



*The Authority in Potassium and Magnesium*

K+S KALI GmbH

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**IFA Indonesia Seminar on sustainable  
fertilizer management**

<http://kimochimabes.blogspot.com/>

Importance of magnesium, sulphur and  
micronutrients for balanced crop nutrition

Andreas Gransee  
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K+S KALI GmbH, Germany

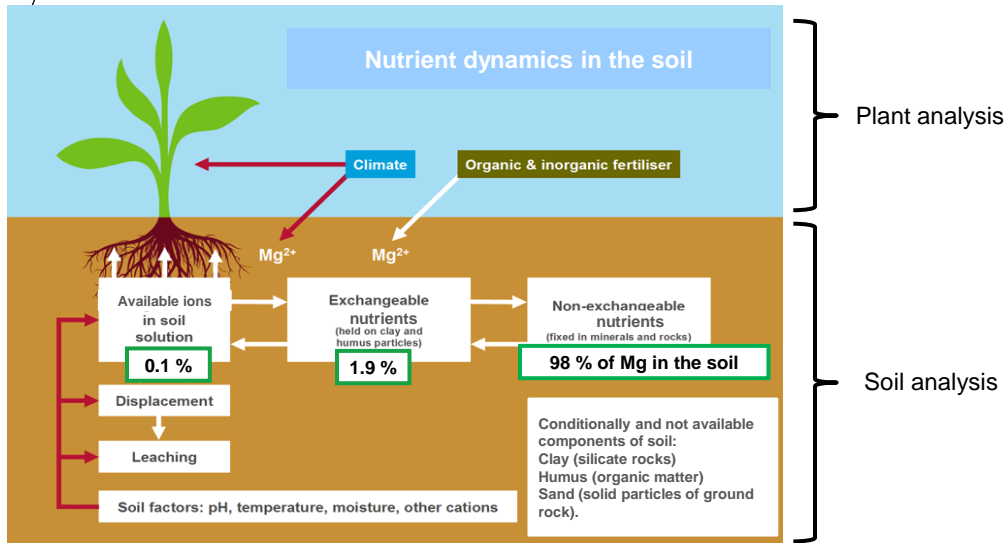
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**MAGNESIUM**

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**Nutrients in the soil**  
 Mainly fixed in minerals and rocks



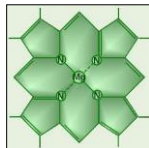
Balanced crop nutrition, Gransee

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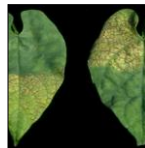
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**Magnesium**  
 – crucial for metabolic processes



**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.



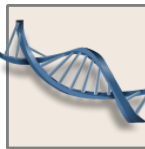
... for synthesis, transport and storage of important plant substances such as **carbohydrates, proteins and fats**.



... 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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**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

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**Ionic and hydrated radius**  
**of Magnesium, Calcium and Potassium**



	Ionic radius	Hydrated Radius	
<b>Mg<sup>2+</sup></b>			<p><b>Magnesium</b> has a large hydrate sphere</p> <p>→ Low binding strength, especially in soils with <b>low Cation Exchange Capacity (CEC)</b> coupled with a <b>low pH</b></p> <p>→ High mobility</p> <p>→ Risk of <b>leaching</b></p>
<b>Ca<sup>2+</sup></b>			
<b>K<sup>+</sup></b>			

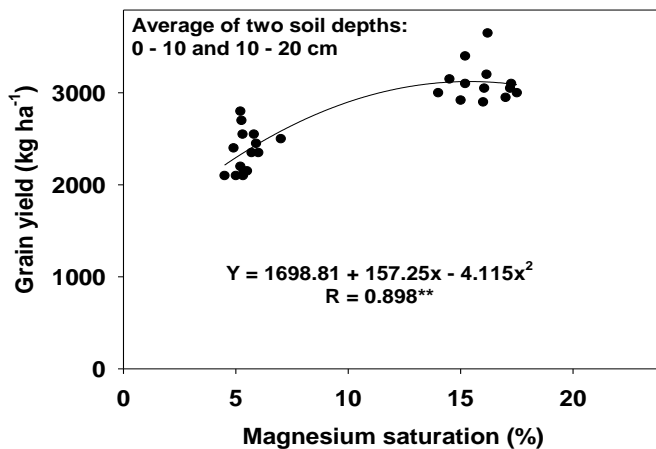
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Magnesium saturation in the soil  
and grain yield, Brazil

