Magnesium in Root Growth and Seed Formation

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Major Physiological Functions of Mg in Plants

- **Photosynthesis**
- **Partitioning of Photoassimilates**
- ***Root Growth and Seed Formation***
- **Mitigation of Stress**
- **….**

Productivity of plants is greatly affected by

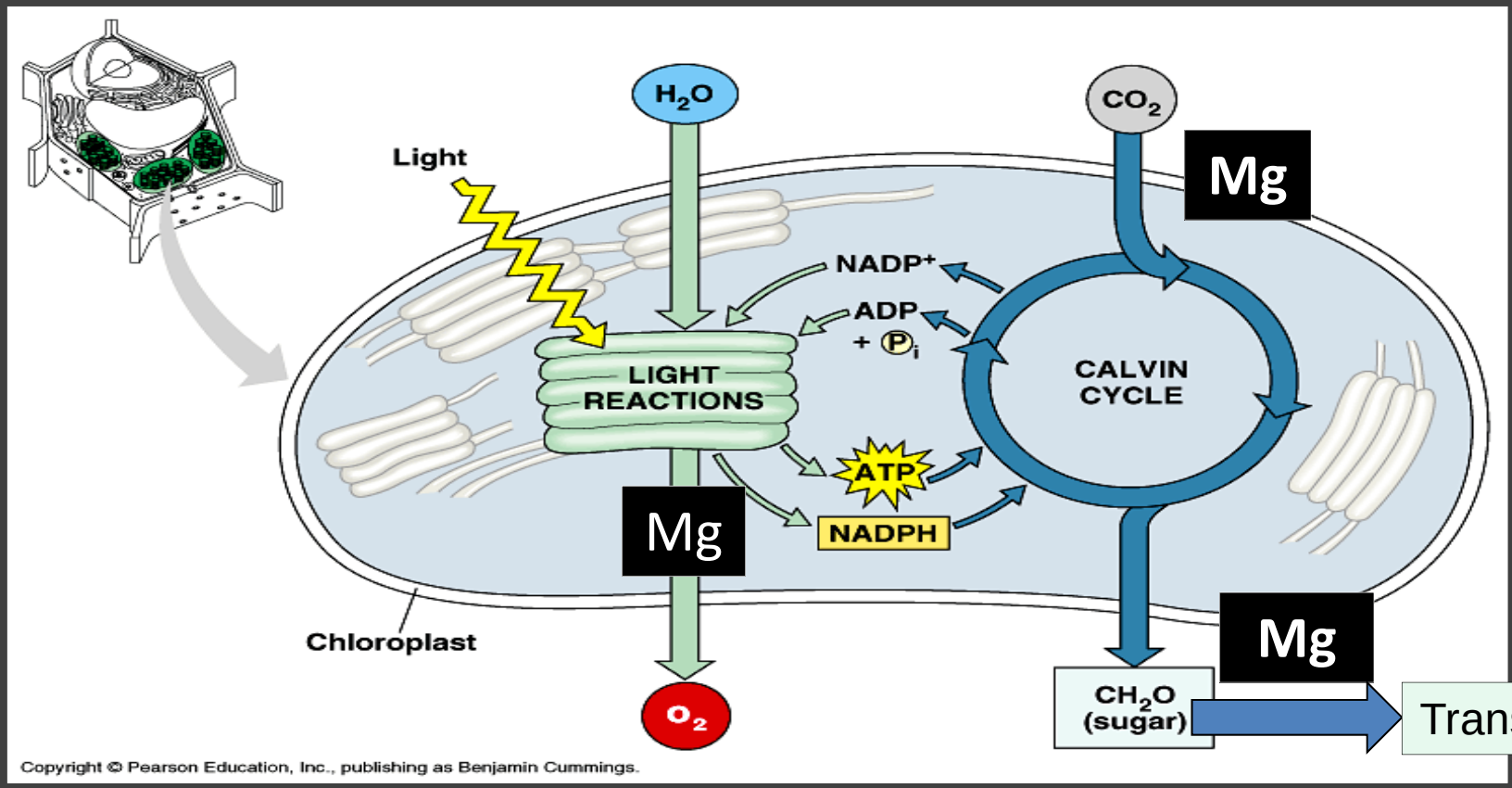
i) the capacity of plants to fix atmospheric carbon into organic carbon through photosynthesis,

ii) translocation of the assimilated carbon from source into sink organs, and

iii) utilization of assimilated carbon in the sink organs for growth

All these steps are substantialy influenced by the mineral nutritional status of plants, especially Mg

Mg in Photosynthesis

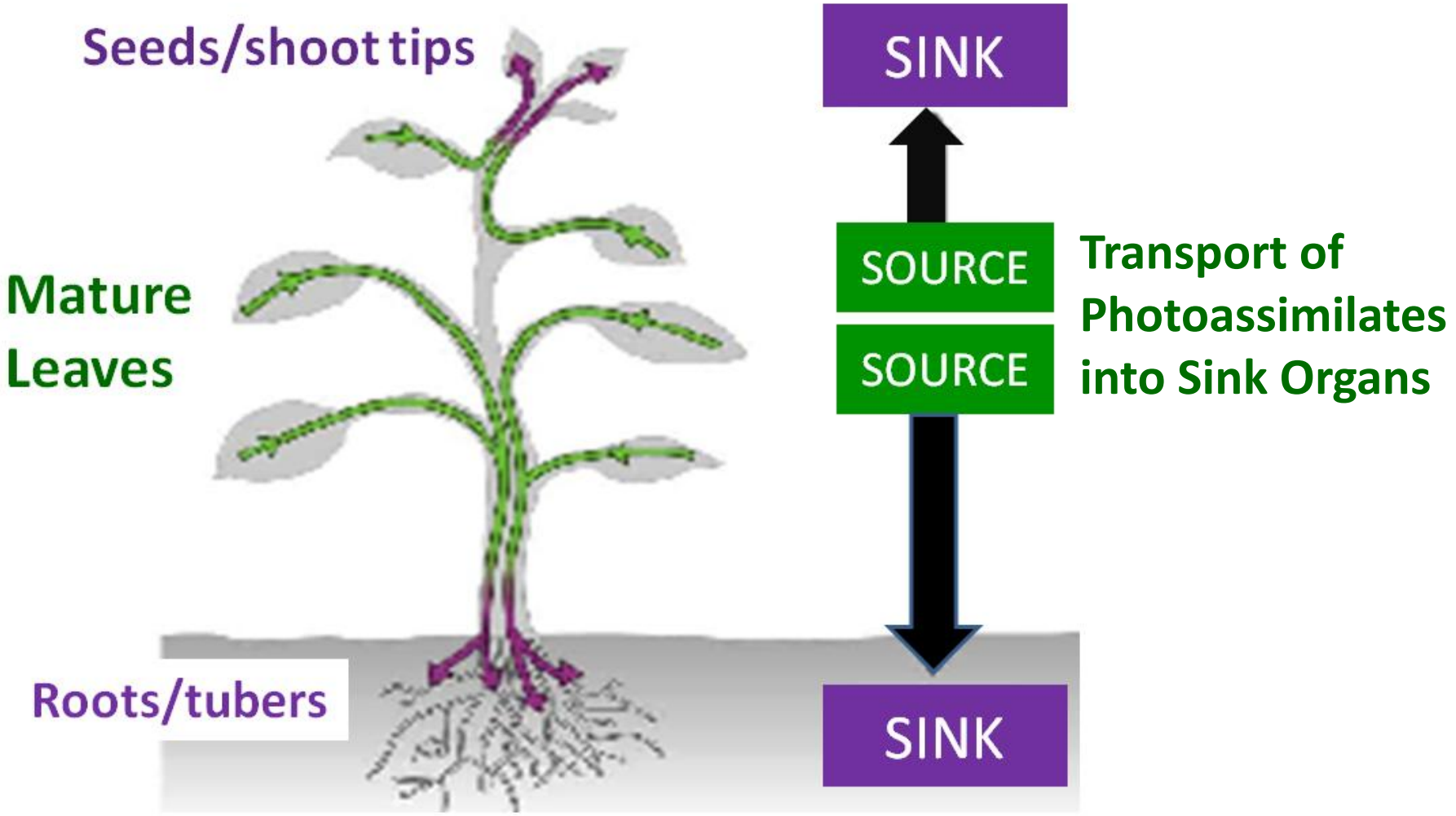


Mg affects i) production of ATP and reducing equivalents during the photosynthesis, ii) activity of the enzymes required for fixation of CO2 and iii) transportation of assimilates.

