Time and dose effect of magnesium application by foliar spray on soybean

Prof. Dr. Godofredo Cesar Vitti
Dra. Fernanda Latanze
Engº Agrº Marcelo Chamie Houmsi
Dr. Thiago Augusto de Moura

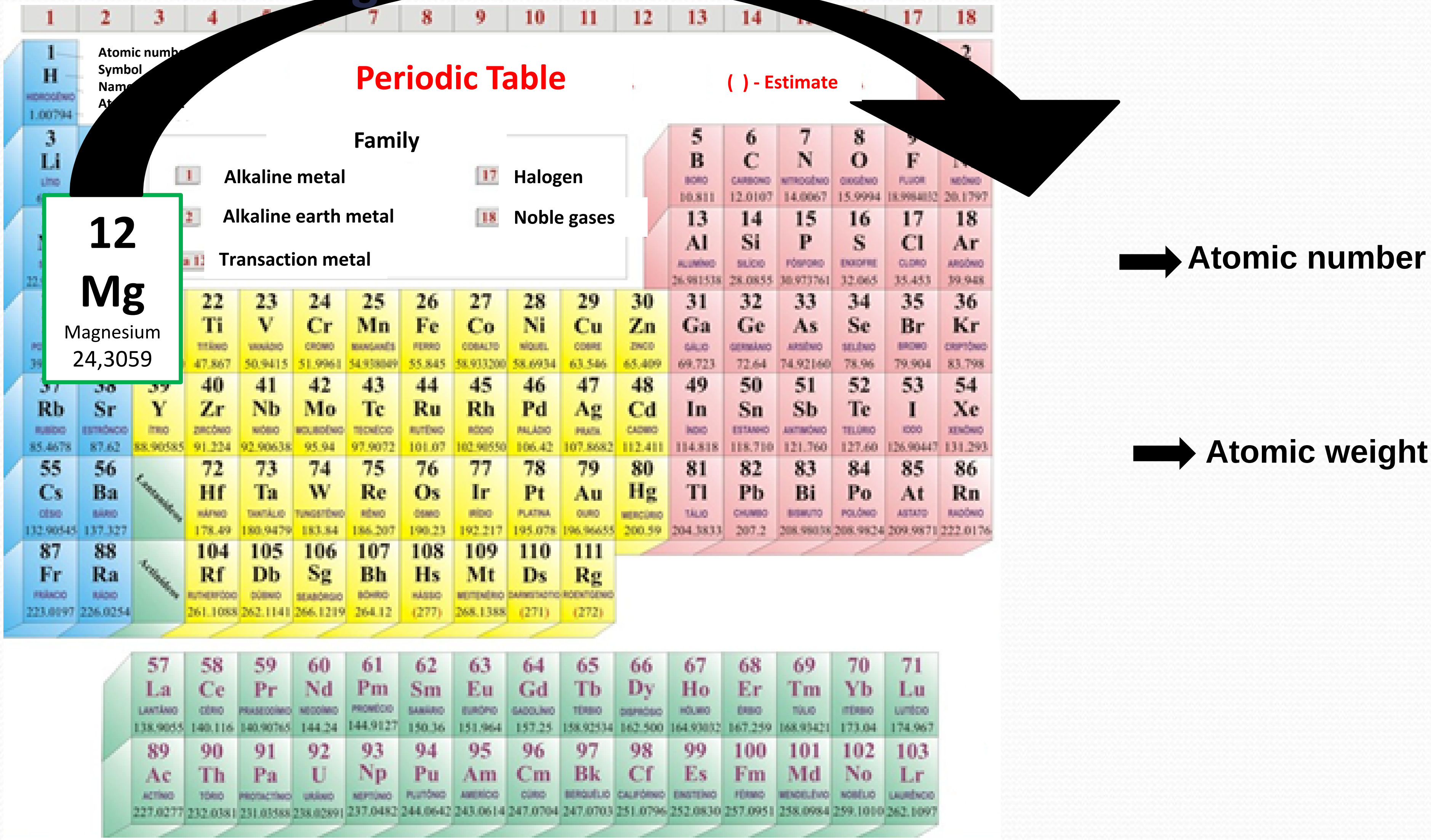
São Paulo, 4th November, 2014.

