K+S KALI GmbH

Beijing, March 2016

The Effect of a Balanced Fertilization including Potassium, Magnesium, Sulphur and Micronutrients on Nutrient Use Efficiency

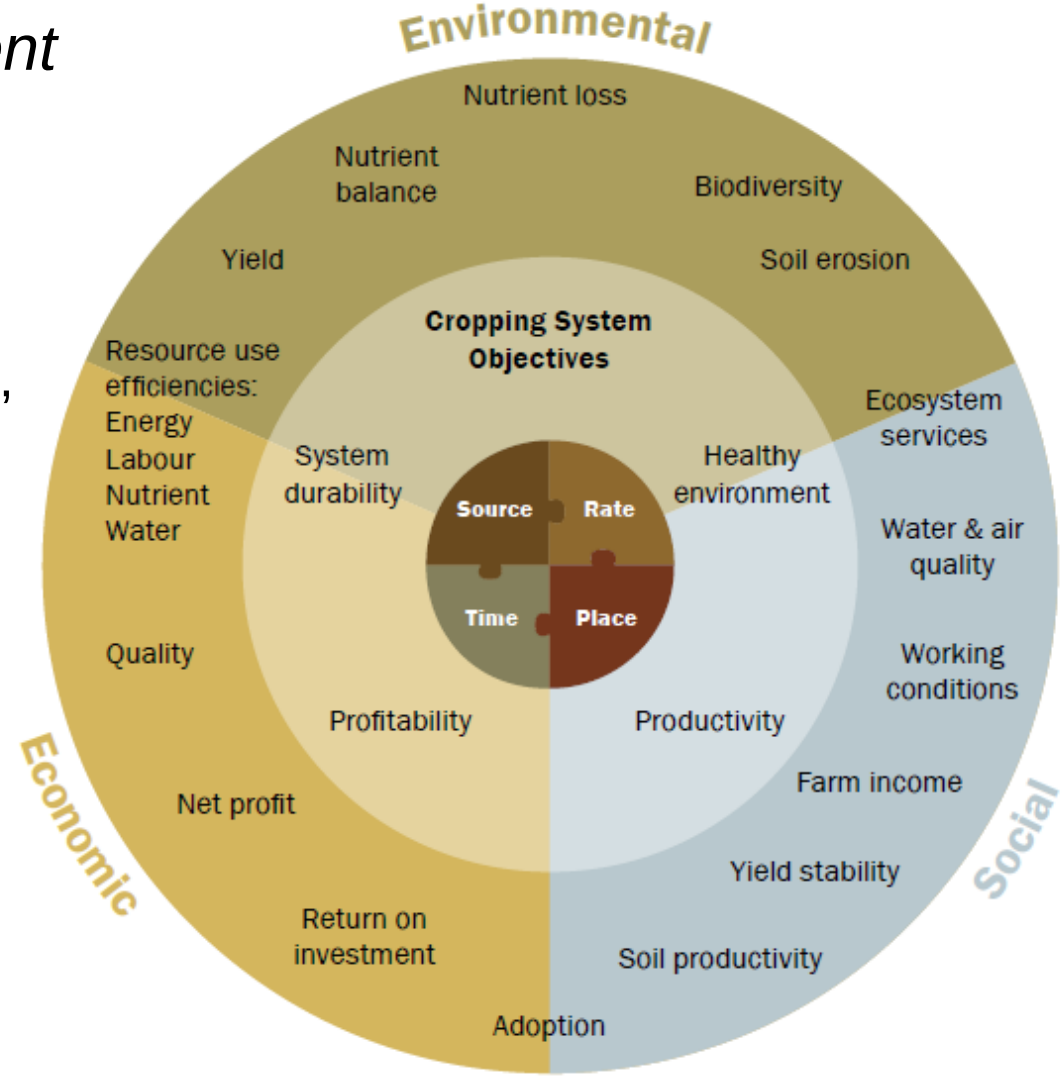
A. Gransee

Fertilizer Management and its Objectives

Fertilizer management

4R principle (IPNI):

- **R**ight rates,
- **R**ight type,
- **R**ight placement,
- **R**ight timing



Graphic: IFA

Fertilizer Management and its Objectives

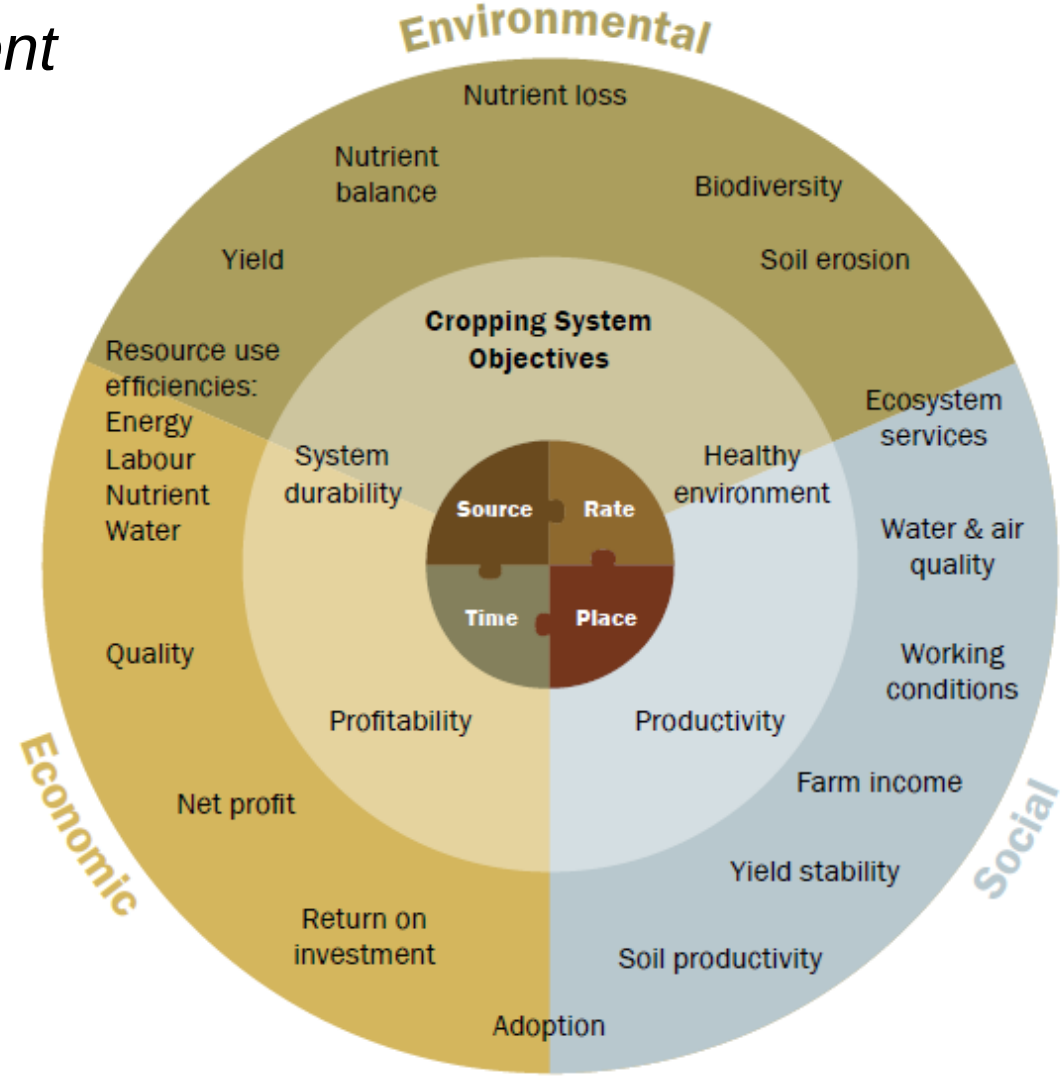
Fertilizer management

4R principle (IPNI):

Right rates

N and **P** rates are limited due to environmental issues

Target high N and P Use Efficiency



Graphic: IFA

Limitation of N and P use

- **Nitrogen (N)** und **Phosphorous (P) use are limited**

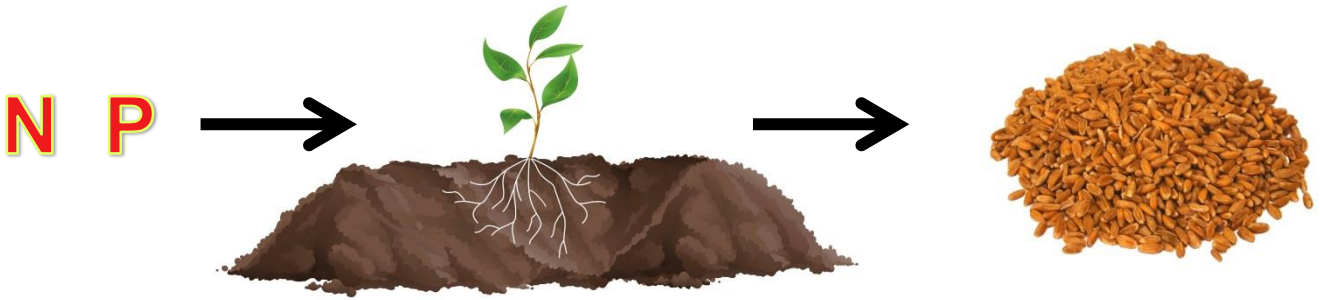
➢ High yields and quality (such as proteins in cereals) can only be achieved with **special attention on other factors**:

Balanced Fertilization K, Mg, S

Special Cultivars

…

➢ N and P uptake and use within the plant needs to be **efficient**



Definition: Nitrogen Use Efficiency (NUE)

How much **yield** can be achieved per kg **N**?

or

N ↔ 

How much **N** is necessary, to achieve a defined **yield**?

For economic and ecological reasons as well as for legal restrictions the goal is:

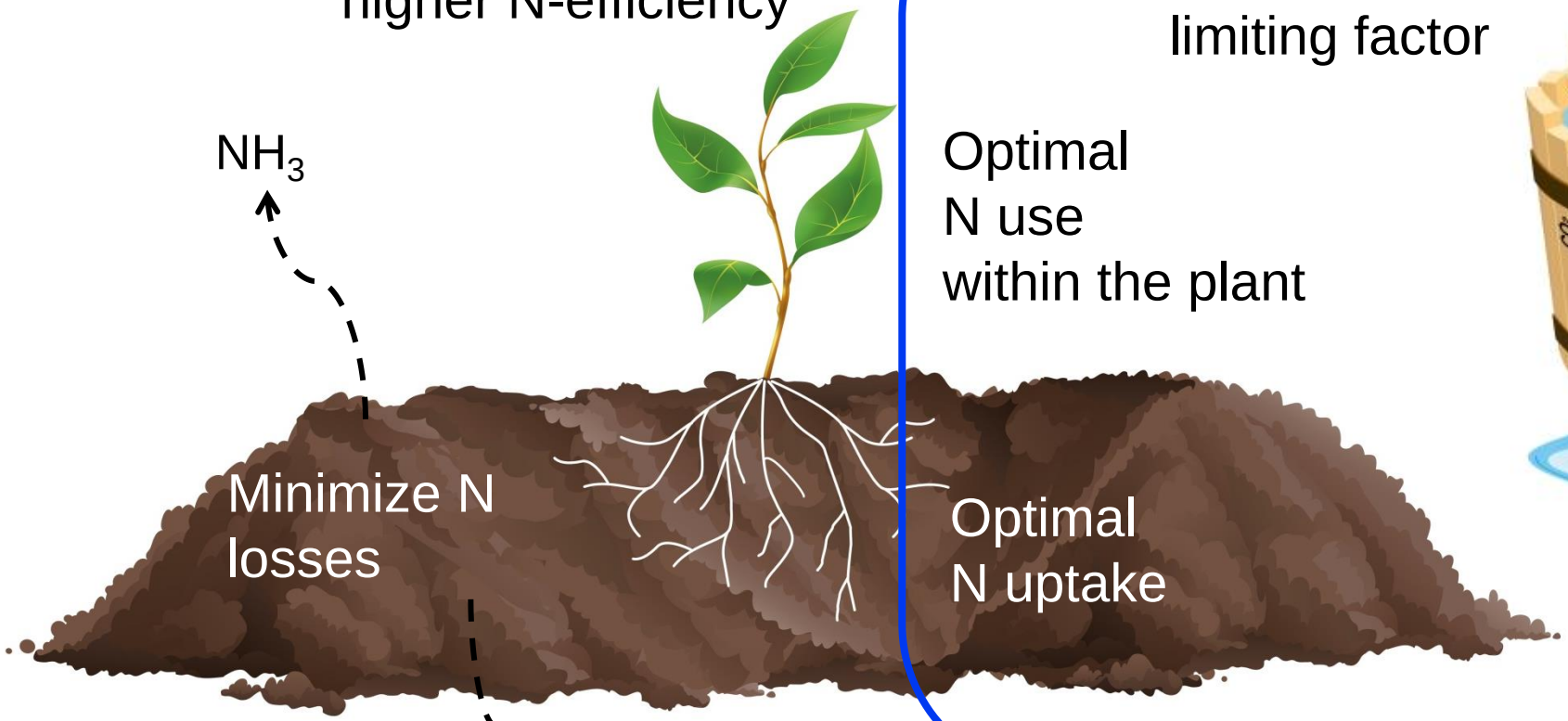
Maximize Nitrogen Use Efficiency

How to increase Nitrogen Use Efficiency?