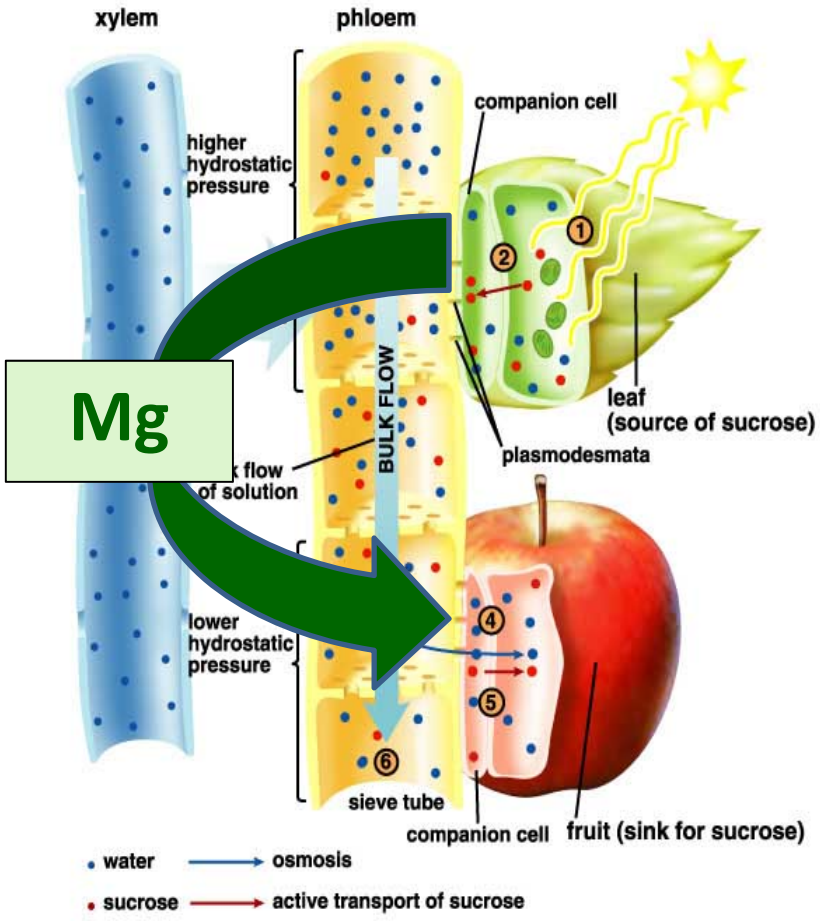
Marschner, 2012

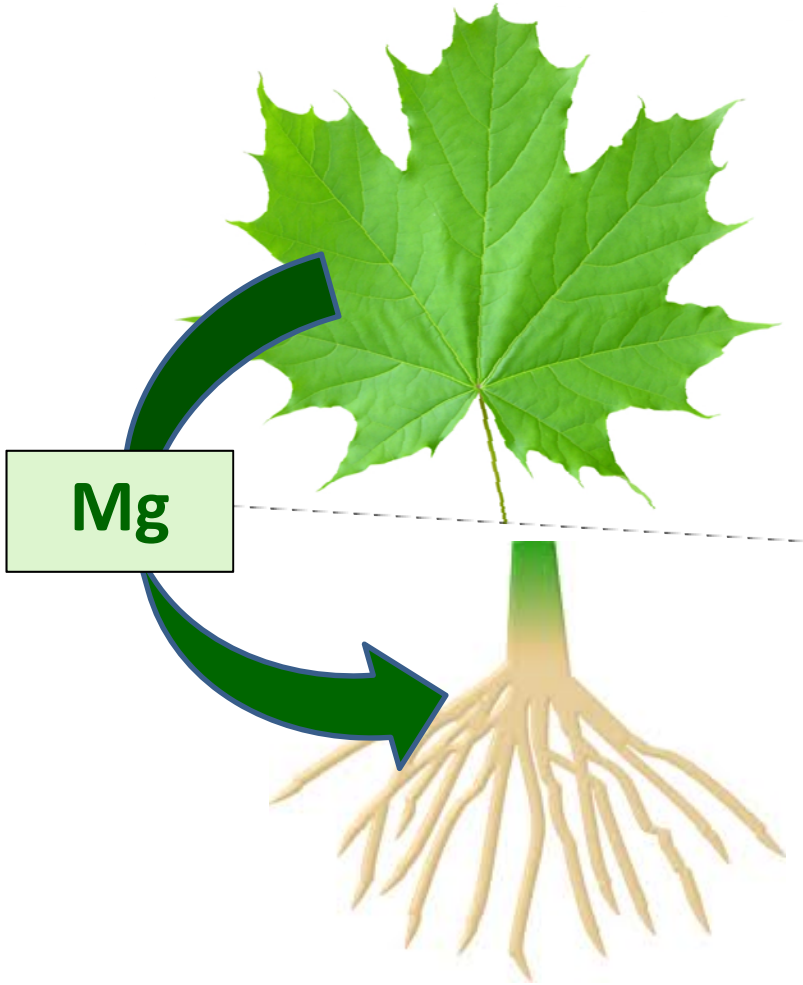
Transport of photoassimilates from **source organs** into **sink organs**

Source organs (e.g., mature levaves) deliver sugars into actively growing parts (e.g., **sink organs**) of plants such as seeds, roots, flowers...)

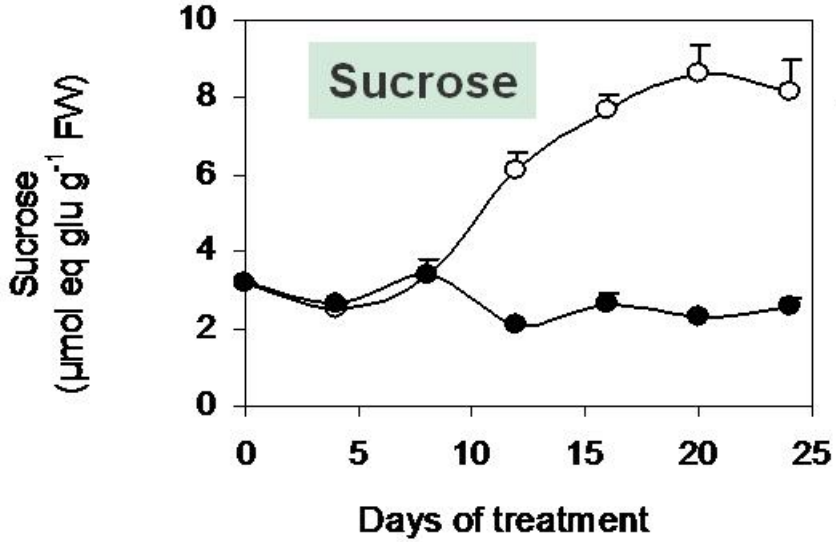


Mg is Required for Sugar Transport from Source Leaves into Sink Organs (roots, seeds, fruits…)





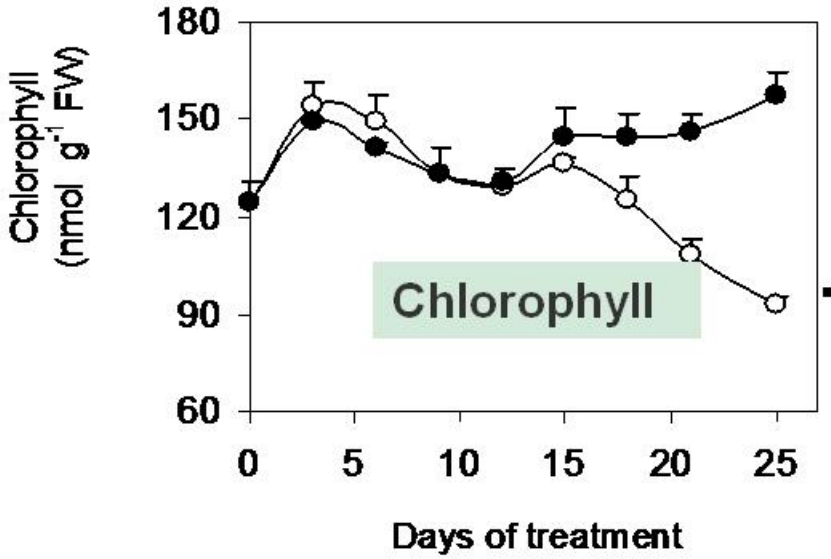
Changes in leaf concentration of chlorophyll and sucrose during Mg deficiency stress