2nd INTERNATIONAL SYMPOSIUM ON
MAGNESIUM
IN CROP PRODUCTION, FOOD QUALITY AND HUMAN HEALTH

Mg^{2+}

1. Introduction

1.1. Mg Classification in the Periodic Table

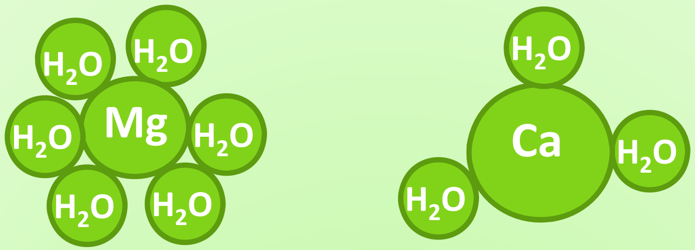


1. Introduction

1.2. Mg chemical characteristics

12
Mg
Magnesium
24,3059

- Alkaline earth
- Ionic charge bivalent (Mg^{2+} e Ca^{2+})
- Ionic radius (A) - Mg= 0,65 x Ca= 0,99



- **Electronegativity** - Mg= 1,31 x Ca= 1,00
- Hydration energy (J mol^{-1}):

Mg = 1908

Ca = 1577

Ca^{++} > Mg^{++} > K^{+}

Release →

← Adsorption