Use of cultivars with higher N-efficiency

Avoid that any other nutrient becomes the limiting factor

Optimal N use within the plant



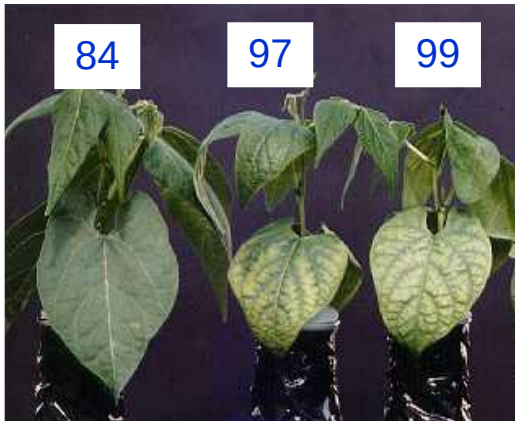
Optimal N uptake

Balanced Fertilization with K, Mg and S

OPTIMAL N-UPTAKE

Potassium and Magnesium Promote Root Growth

Proportion of carbohydrates in the shoot in per cent



+K/+Mg -K -Mg

Proportion of carbohydrates in the root in per cent

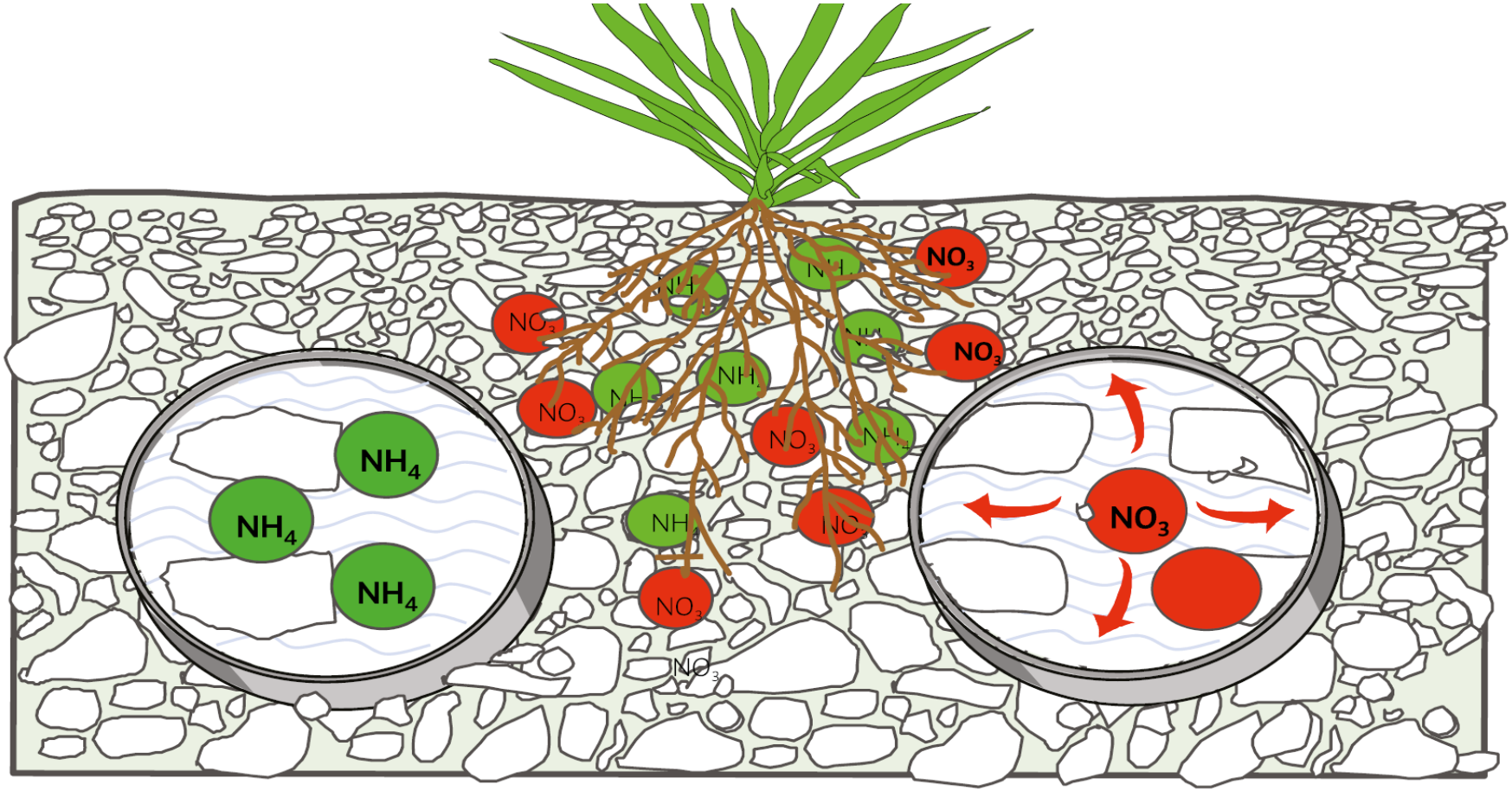
Source: Cakmak, Sabanci Universität Istanbul

Potassium and Magnesium enable carbohydrate translocation from the leaves/shoot (source) to the root (sink)

Better root system to explore the water and nutrients in the soil

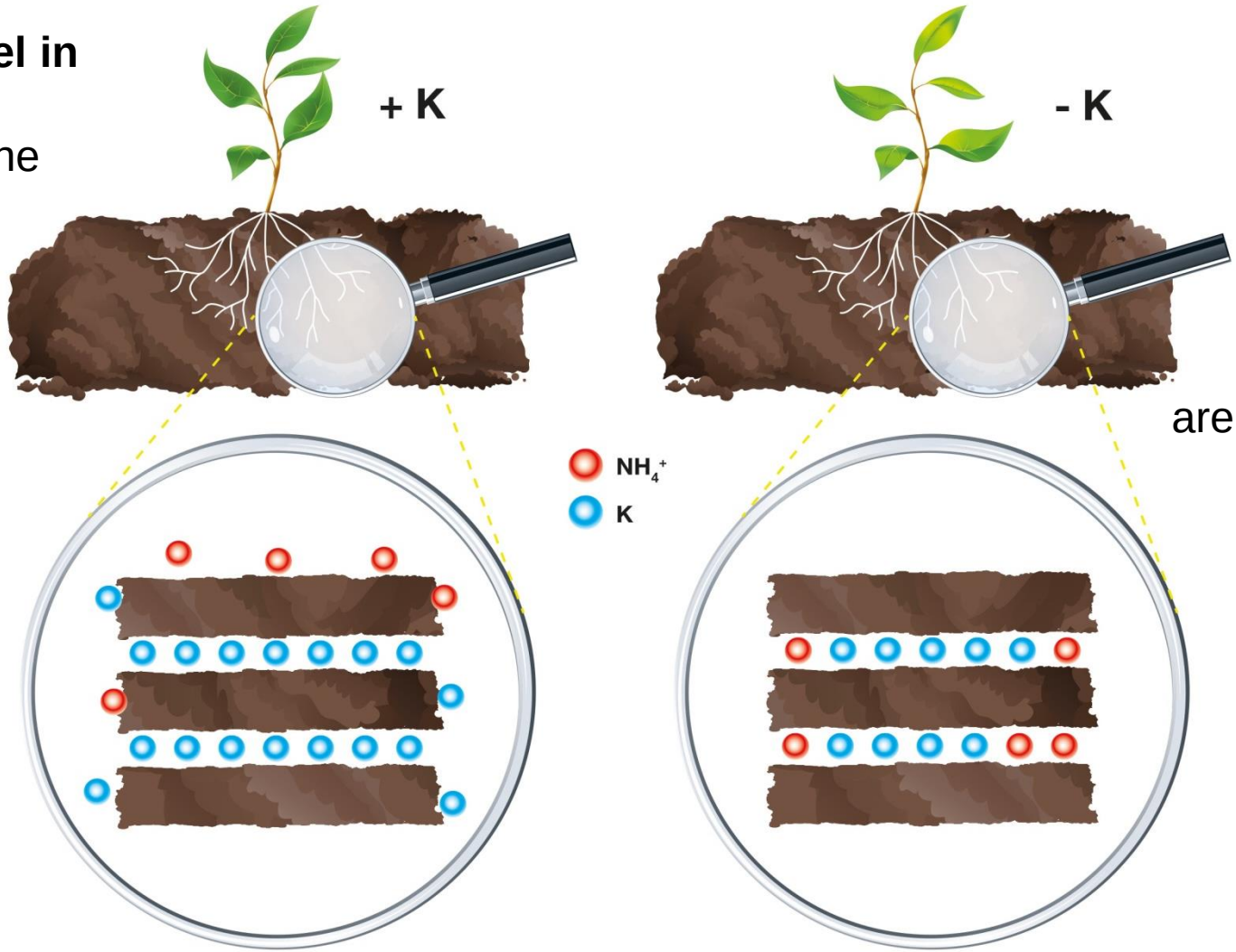
→ Increased N-Uptake from the soil

Nitrogen uptake: As NH_4^+ or NO_3^-



Low K-supply in the soil : NH_4^+ is bound

Optimal K level in the soil:
K is bound to the layers of clay minerals, NH_4^+ is plant-available



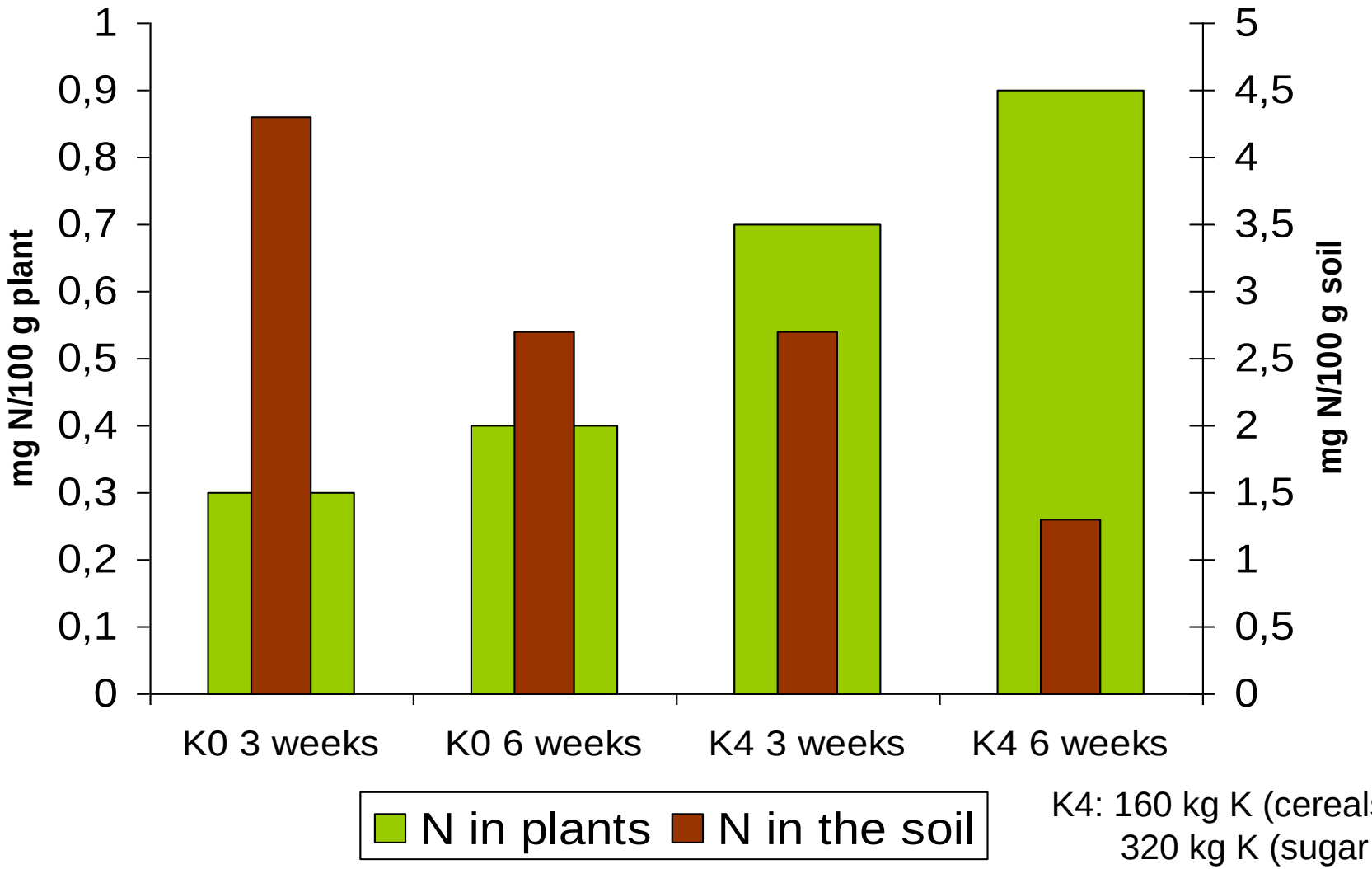
K deficiency in the soil:
Plants take up the K from the layers of clay minerals, the spaces are filled with NH_4^+