→ Low Mg

→ Adequate Mg

Sugar beet plants

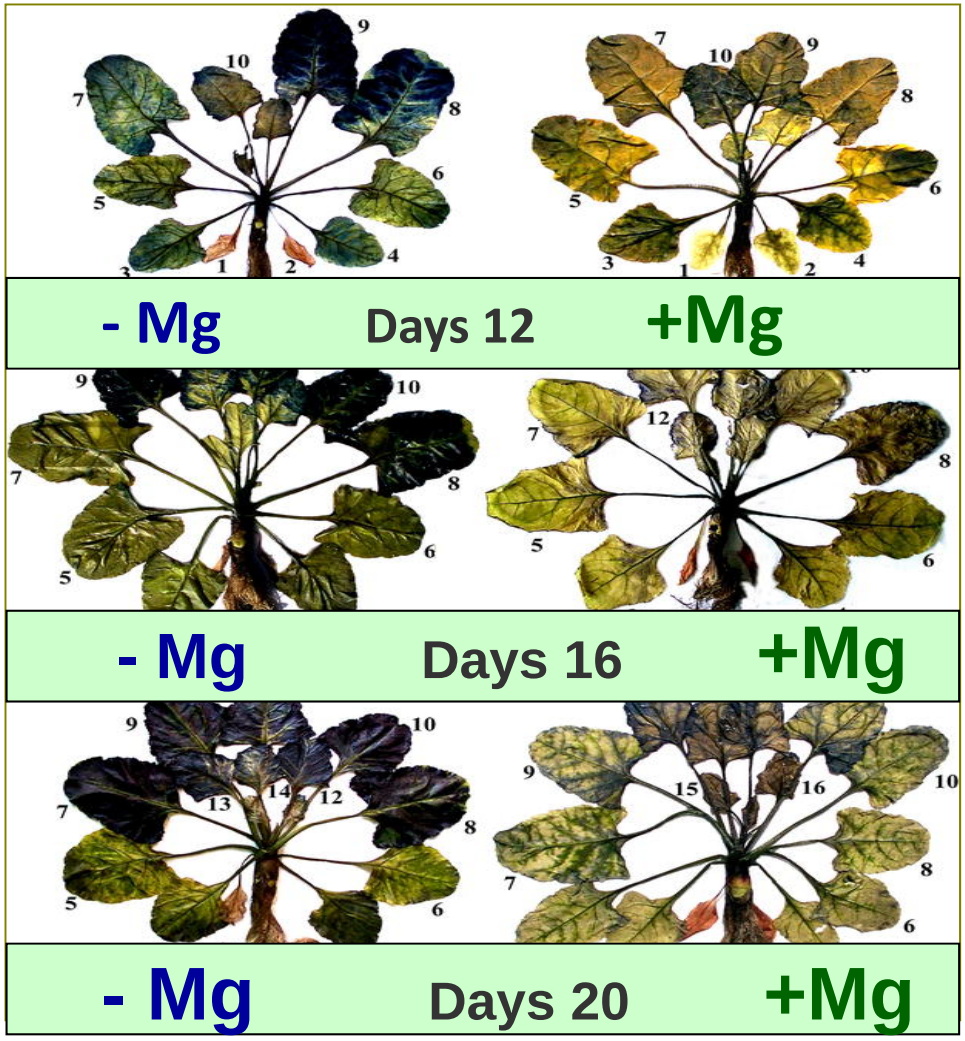


→ Adequate Mg

→ Low Mg

Hermans et al., 2004 Planta

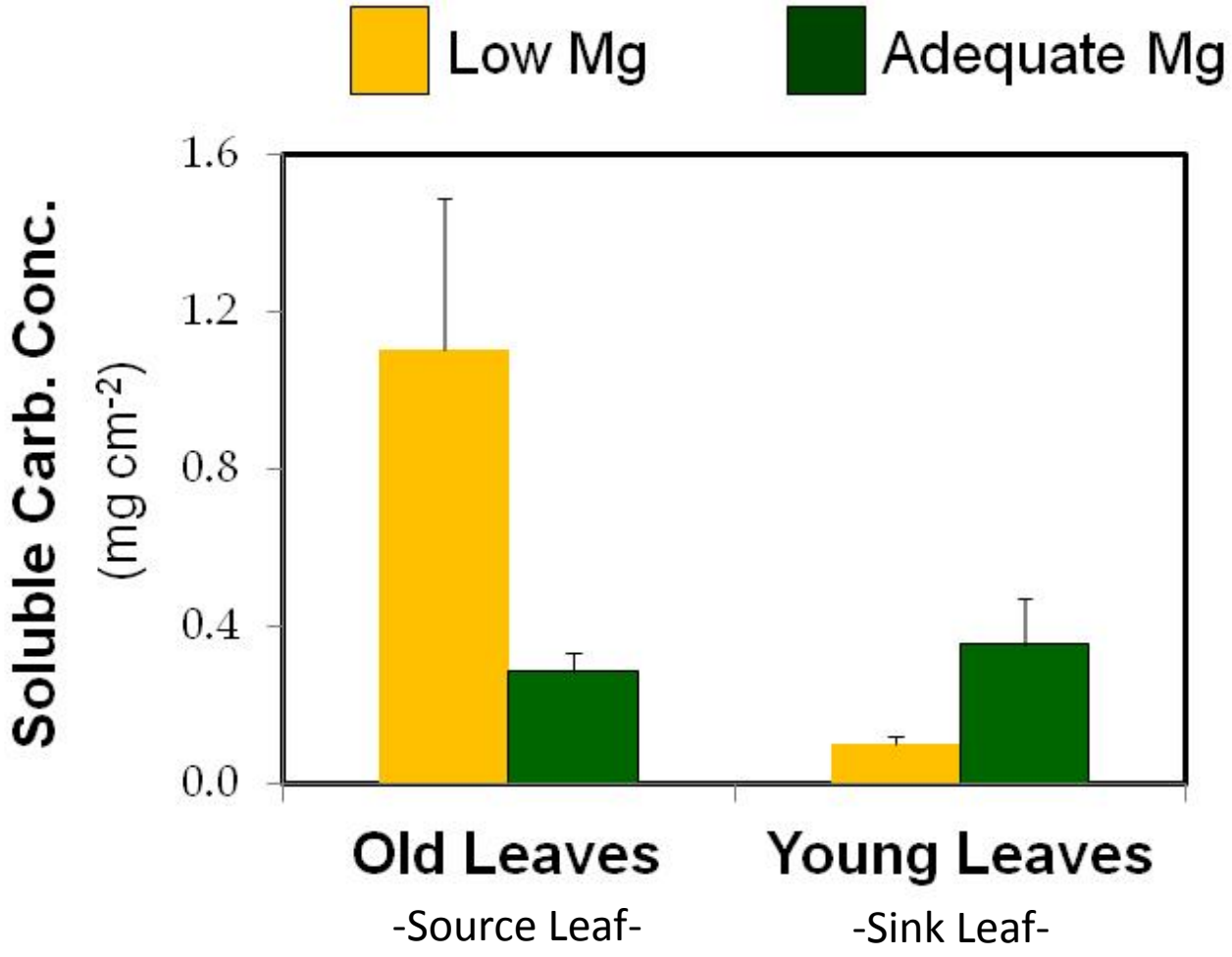
Effect of Mg deficiency on starch content in sugar beet leaves, as detected by lugol staining



Before any noticeable change in shoot growth happens, photoassimilates accumulate in Mg-deficient leaves

Hermans et al., 2005 Planta 220: 541-549

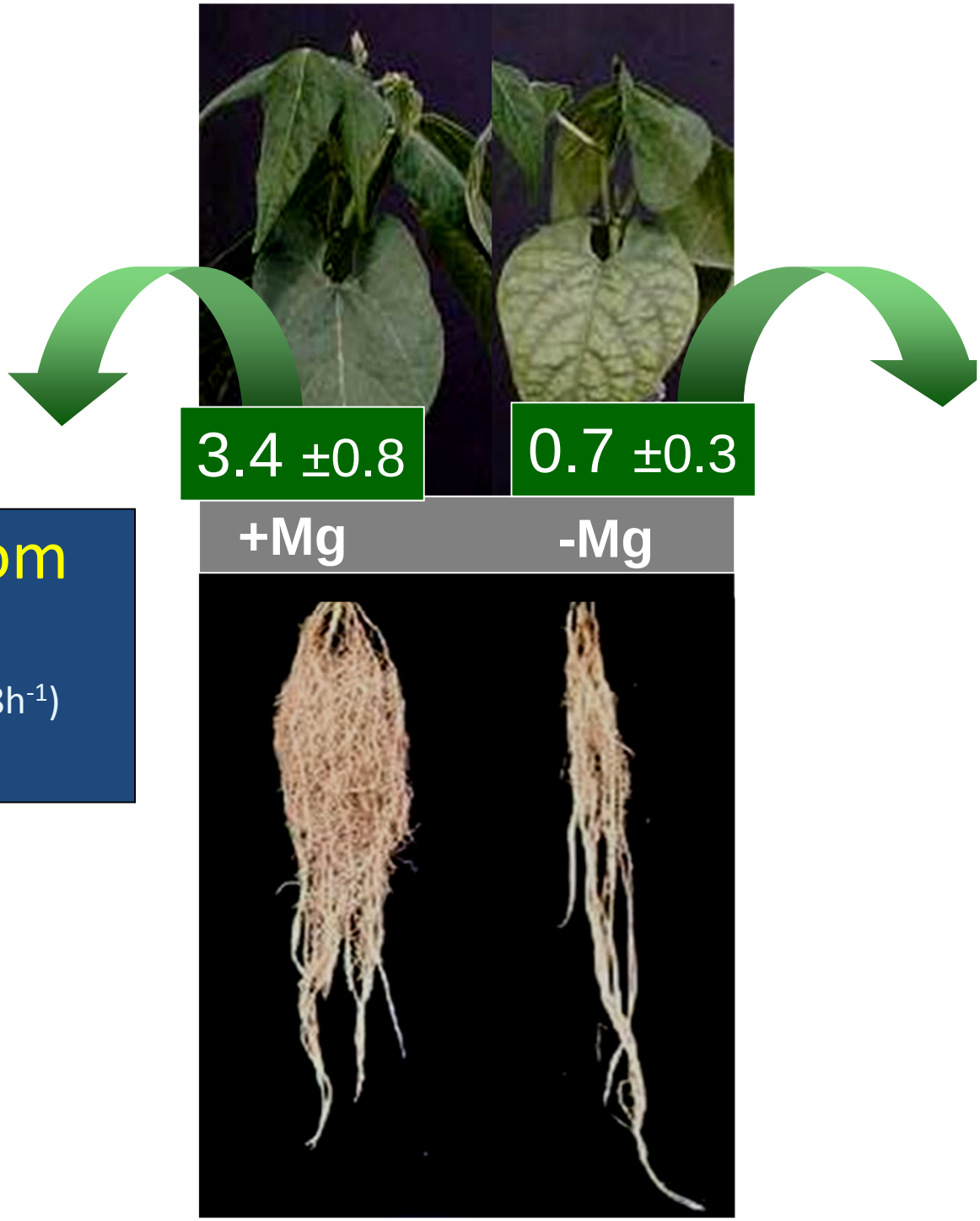
Soluble Carbohydrate Concentrations (mg cm^{-2}) of Old and Young Maize Leaves