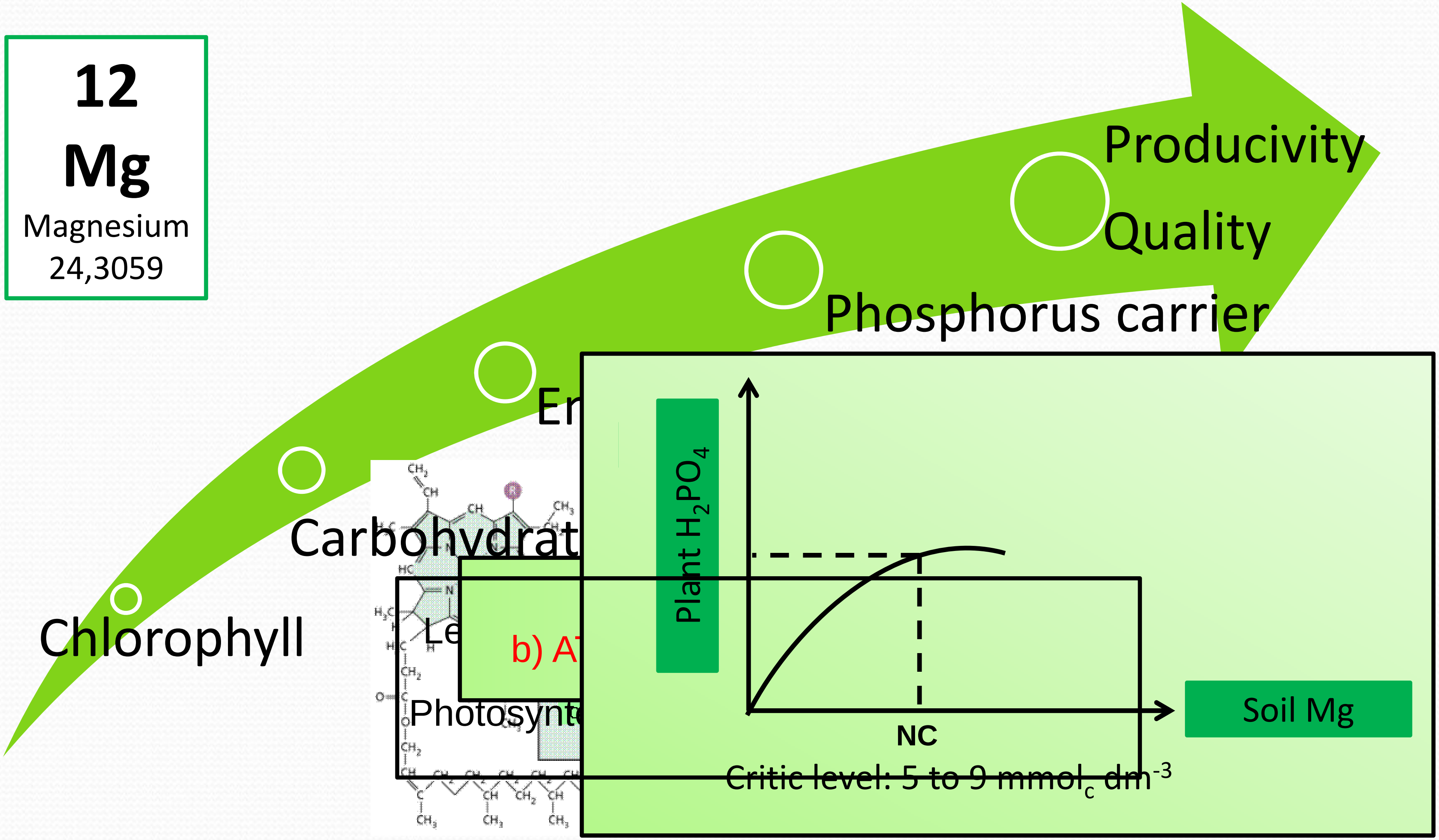
1. Introduction

1.3. Elemental composition from lithosphere and of the soil

Element	Lithosphere	Soil
	mg dm^{-3}	
O	465.000	490.000
Si	276.000	320.000
Al	81.000	71.000
Fe	51.000	38.000
Ca	36.000	13.700
Na	28.000	6.300
K	26.000	8.300
Mg	21.000	5.000
C	950	20.000

Source: Lindsay (1979).

2. Magnesium functions

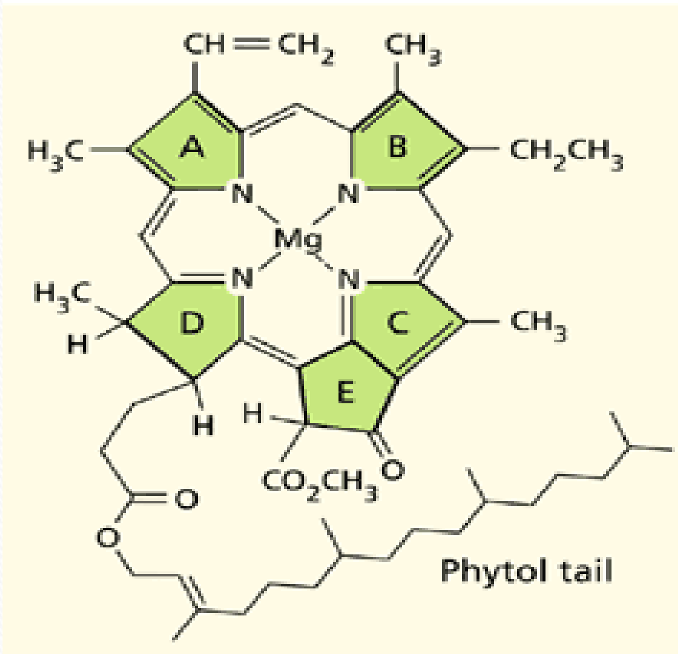


2. Magnesium functions

2.1. Photosynthesis

Central atom of chlorophyll molecula

- ✓ **Photosynthesis efficiency**
- ✓ **Productivity**
- ✓ **Dry matter acumulation**

