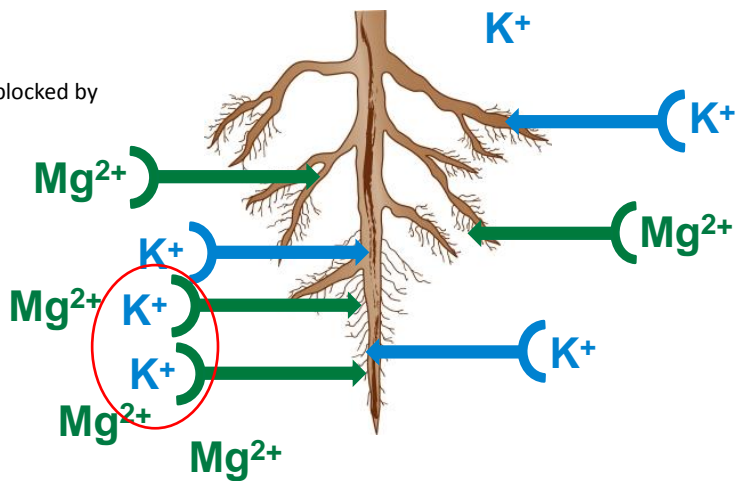
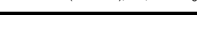
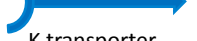
Antagonism: Potassium reduces the Magnesium uptake...



Mg²⁺ uptake via
 unspecific transporter



→ these are increasingly blocked by high K supply



K uptake
 via specific



K transporter

K delivery via diffusion

Mg delivery via mass flow

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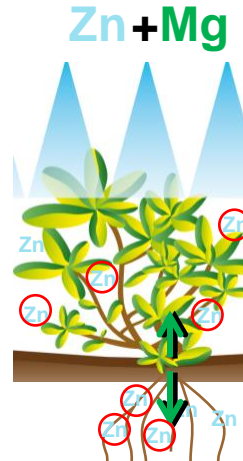
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Interaction of Mg and Zn
Two nutrients to be managed together



Foliar Application of Zinc



Foliar Application of Zinc and Magnesium



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Research results from Ozturk, Sabanci University

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Take Home-Message



- Mg and S are important for a balanced fertilization of the crops
- Mg and S mitigate the impact of abiotic stress
- Mg, S and micronutrients can boost agricultural productivity

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**THANK YOU
FOR YOUR ATTENTION**