Picture: K+S KALI GmbH

Potassium and Ammonium are Antagonists

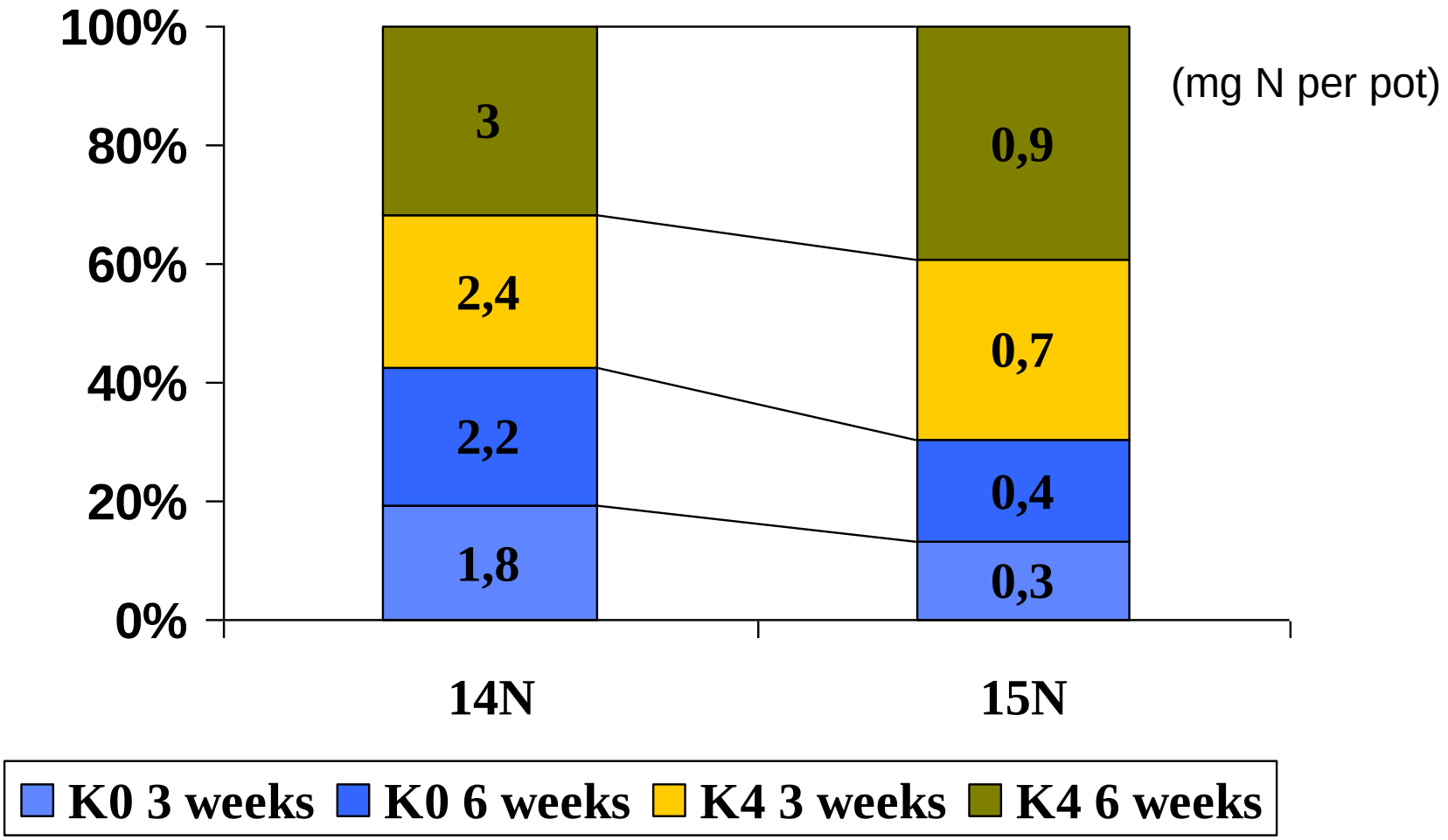
	Concentration in the Roots (µmol/g DM)			
	Ammonium		Potassium	
$(NH_4)_2SO_4$ (mM)	-K	+K	-K	+K
0,00	6,9	6,7	8,2	53,7
0,15	7,3	7,1	6,7	48,4
0,50	17,1	13,5	8,9	41,1
5,00	29,4	31,5	9,3	27,1

N^{15}-Content in Soil and Plant 3 and 6 Weeks after Potassium Fertilization

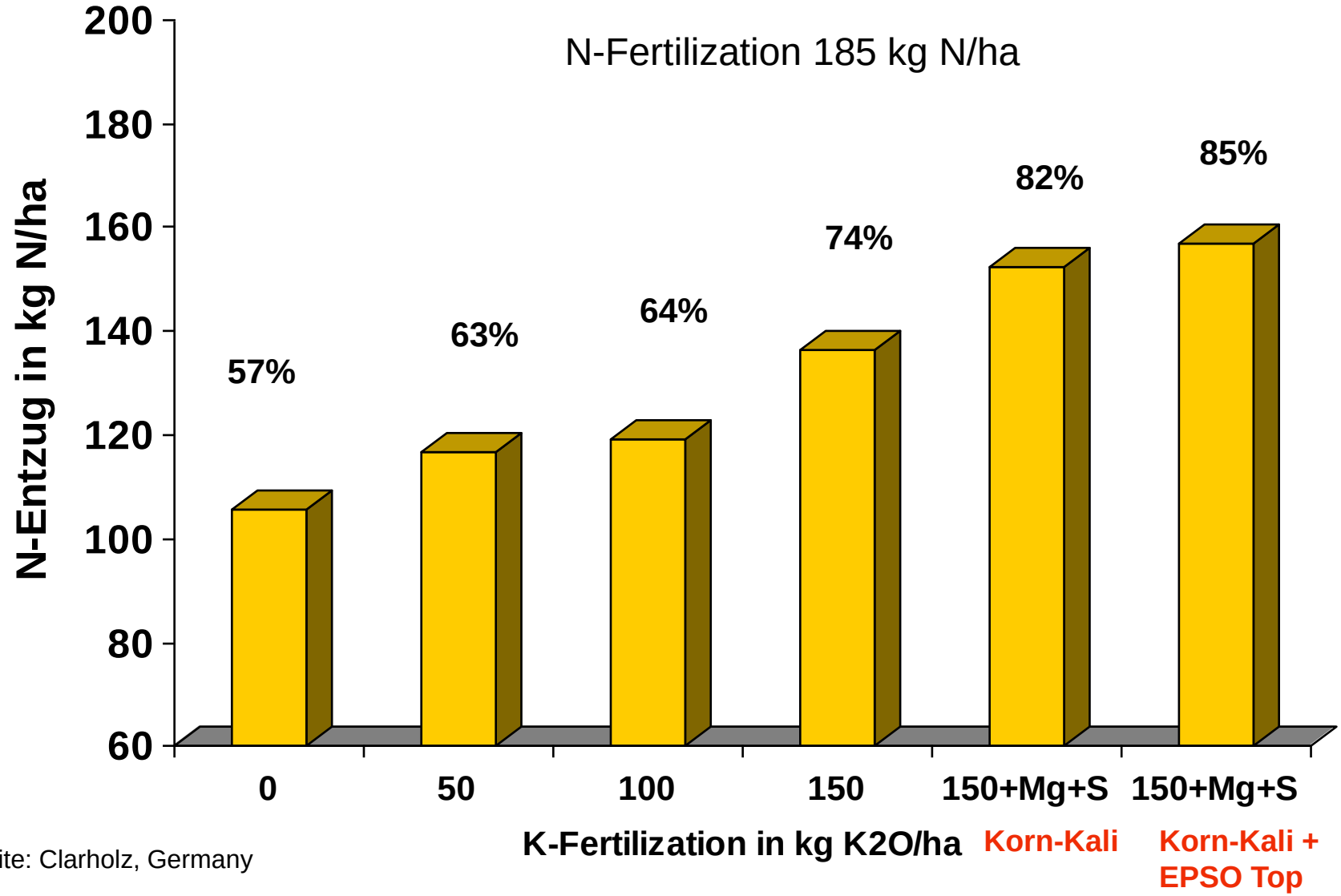


K4: 160 kg K (cereals) p.a.
320 kg K (sugar beet) p.a.

Total N and N^{15} Content in the Shoot 3 and 6 Weeks after Potassium Fertilization