Mengutay et al, 2013, Plant and Soil

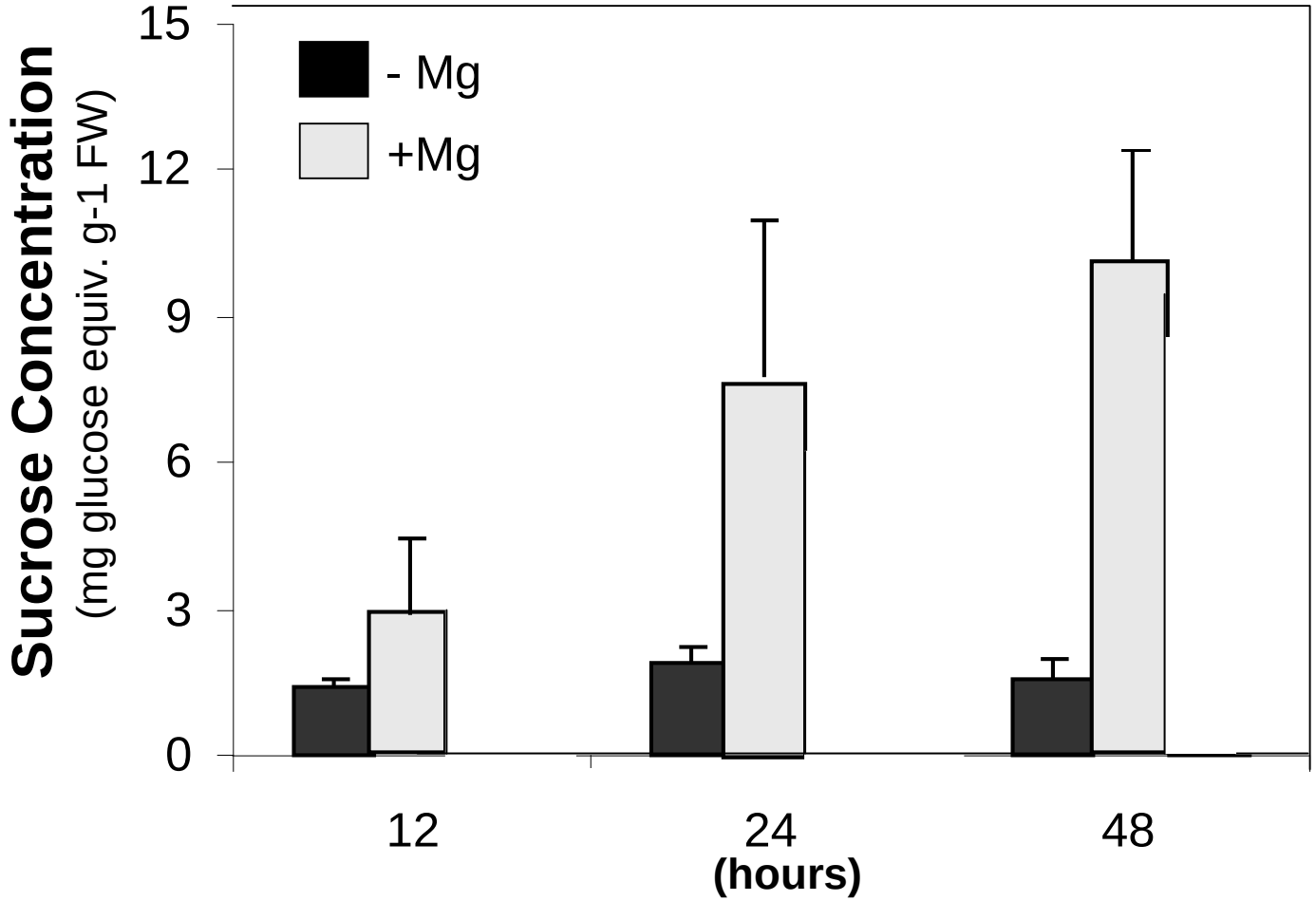
Sucrose export from Leaves

(mg Glucose equiv . g-1 DW . $8h^{-1}$)



Cakmak et al., 1994b J. Exp Bot.

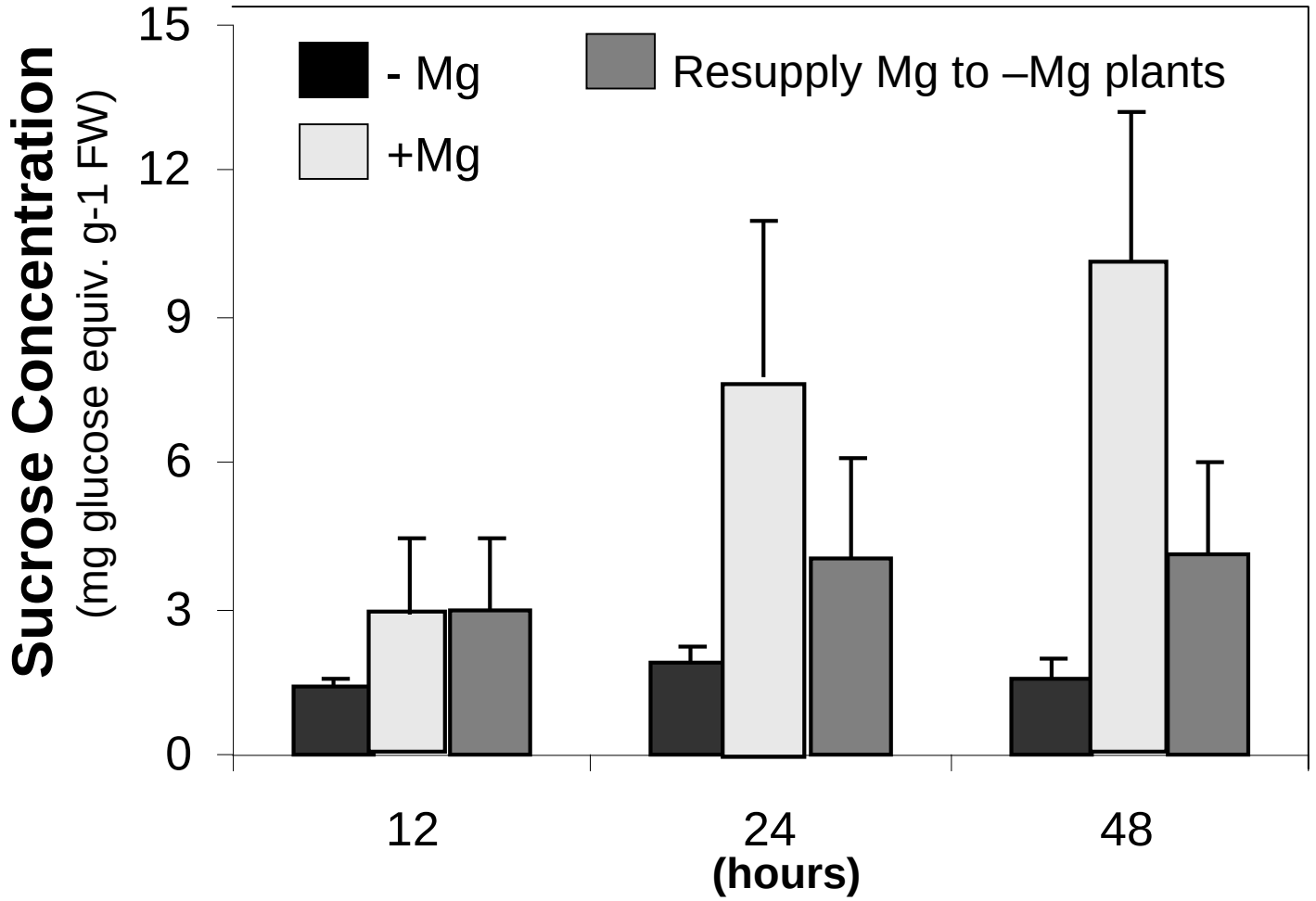
Phloem transport of sucrose dependig on Mg treatments



Time for the collection of phloem exudates

Cakmak et al., 1994a J. Exp Bot.