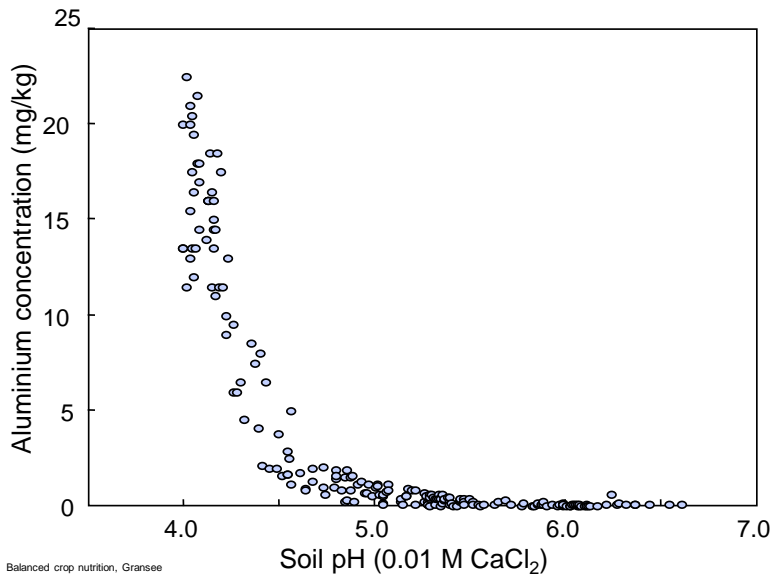


Grain yield of dry bean, Brazil, Oxisol



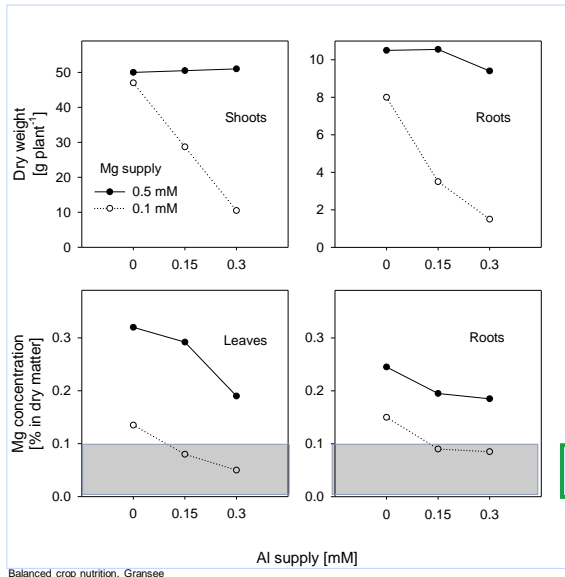
Fageria, 2009

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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!

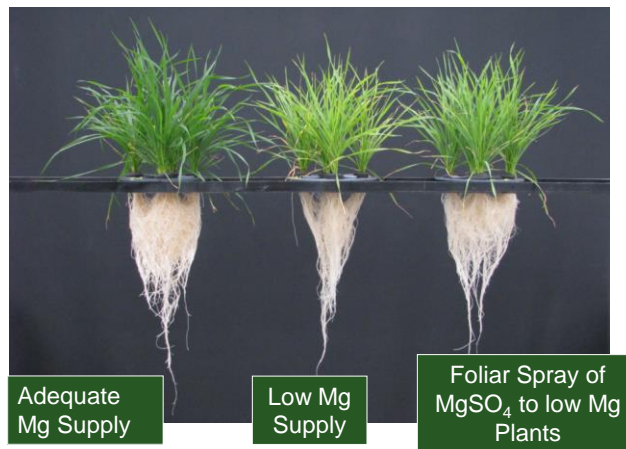
Based on Grimme, 1984,  
 redrawn from Marschner, 2012

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**Magnesium Promotes Root Growth**



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



Adequate Mg Supply

Low Mg Supply

Foliar Spray of MgSO<sub>4</sub> to low Mg Plants

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Hakli and Cakmak, 2011

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Mg-deficient Maize in Uganda:  
High light causes damages