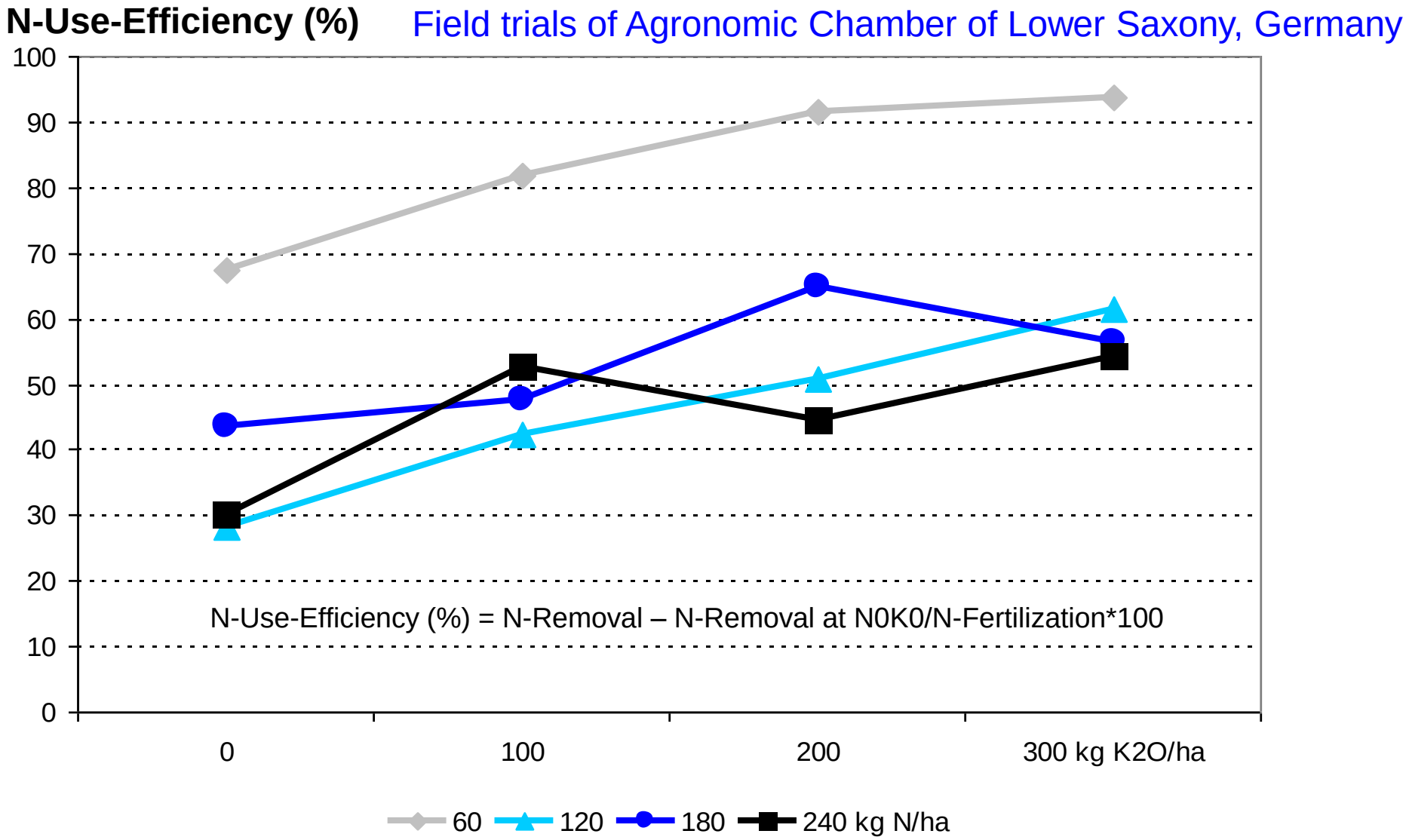


Effect of K-, Mg- and S-Fertilization on Nitrogen Use Efficiency of Triticale



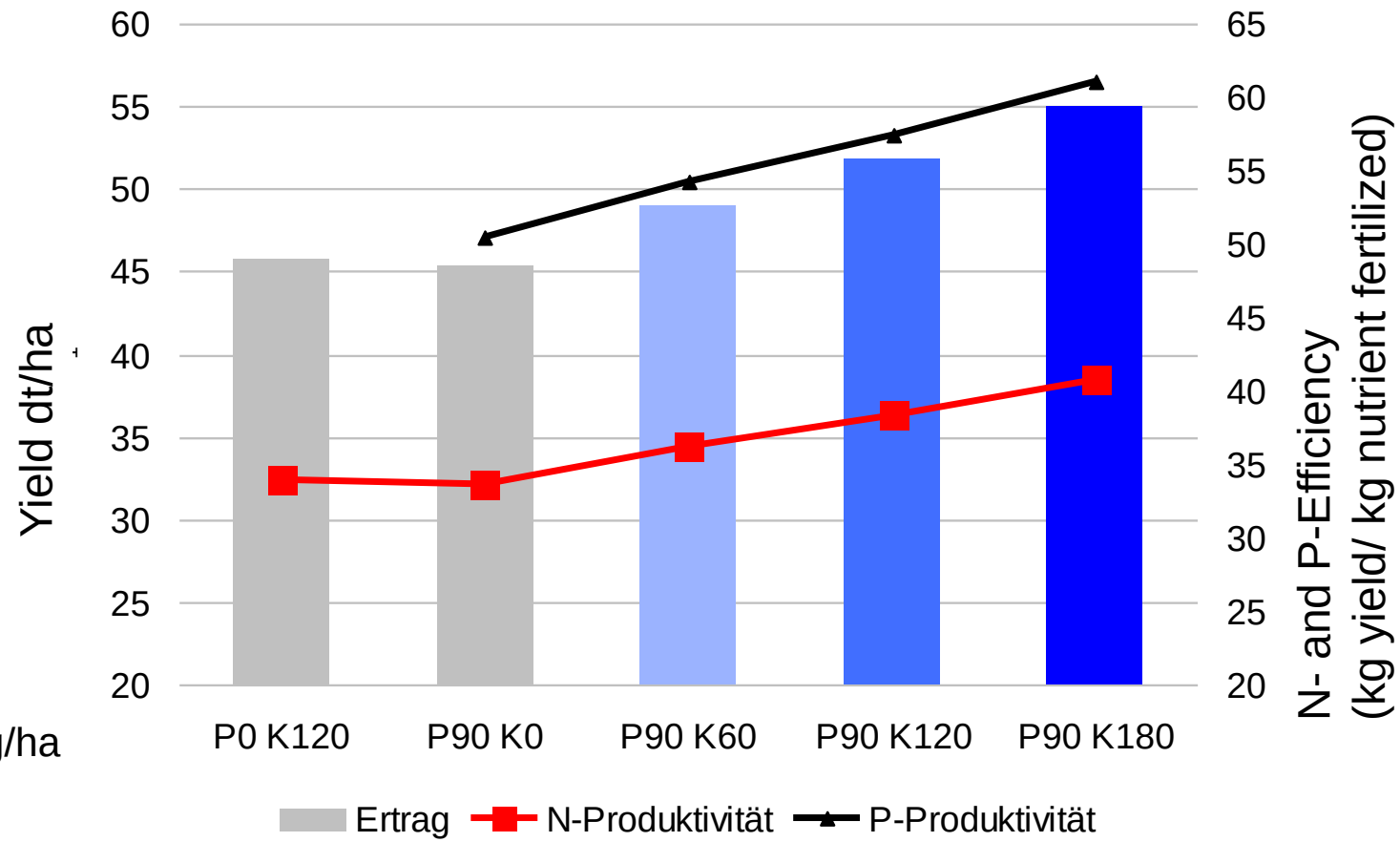
Site: Clarholz, Germany

Effect of an Increasing N- und K-Fertilization on Nitrogen Use Efficiency of Potatoes



Effect of Potassium on N and P Efficiency of sunflowers

Inner Mongolia, 2013

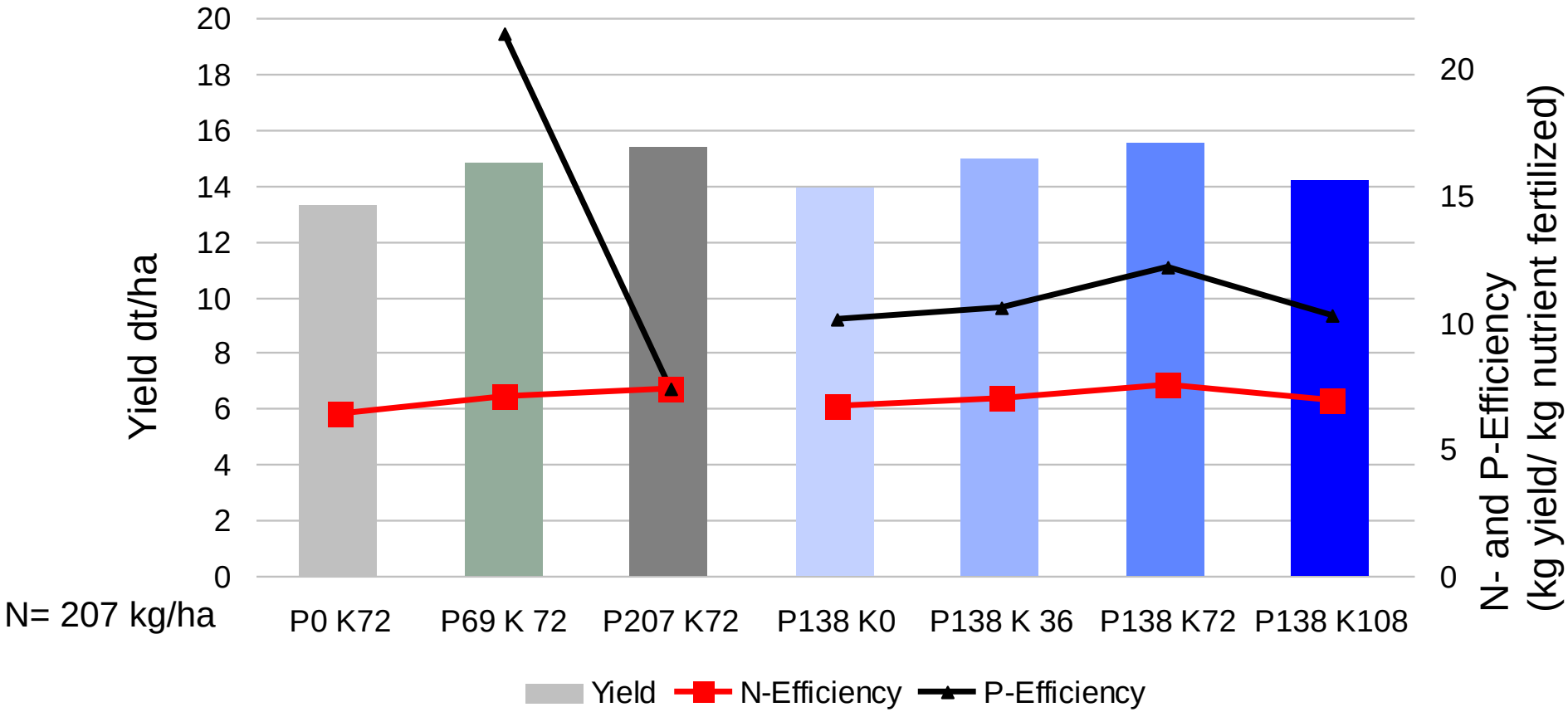


N= 235 kg/ha

Source: IPNI

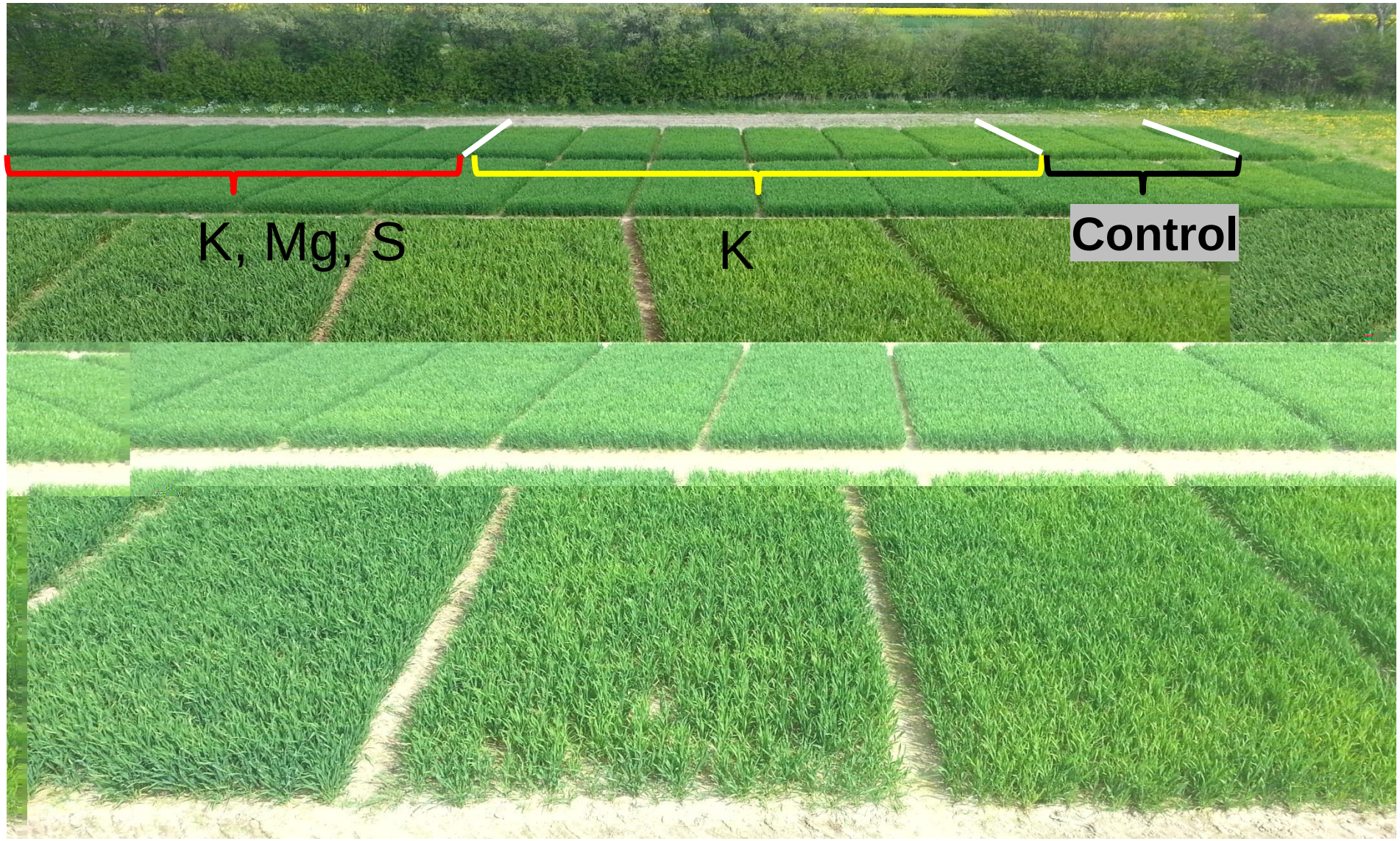
Effect of Potassium on N and P Efficiency of Cotton