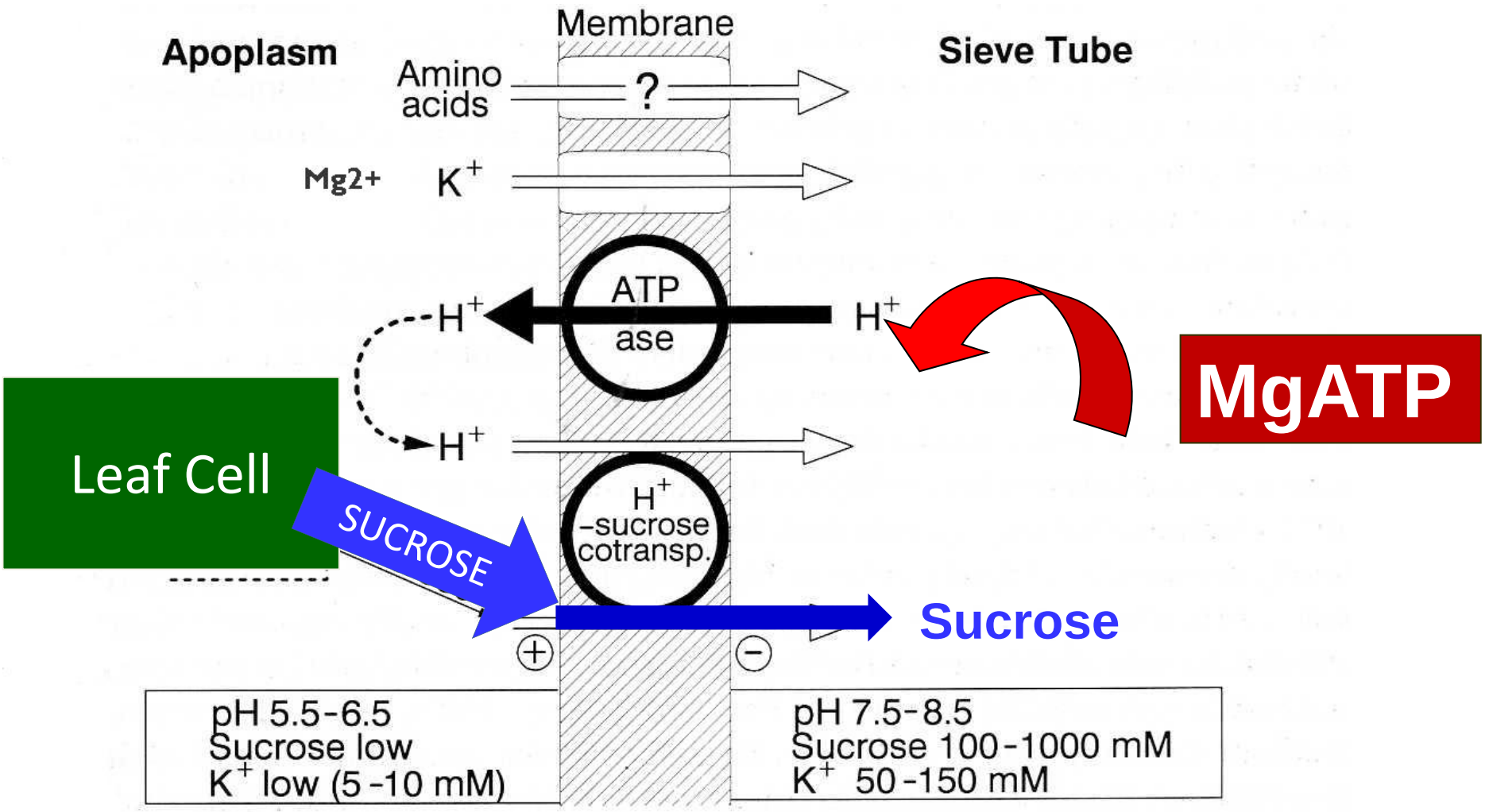
Phloem transport of sucrose dependig on various Mg treatments



Time for the collection of phloem exudates

Cakmak et al., 1994a J. Exp Bot.

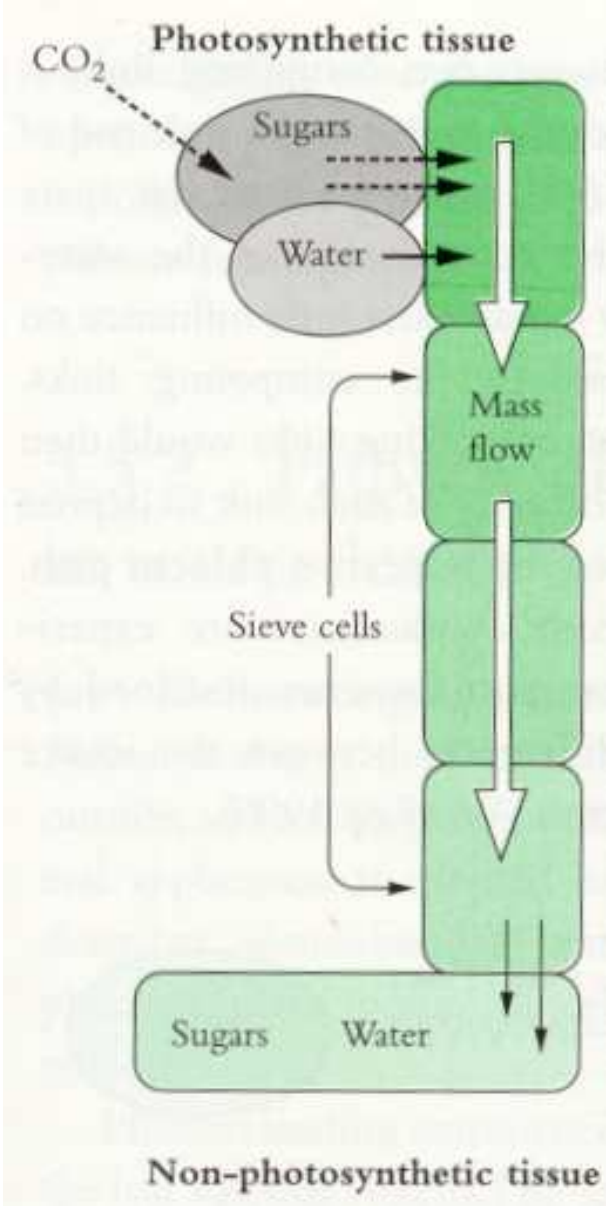
Mg plays a key role in phloem loading of carbohydrates



White, 2012 in: Marschner's Mineral Nutrition of Higher Plants

In acidic and sandy soils, foliar application of Mg fertilizers could be important due to high leaching of Mg from soil profile and subsoil-acidity problem, *particularly during the reproductive growth stage*

Consequences for Growth and Yield



Transport of Photoassimilates

Source

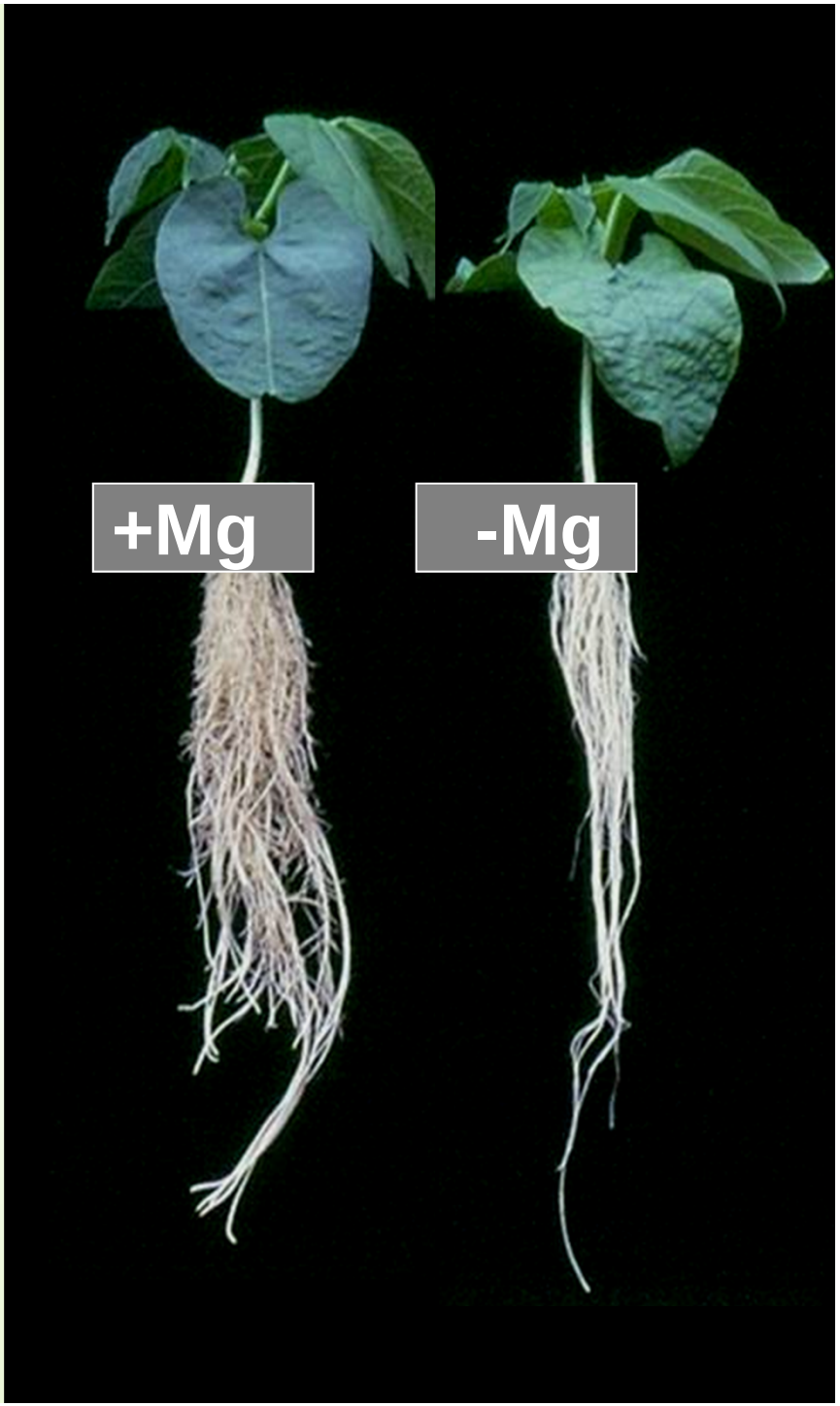
(leaves)