**Plants in the background:**  
Shadow from the tree

**Plants in the front:**  
No shadow

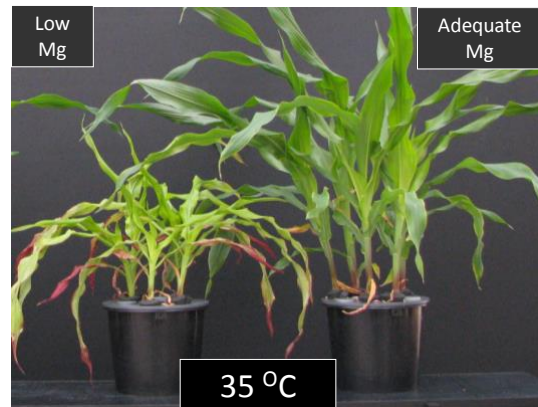
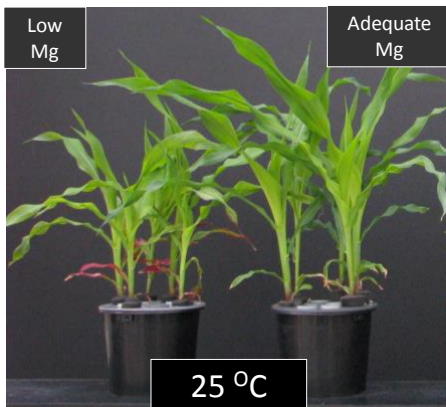


Cakmak

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Effect of Mg nutrition on heat stress tolerance of  
maize plants



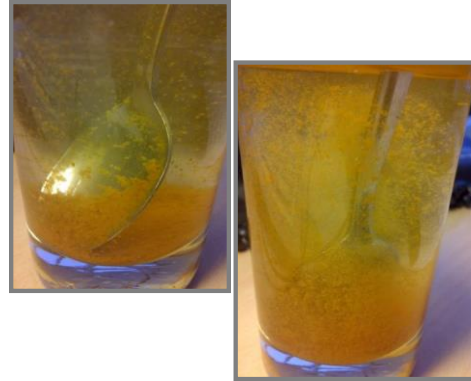
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M. Mengutay et al, 2013

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Synthetic magnesium sulphate (SMS)



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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www.kali-gmbh.com/deficiency-symptoms



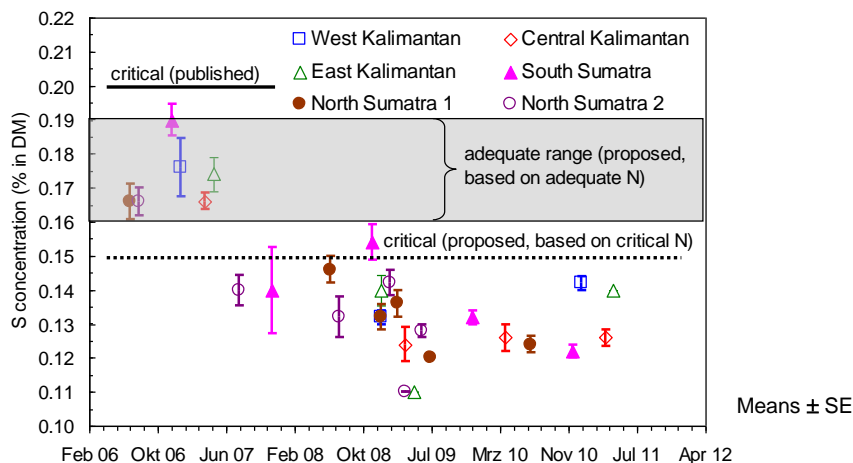
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 Effect of Sulphur Fertilisation  
 Field Trial Ostenfeld, Germany