Xinjiang, 2002



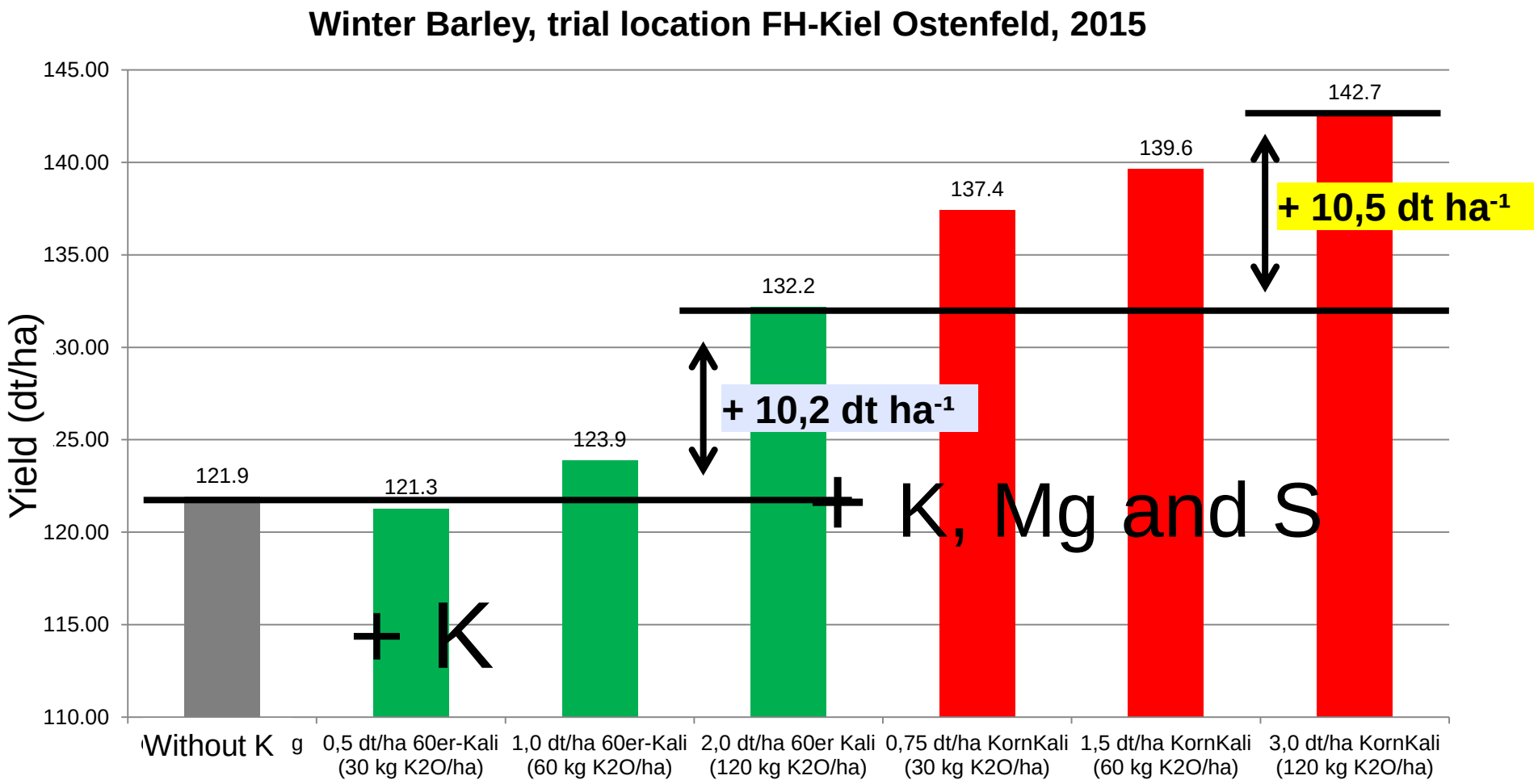
Source: IPNI

K Fertilization Field Trial, Winter Barley, Germany



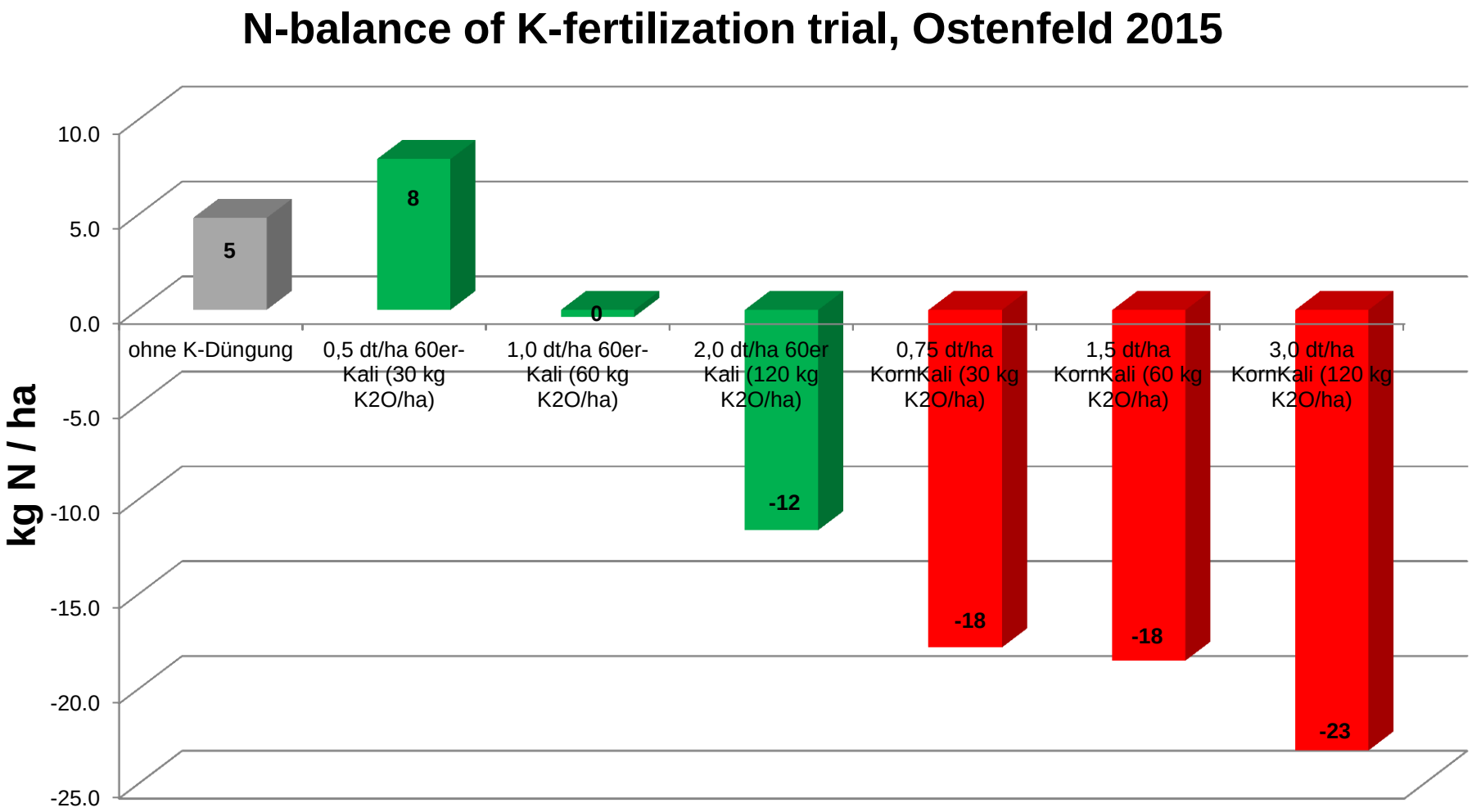
Field trial in Ostenfeld, Germany, 2015

K Fertilization Field Trial, Winter Barley, Germany



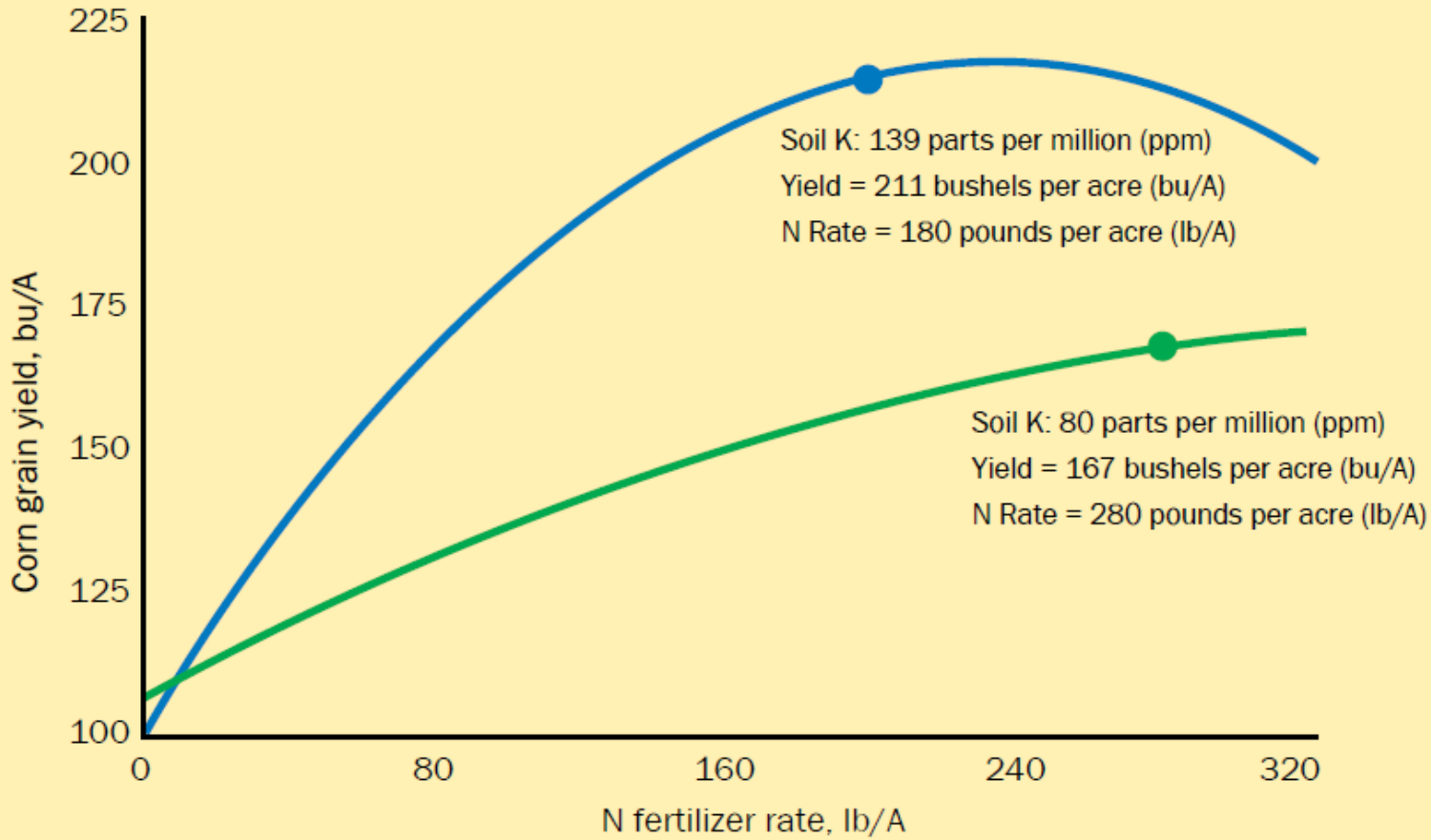
sL; pH: 6,1 (B); 24 mg P_2O_5 (C); 12 mg K_2O (B); 5,5 mg Mg (A);

N-Balance of the K Fertilization Trial



- Pre-crop: winter heat; crop: winter barley; cultivar: KWS Meridian
- Nmin: 31 kg N ha^{-1}; N-fertilisation: 190 kg N ha^{-1} → total: 221 kg N ha^{-1}

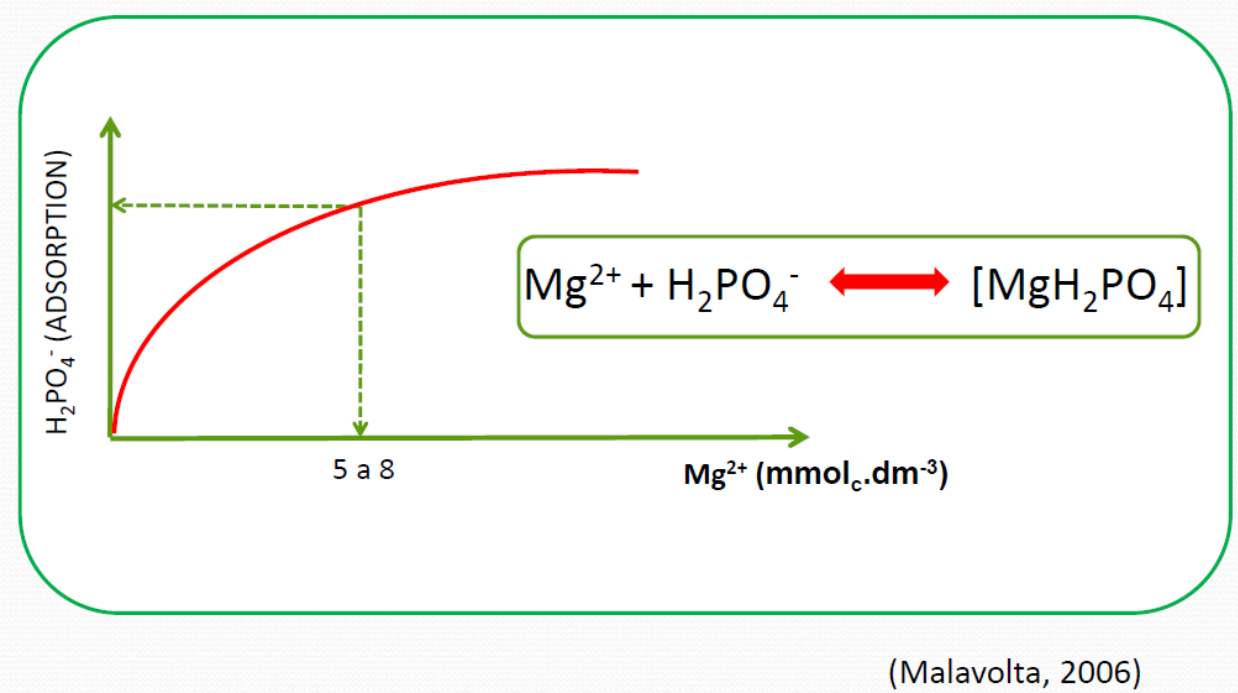
Effect of K on NUE of Corn



High yields of corn are obtained with less N fertilizer when other nutrients, such as K, are present in adequate concentrations. Balanced nutrition is key to improving yields and minimizing N fertilizer loss (Ohio, USA). Murrell and Munson. 1999. *Better Crops* 83 (3): 28-31.