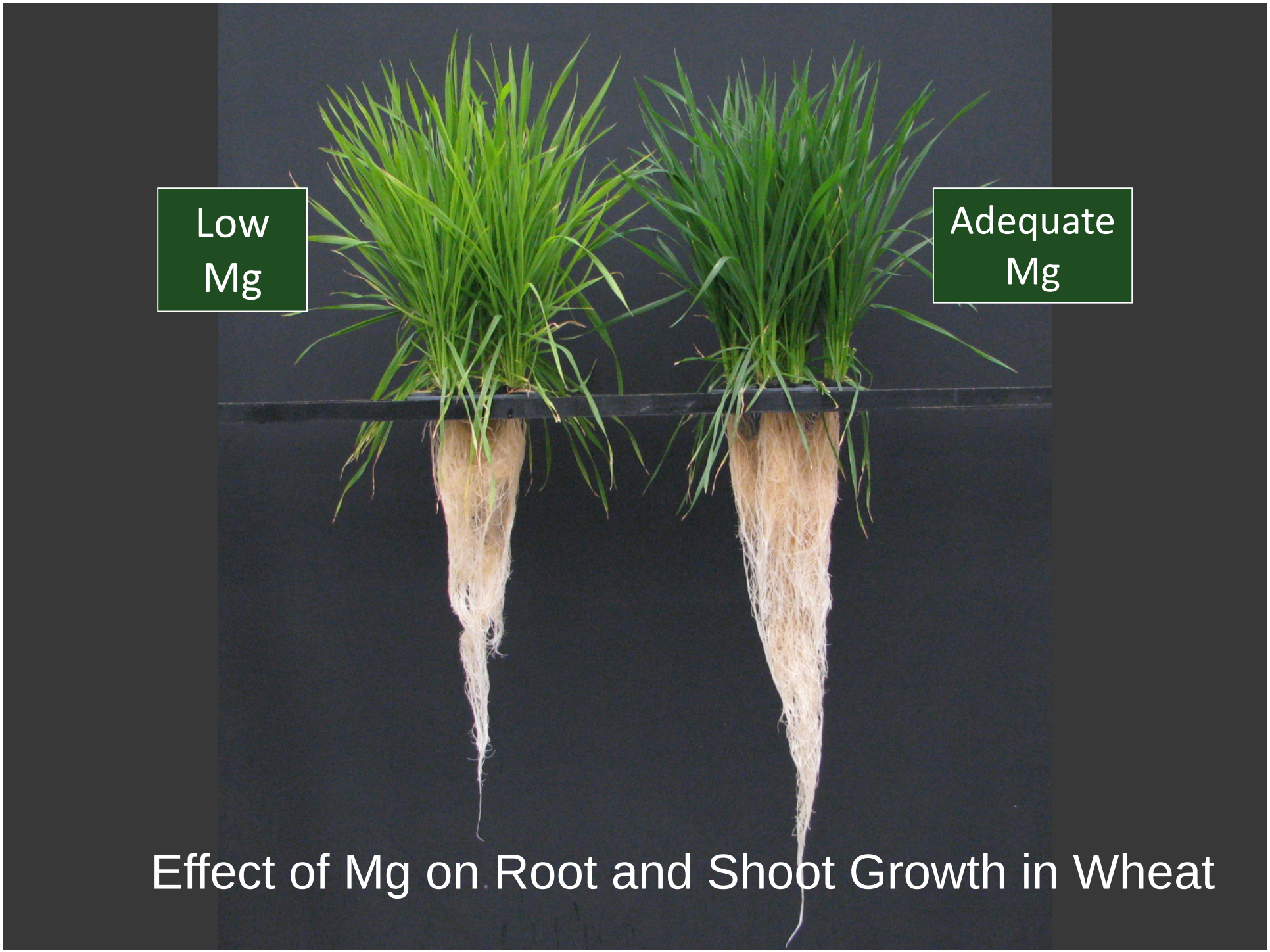
Limited due to Mg deficiency

Sink **(roots, fruits, seeds…)**

Sink Organs are very sensitive to Mg deficiency

Cakmak and Kirkby, 2008, Physiol. Plant.