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

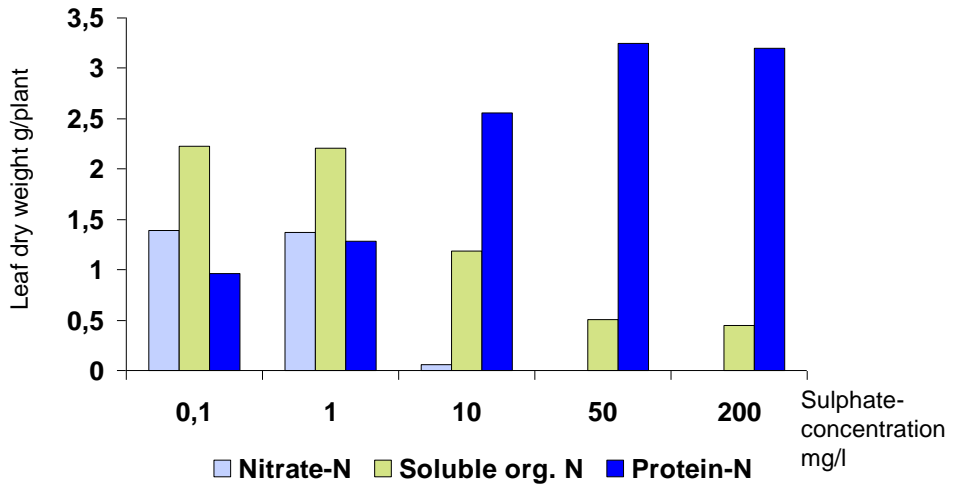


**➔ The S status of oil palm in Indonesia is declining!**

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Source: Gerendás, Donough & Oberthür, PIPOC 2011

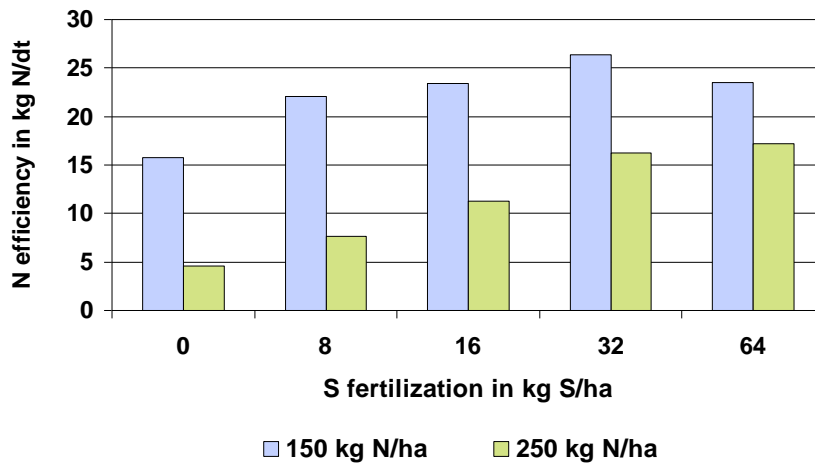
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Source: Marschner (1997)

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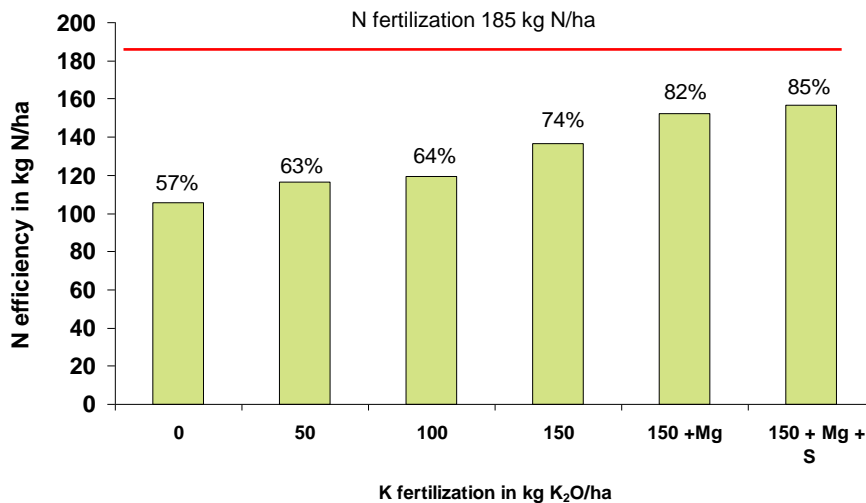


Source: Walker und Booth (1994)