Source: IPNI

Magnesium increases P-Uptake



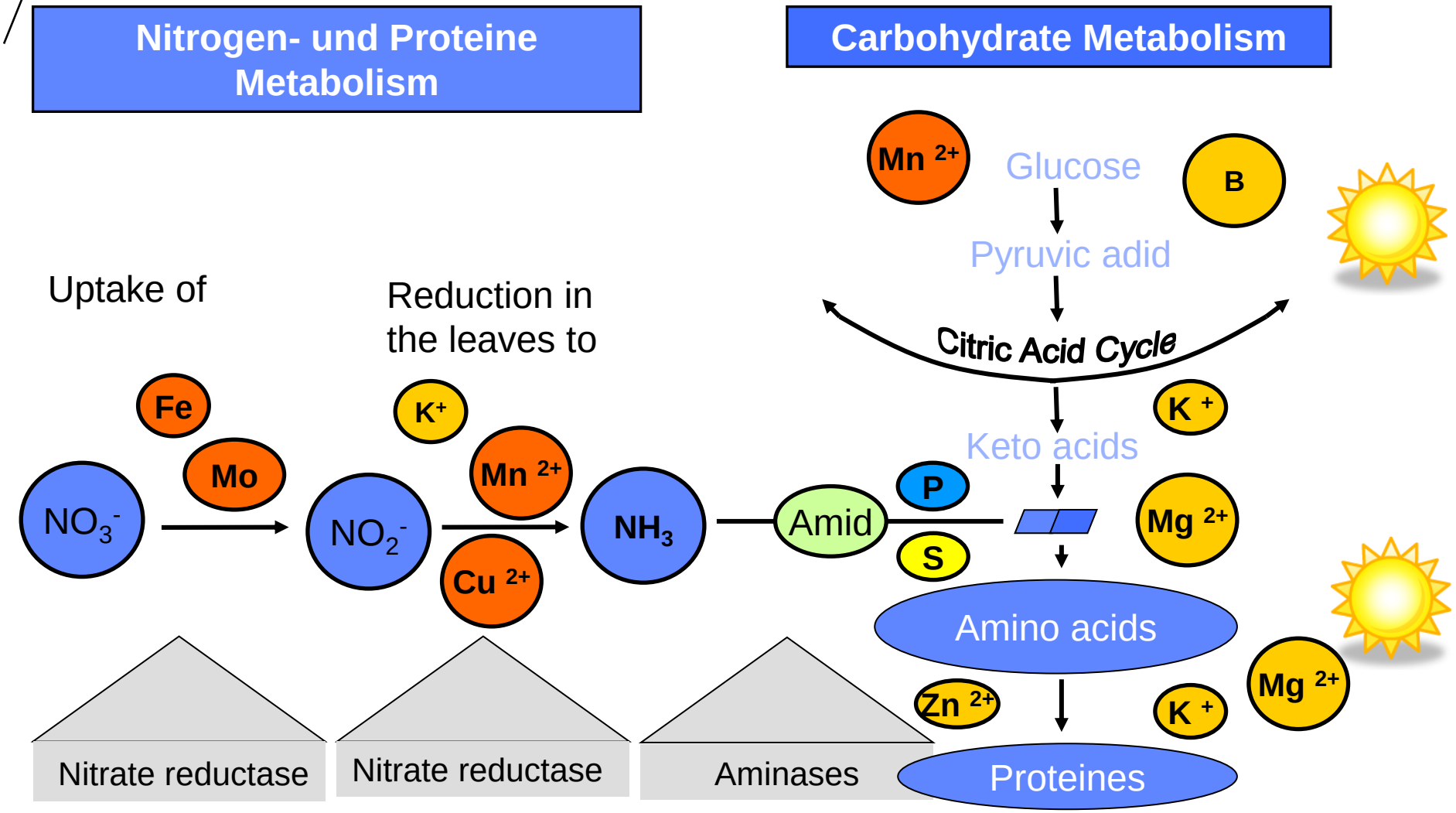
Magnesium is a P-Carrier

Mg-Dose (ppm)	P-Uptake (ppm)
0,0	70
2,0	120
5,0	150

Malavolta & Ponchio (1987)

OPTIMAL N-USE WITHIN THE PLANT

Uptake and Integration of Nitrogen in Amino Acids and Proteines



N.U. Agrar 2010

Influence of Potassium on Protein Metabolism during N Integration

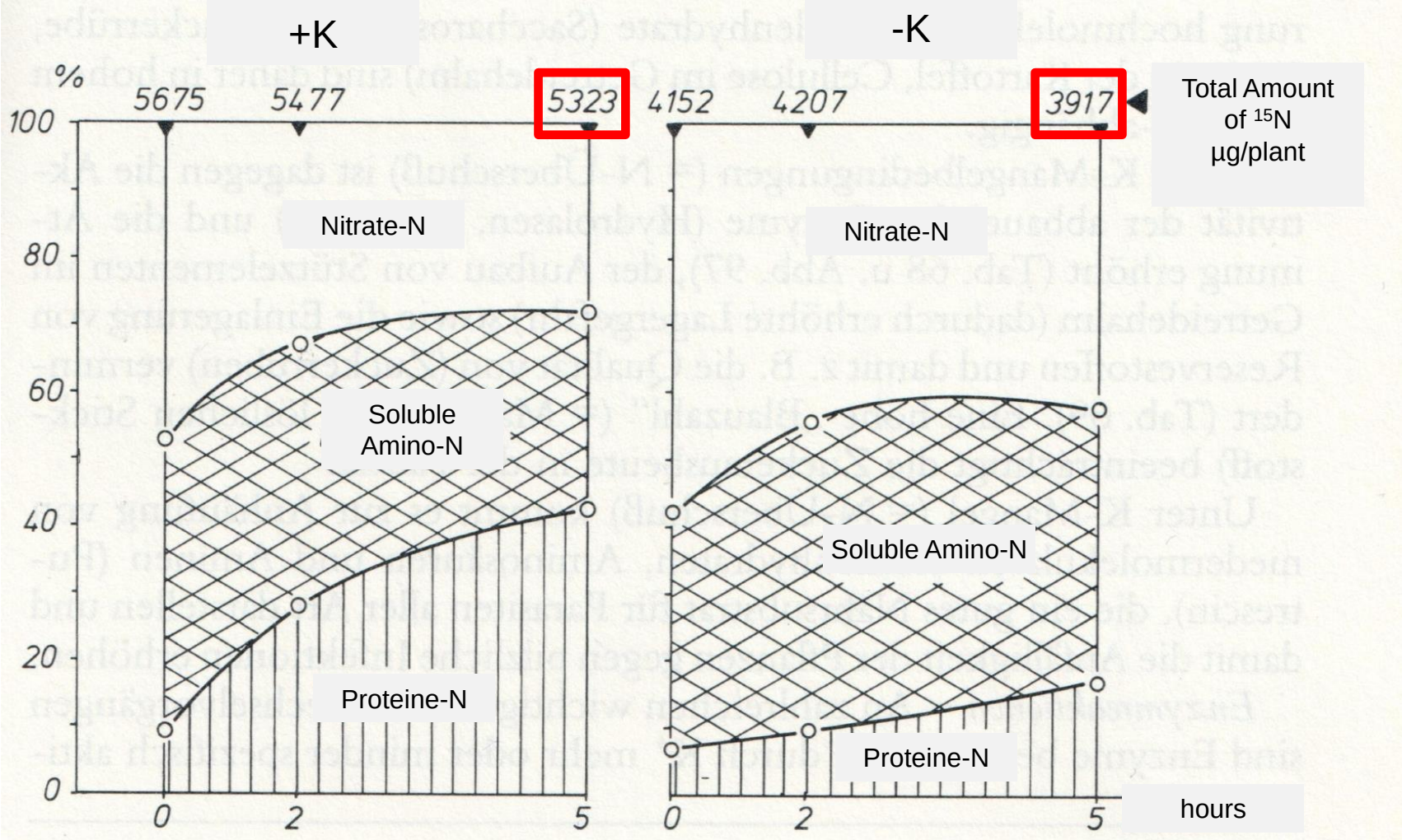
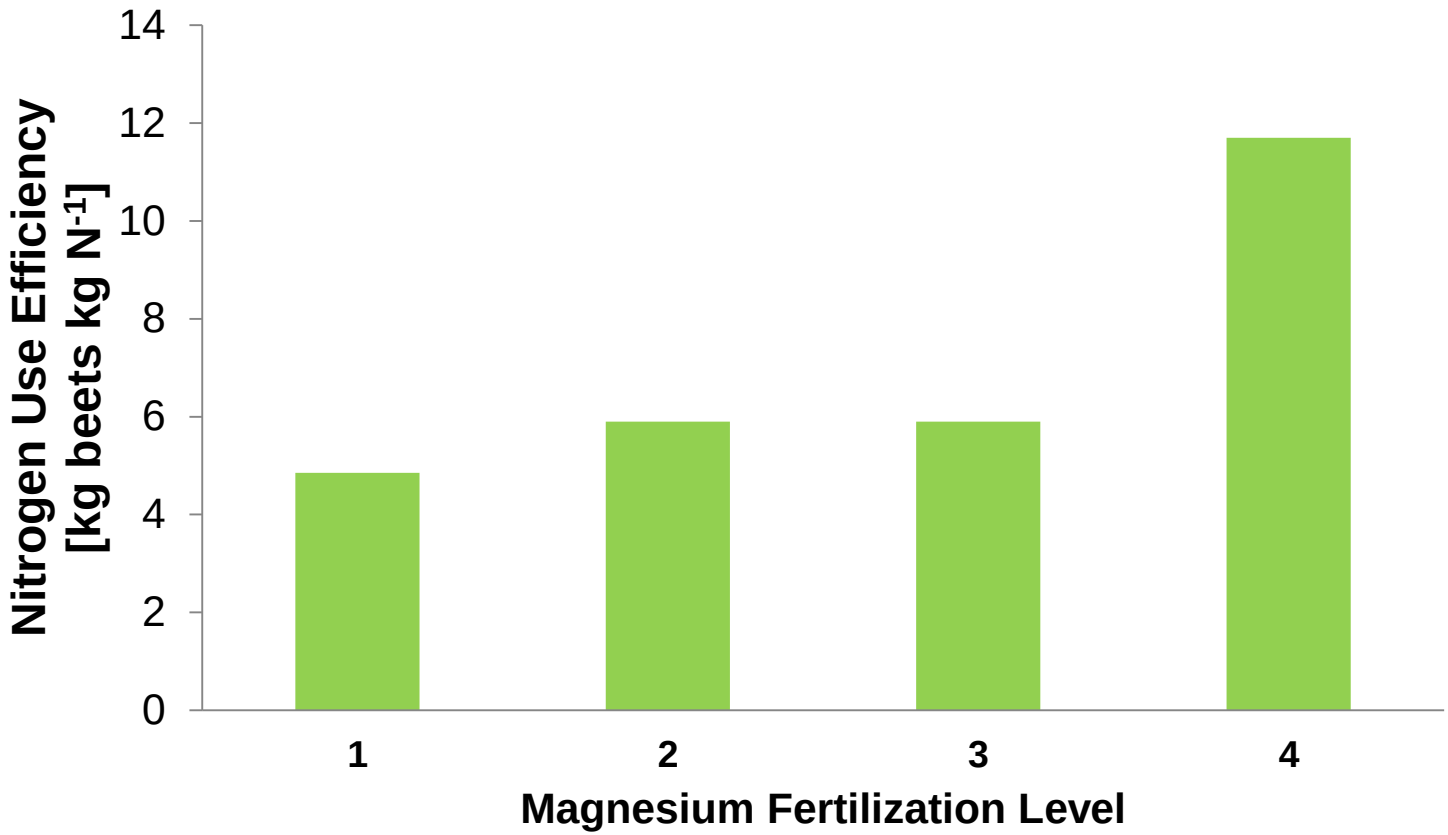