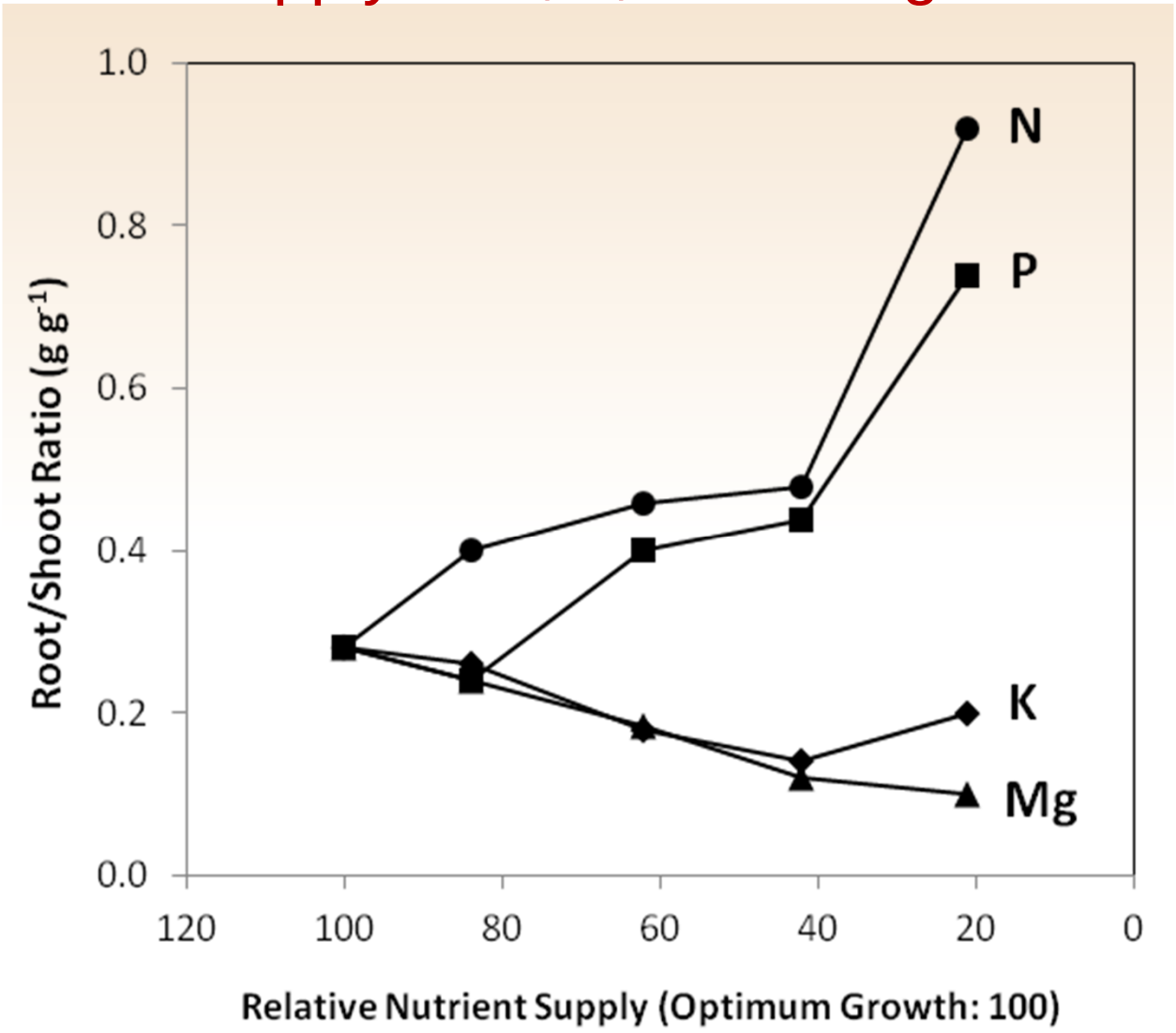




Effect of Mg on Root and Shoot Growth in Wheat

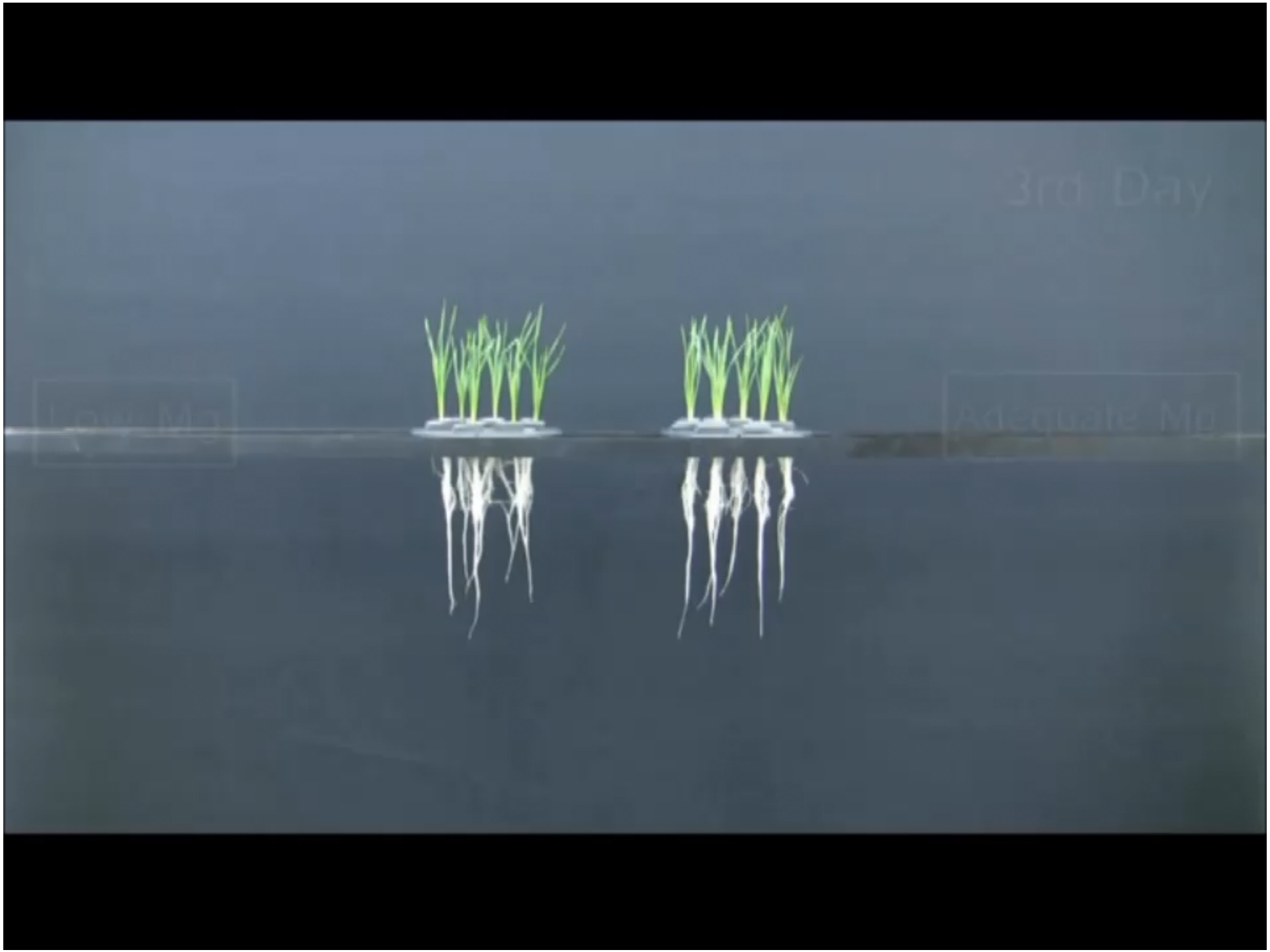
Cakmak, 2013, Plant and Soil

Changes in root to shoot dry weight ratio in silver birch seedlings depending on the differential supply of N, P, K and Mg



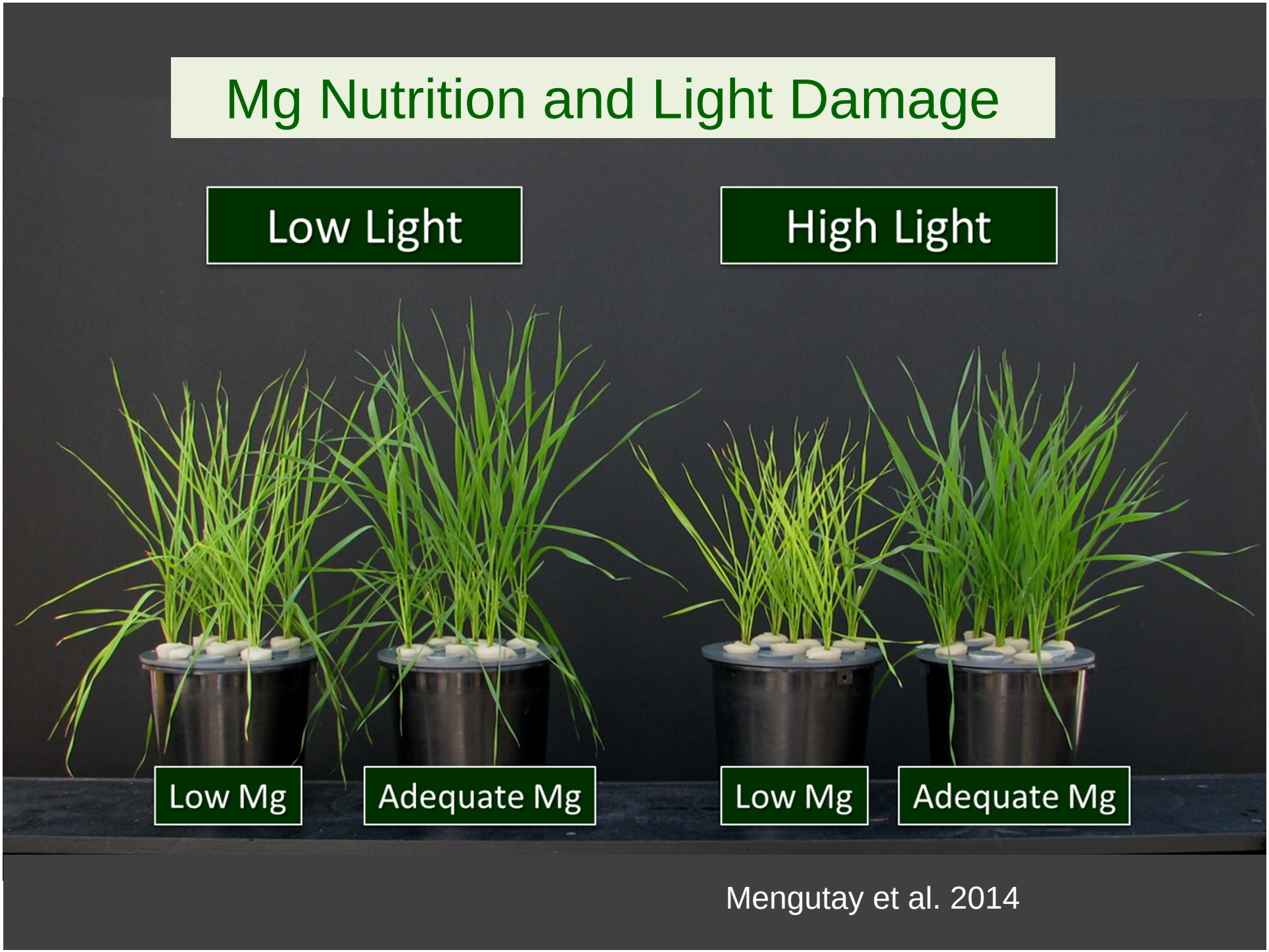
McDonald et al. 1996. J. Exp. Bot

VIDEO


3rd Day
Low Mg
Adequate Mg

Plants with low Mg are highly susceptible to high light intensity and heat stress