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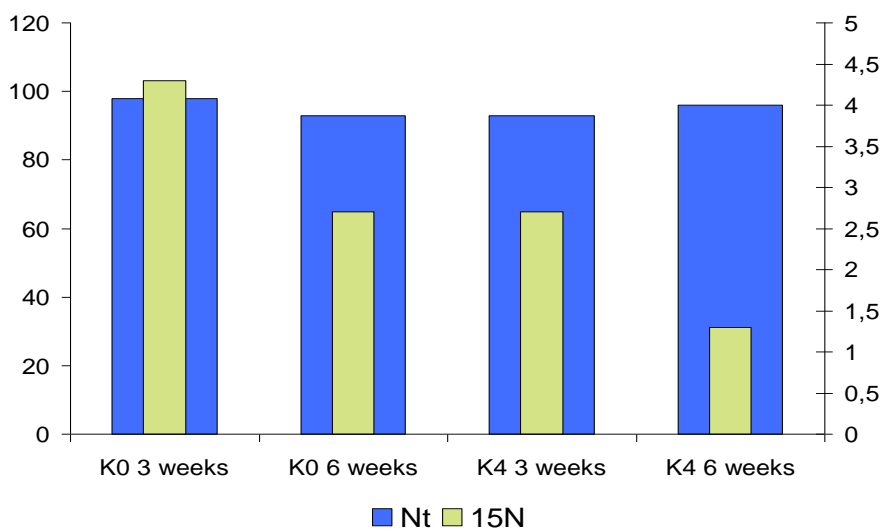
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 Effect of different K and Mg fertilization on the N uptake of triticale



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 N<sub>t</sub> and <sup>15</sup>N content in soil after 3 and 6 weeks  
 (in mg N/ 100 g soil)



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# ZINC

## 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**

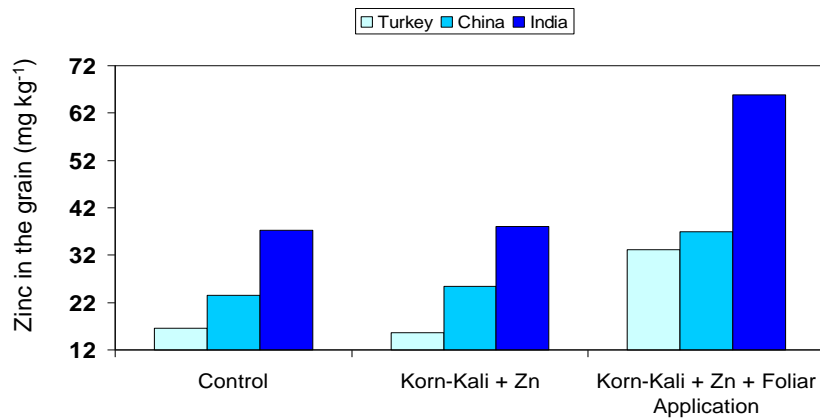


**Zn Deficiency Maize**

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



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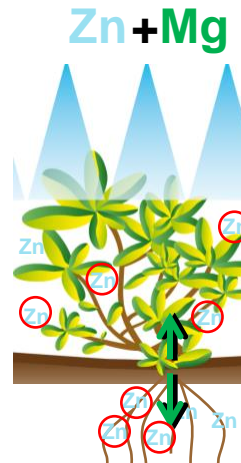
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Interaction of Mg and Zn  
Two nutrients to be managed together



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
- K, Mg and S enhance the Nitrogen Use efficiency
- Mg, S and micronutrients can boost agricultural productivity

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2<sup>nd</sup> INTERNATIONAL SYMPOSIUM ON  
**MAGNESIUM**  
IN CROP PRODUCTION, FOOD QUALITY  
AND HUMAN HEALTH  
NOVEMBER 4 - 6, 2014  
SÃO PAULO, BRASIL

### Confirmed Speakers

<b>Martin Broadley</b>	United Kingdom
<b>Ismail Cakmak</b>	Turkey
<b>Andreas Gransee</b>	Germany
<b>Jian Feng Ma</b>	Japan
<b>Zed Rengel</b>	Australia
<b>Andrea Rosanoff</b>	USA
<b>Rhian M. Touyz</b>	United Kingdom
<b>Godofredo C. Vitti</b>	Brazil
<b>Philip White</b>	United Kingdom

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**THANK YOU  
FOR YOUR ATTENTION**

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