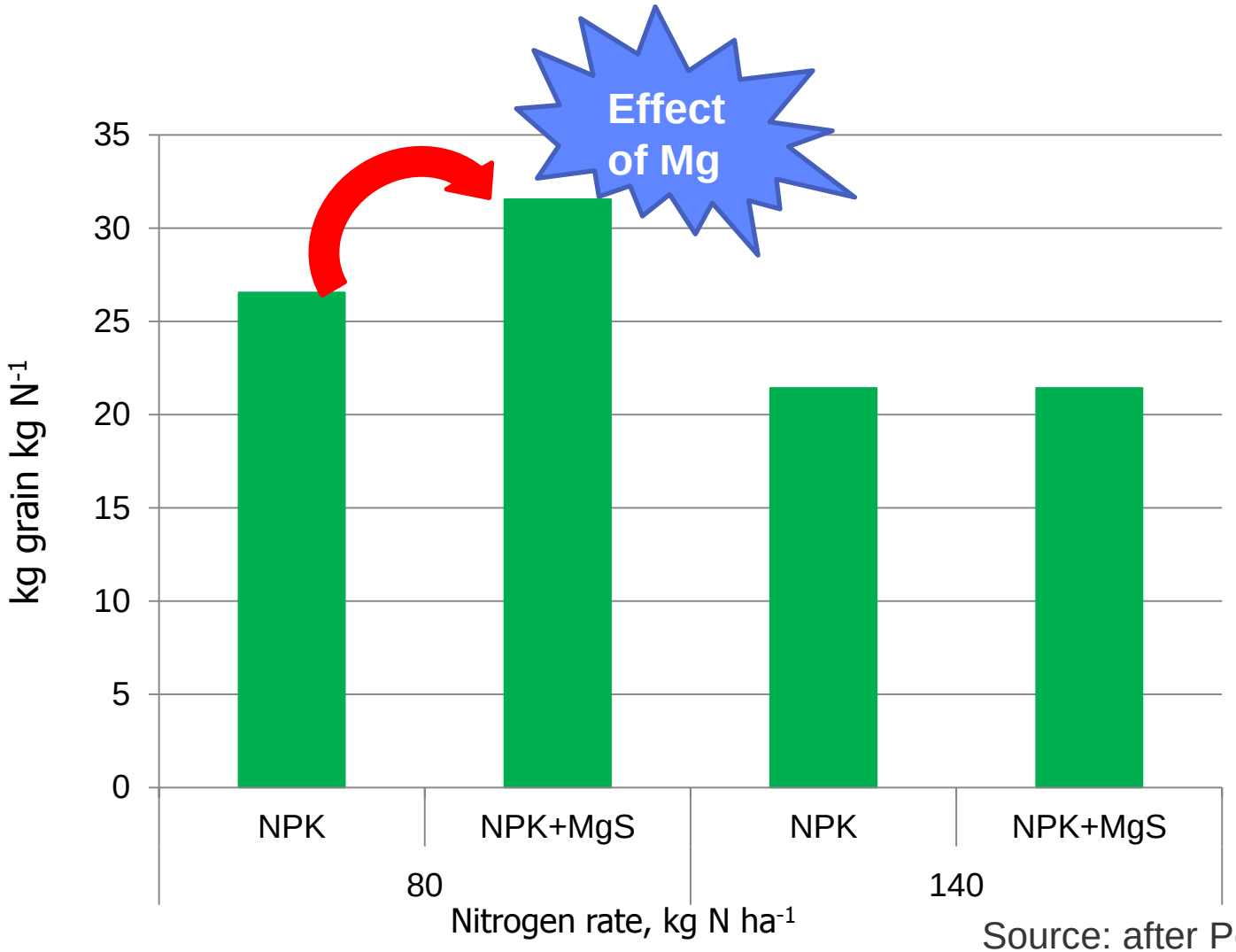
Abb. 96. Influence of Potassium on N Metabolism (after MENGEL and KOCH)

Magnesium Fertilization Increases Nitrogen Use Efficiency of Sugar Beets



Modified after Grzebisz et al., 2010

Effect of Magnesium on Nitrogen Use Efficiency of Maize at several Levels of N Fertilization



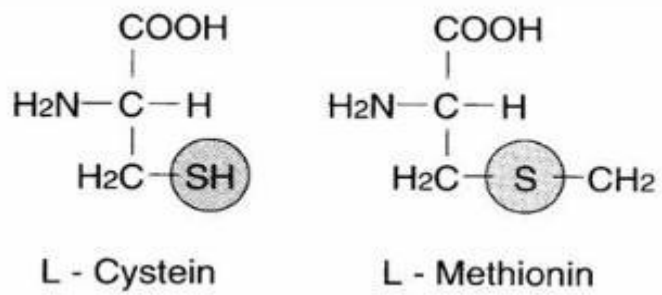
Source: after Potarzycki, 2010

Sulphur improves Nitrogen Efficiency during the Formation of Proteins

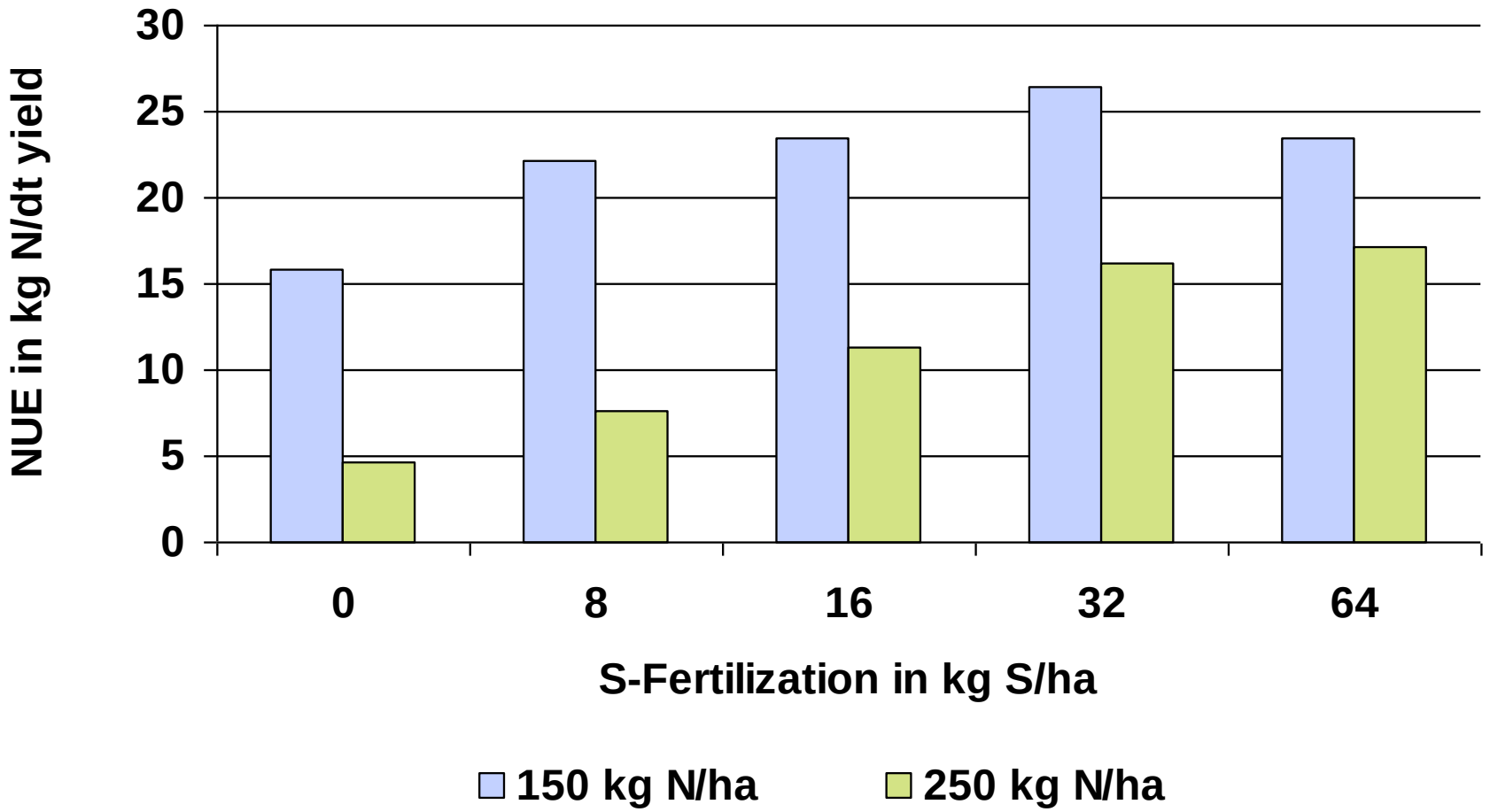
- Sulphur is important for the formation of proteins and sulphur-containing substances
- S-deficiency = N-Use-Efficiency within the plant is reduced
  → N-cycle of the plant is blocked
- N/S ratio becomes wider = Nitrate content increases, as S-containing amino acids are missing

Perfect Nitrogen/Sulphur Ratio
Stickstoff:Schwefelverhältnis: 5:1 – 12:1

$$NO_3^- \xrightarrow[\text{reductase}]{\text{Nitrate}} NO_2^- \xrightarrow[\text{reductase}]{\text{Nitrite}} NH_4^+$$

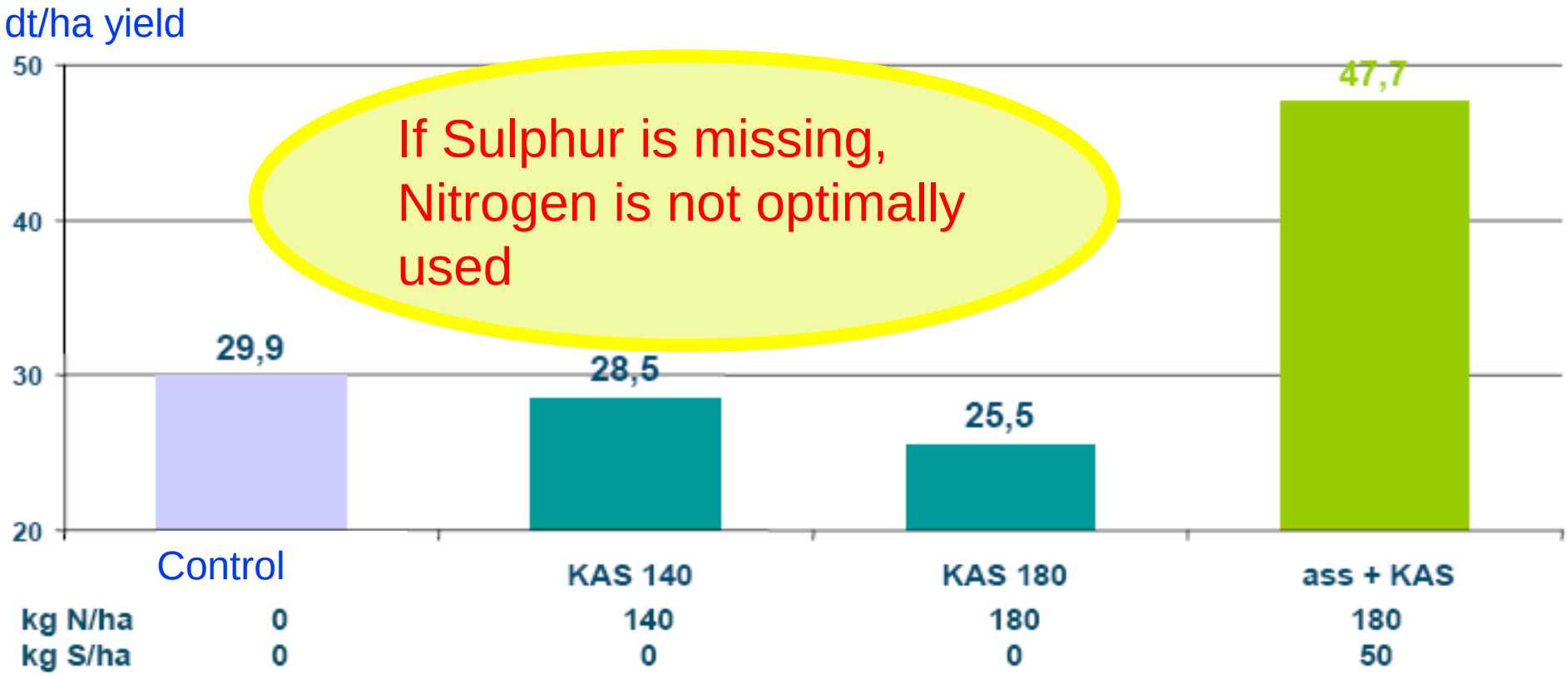


Influence of S-Fertilization on N Use Efficiency of Winter Wheat in a Field Trial