Mg Nutrition and Light Damage



Mengutay et al. 2014

Mg-deficient plants highly sensitive to high light

Bean plants grown at low Mg supply

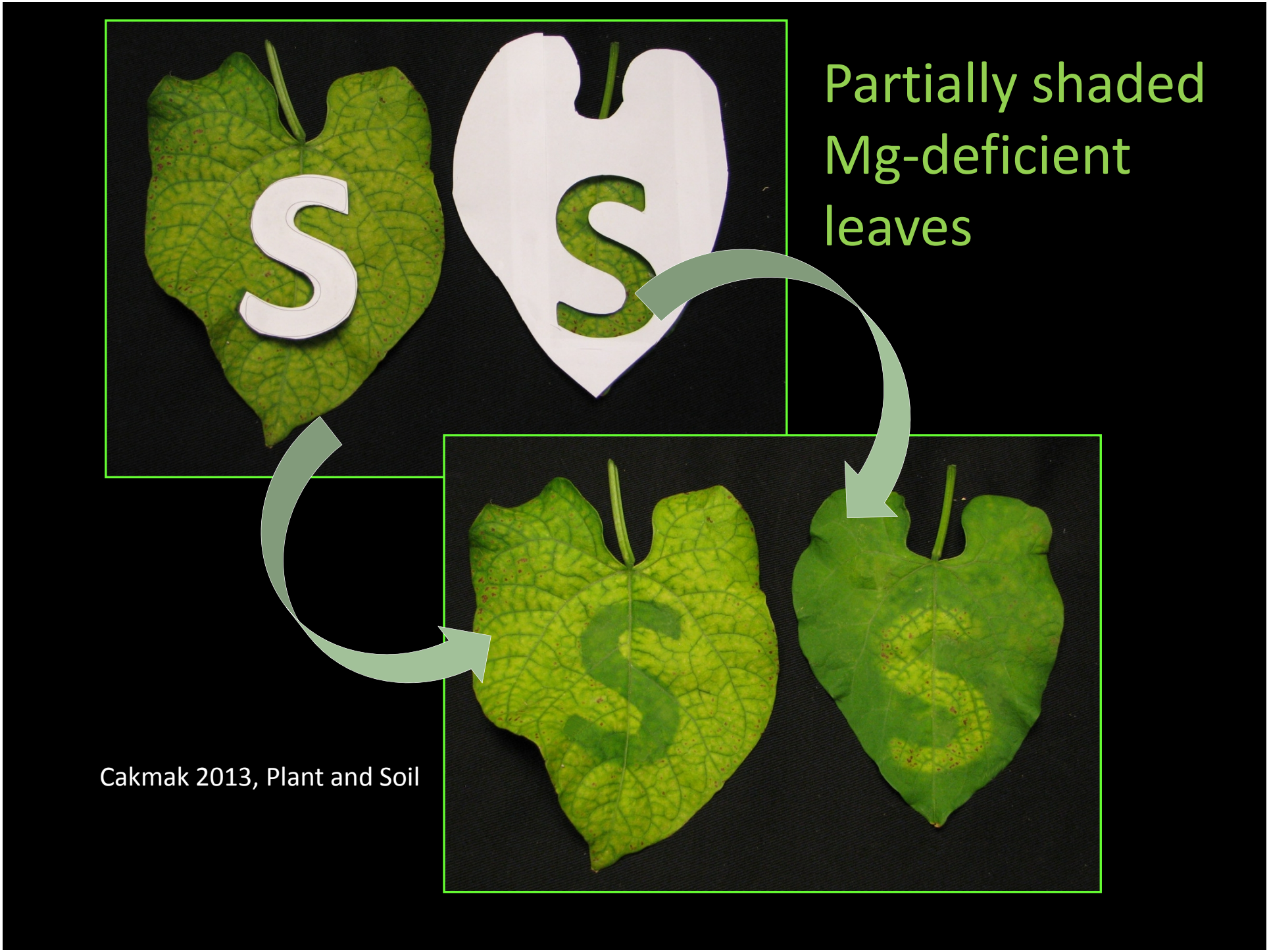
Cakmak and Kirkby, 2008, Physiol Plant

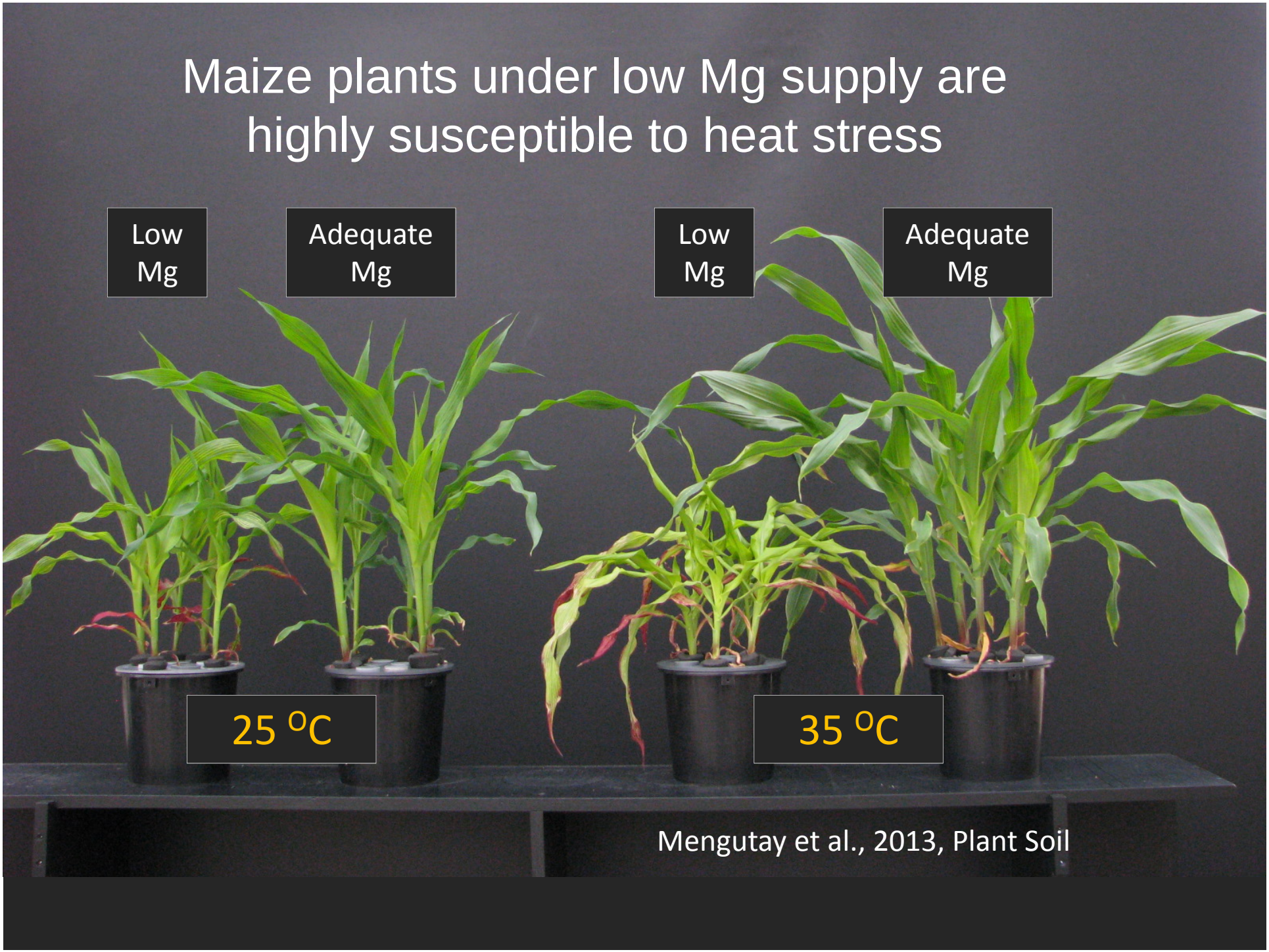
Shaded and not-shaded primary leaves of the same Mg deficient plants

Cakmak and Kirkby, 2008, Physiol Plant

Mg deficient plants are highly susceptible to high light intensity

Cakmak and Kirkby, 2008, Physiol Plant


Partially shaded
Mg-deficient
leaves
Cakmak 2013, Plant and Soil


Maize plants under low Mg supply are highly susceptible to heat stress
Low Mg
Adequate Mg
Low Mg
Adequate Mg
25 °C
35 °C
Mengutay et al., 2013, Plant Soil

Conclusions

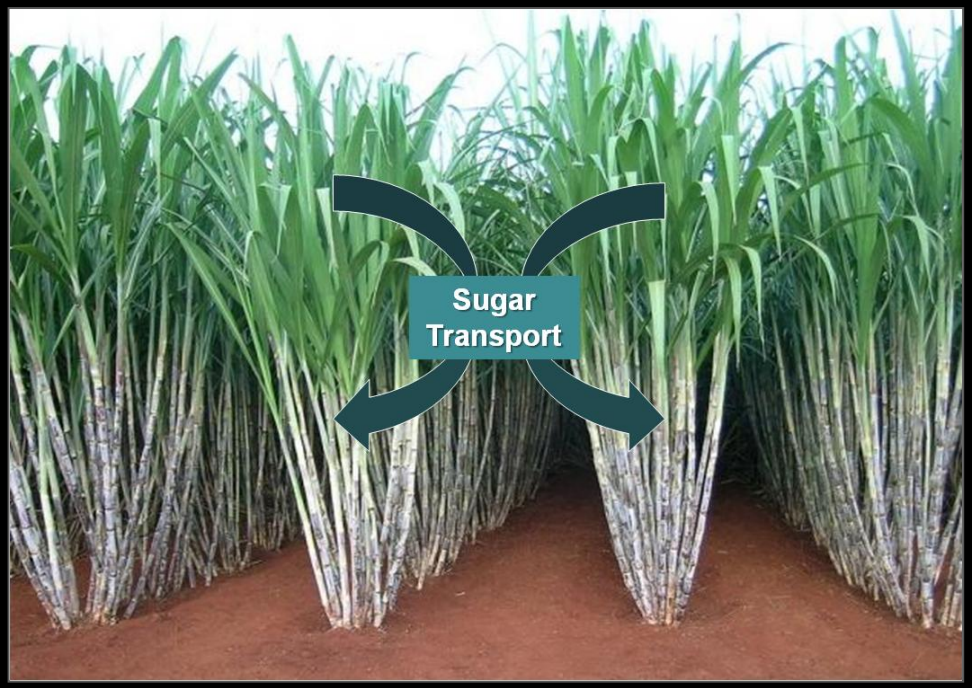
Impairments in maintenance of phloem transport of sugars into the sink organs (e.g., roots and seed) by Mg deficiency may affect the size and number of sink organs and consequently yield.

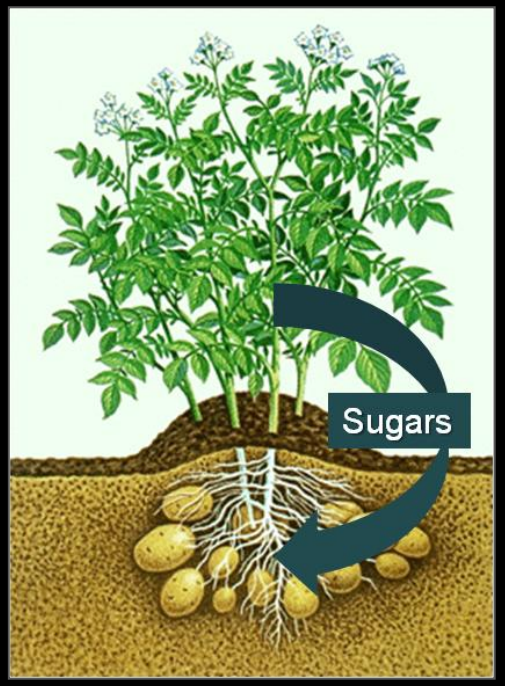
Impaired Root Growth and Consequences

Very early impairments in root growth and related decline in root surface by Mg deficiency may have serious impacts on the acquisition of mineral nutrients and uptake of water by roots, **especially under water-limited and nutrient-deficient soil conditions.**

Maintenance of adequate Mg status of leaves is needed to guarantee sufficient re-translocation of assimilates into harvest products (e.g. grains, fruits, tubers)…

Late foliar application of Mg might be important to guarantee efficient retranslocation of carbon into sink organs, especially in acidic soils





Obrigado...

Sabanci University