Source: Walker und Booth (1994)

N and S Interactions in Canola

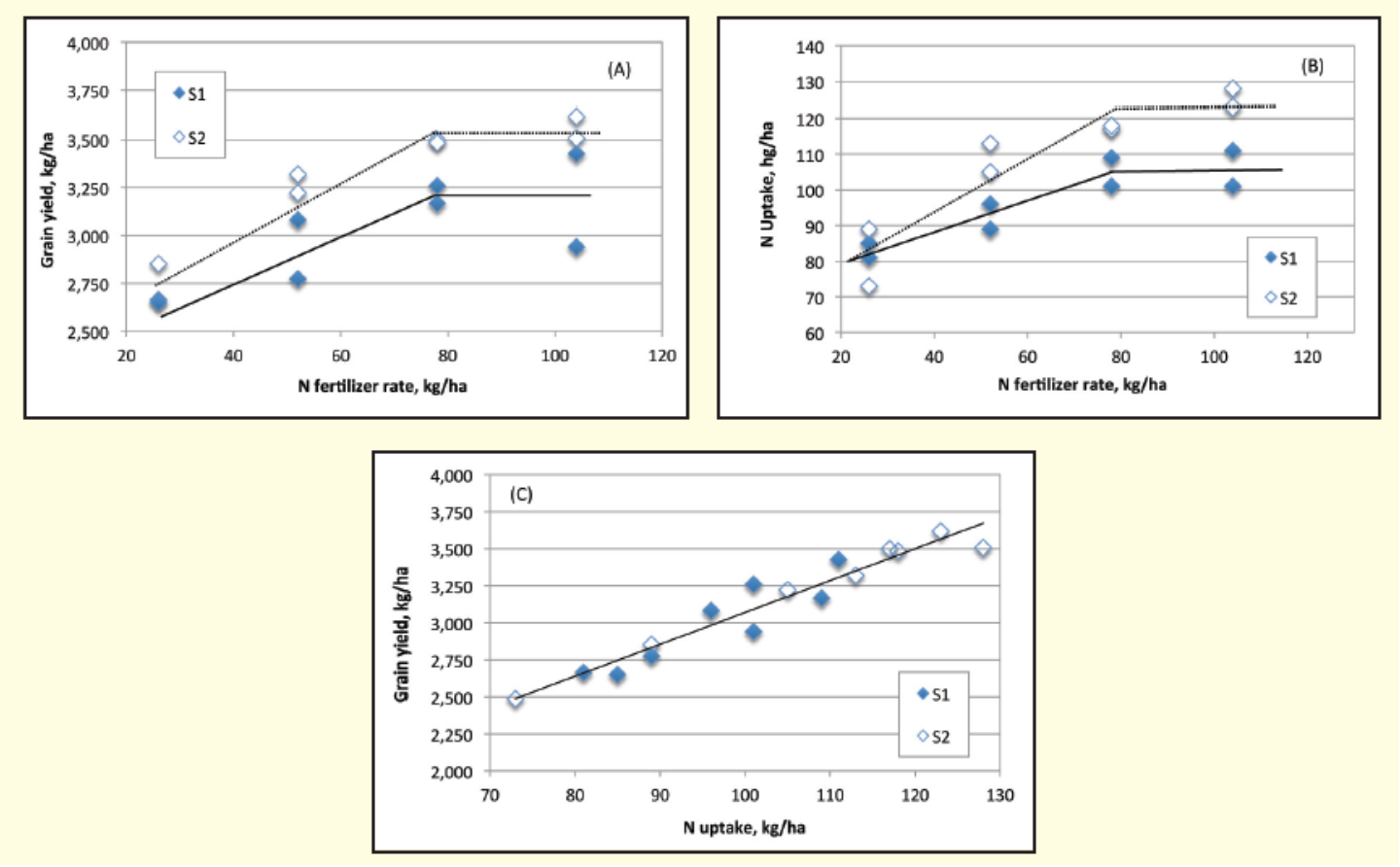


➔ **Sulphur is the yield-limiting nutrient**

➔ **Additional Nitrogen remains useless in case of S Deficiency**

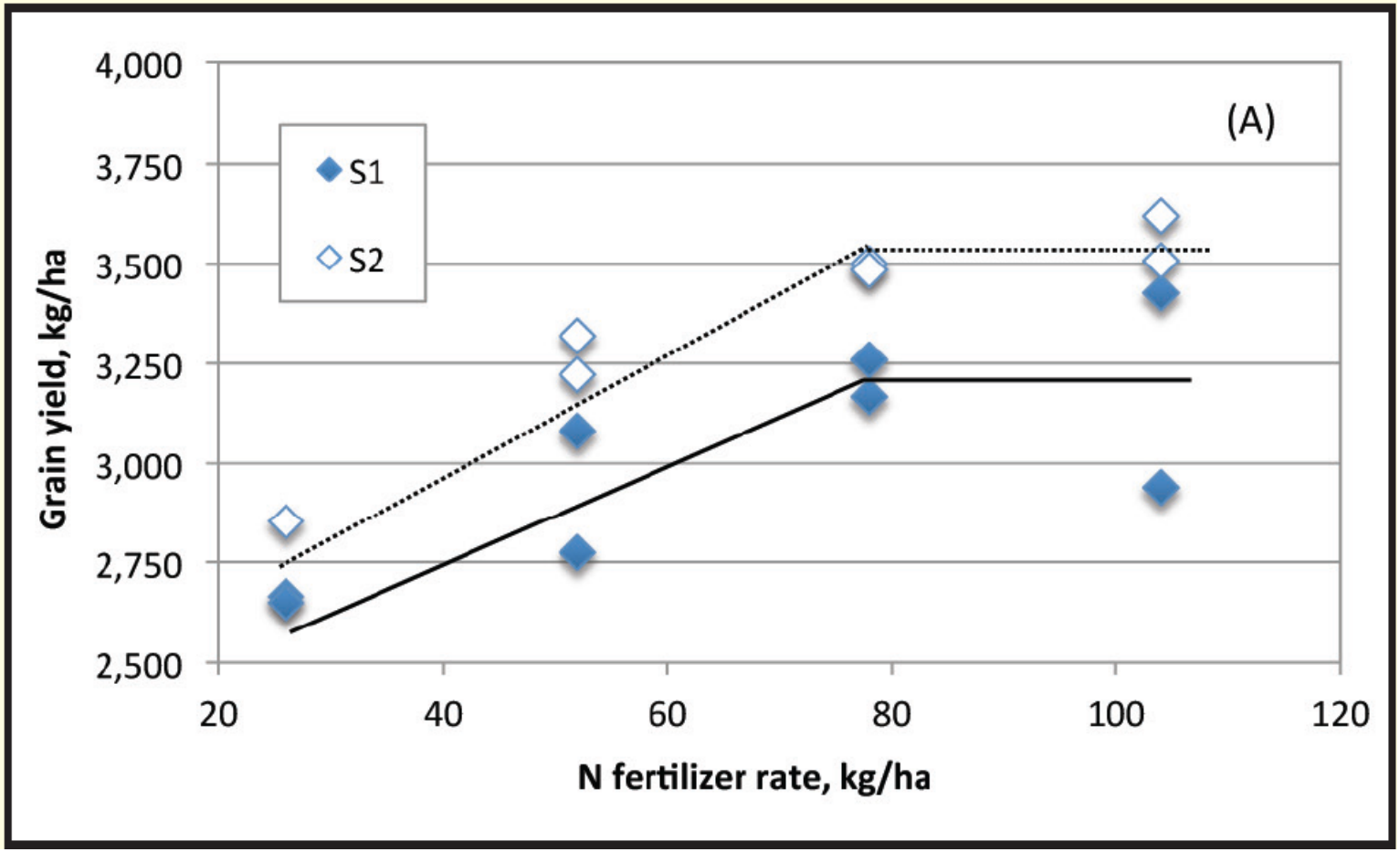
3 Versuche BASF

Fertilization with sulfur improves nitrogen use efficiency of wheat in Argentina



Salvagiotti et al. (2009). Taken from F. Garcia, IPNI, Argentina, 2013.

Fertilization with sulfur improves nitrogen use efficiency of wheat in Argentina



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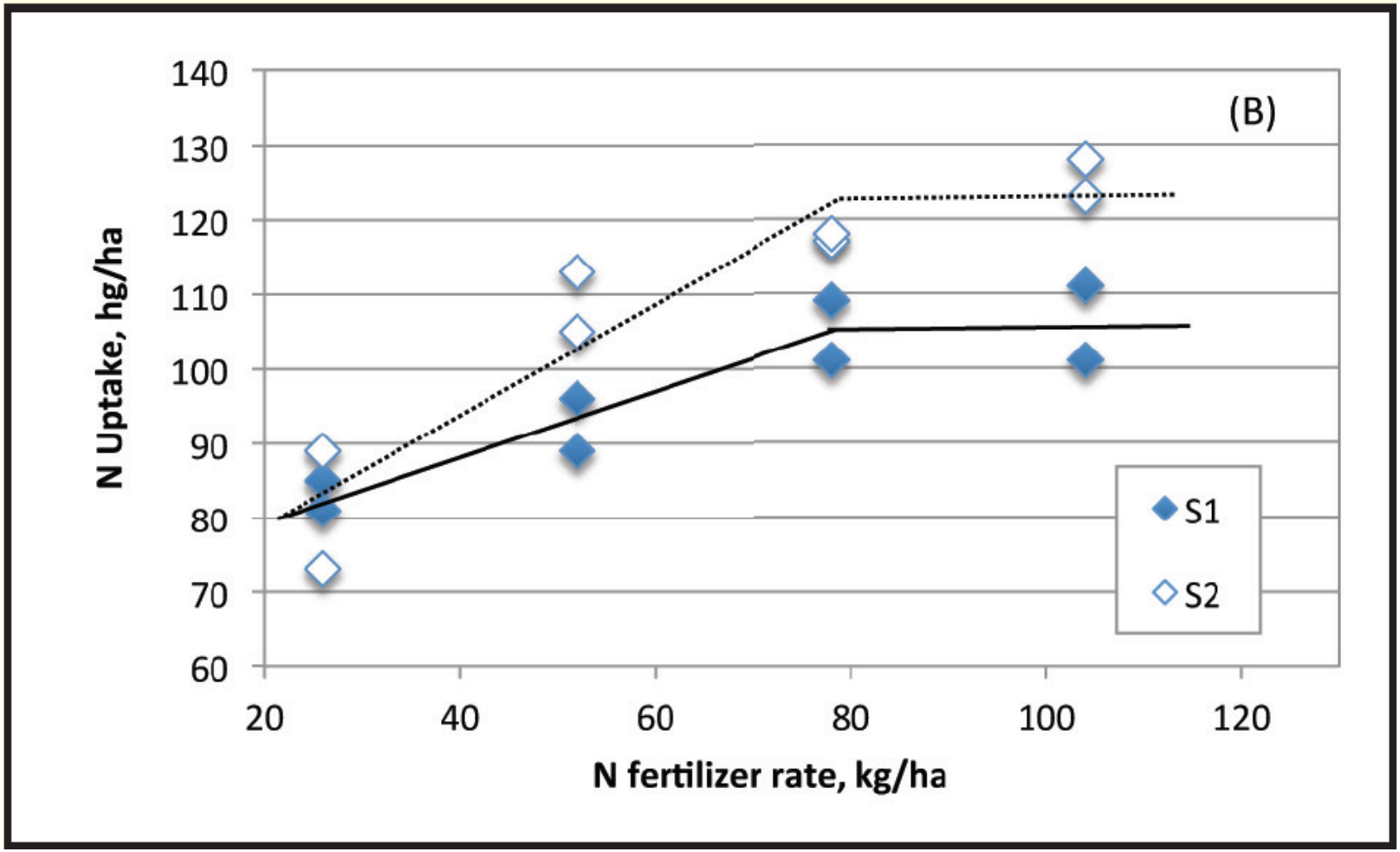

Salvagiotti et al. (2009). Taken from F. Garcia, IPNI, Argentina, 2013.

Conclusion

- **For ecological, economical and legal reasons a maximum efficiency of N and P fertilizer becomes more and more important.**
- For a high N and P efficiency the balanced plant nutrition with other nutrients such as K, Mg and S needs to be secured.
- K, Mg and S have an influence on physiological processes of N use within the plants and thus on N-Use-Efficiency.
- For a maximum N uptake from the soil, K-/Mg-ratio needs to be considered so that ammonium fertilizer can be used by the plant.
- Mg promotes root growth and Mg has a positive influence on uptake of N and P and its efficiency.

THANK YOU