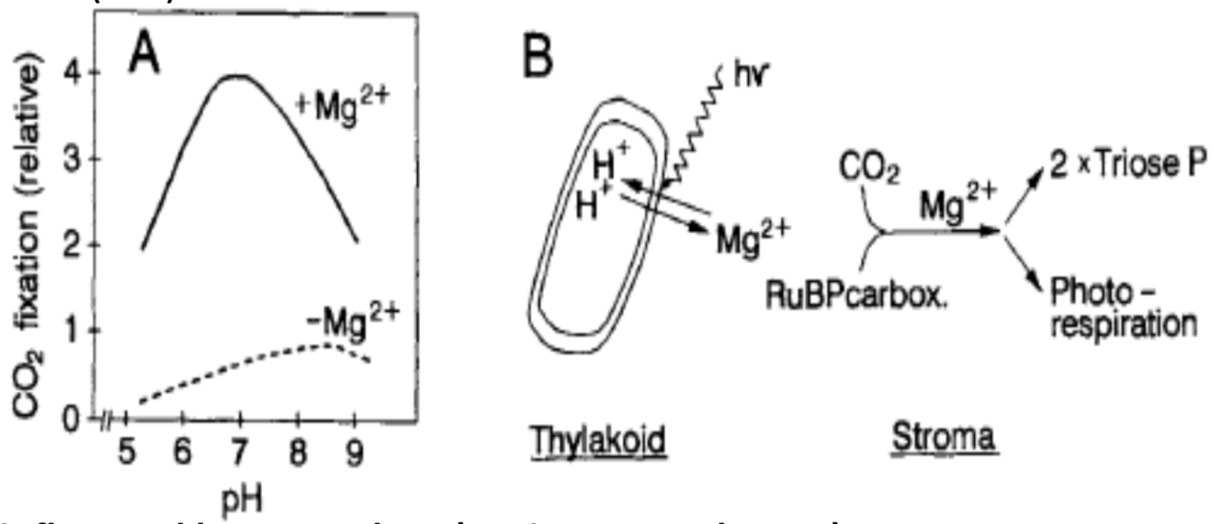


2. Magnesium functions

Magnesium requirement in the incorporation of 14C [Leucine] in the Fraction Protein of Chloroplasts of wheat isolates.

Magnesium concentration (mM)	Incorporation of ^{14}C (cpm mg^{-1} chlorophyll)	Relative value
0	412	11,5
0,5	688	19,5
5,0	3550	100,0

[A] Based on Bamji & Jagendorf (1966).



A. Fixation of CO_2 influenced by Mg and pH (Sugiyama *et al*. 1969).

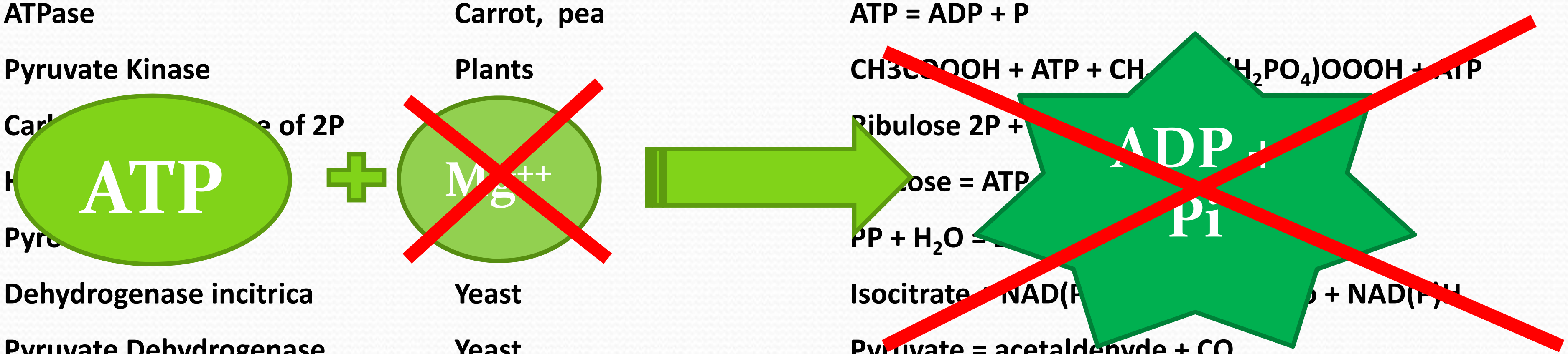
B. Influence of brightness on the transport of Mg and consequent activation enzymes (Marschner, 2012).

2. Magnesium functions

2.2. Activating enzyme

Enzymes activated by magnesium*.

Name	Source	Reation
Acetate Thiokinase	Higher plant	ATP + acetate = adenilacetao + Pi
Glutathione Synthetase	y-Glutamyl	Glutamyl-cysteinyl-glycine + ATP = GSH + ADP + P
Methionine Activator	Yeast	Methionine + ATP = adenosyl methionine + PP
ATPase	Carrot, pea	ATP = ADP + P
Pyruvate Kinase	Plants	CH3C[illegible]OOH + ATP + CH[illegible](H_2PO_4)OOOH + ATP
Car[illegible] of 2P	[illegible]	Ribulose 2P + [illegible]
H[illegible]	[illegible]	[illegible]ose = ATP [illegible]
Pyr[illegible]	[illegible]	PP + H_2O = [illegible]
Dehydrogenase incitrica	Yeast	Isocitrate + NAD(P[illegible] + NAD(P)H
Pyruvate Dehydrogenase	Yeast	Pyruvate = acetaldehyde + CO_2
Phosphopyruvate Synthetase	Sugar cane, corn, sorghum	Pyruvate + ATP + P = Phosphoenolpyruvate + AMP + P

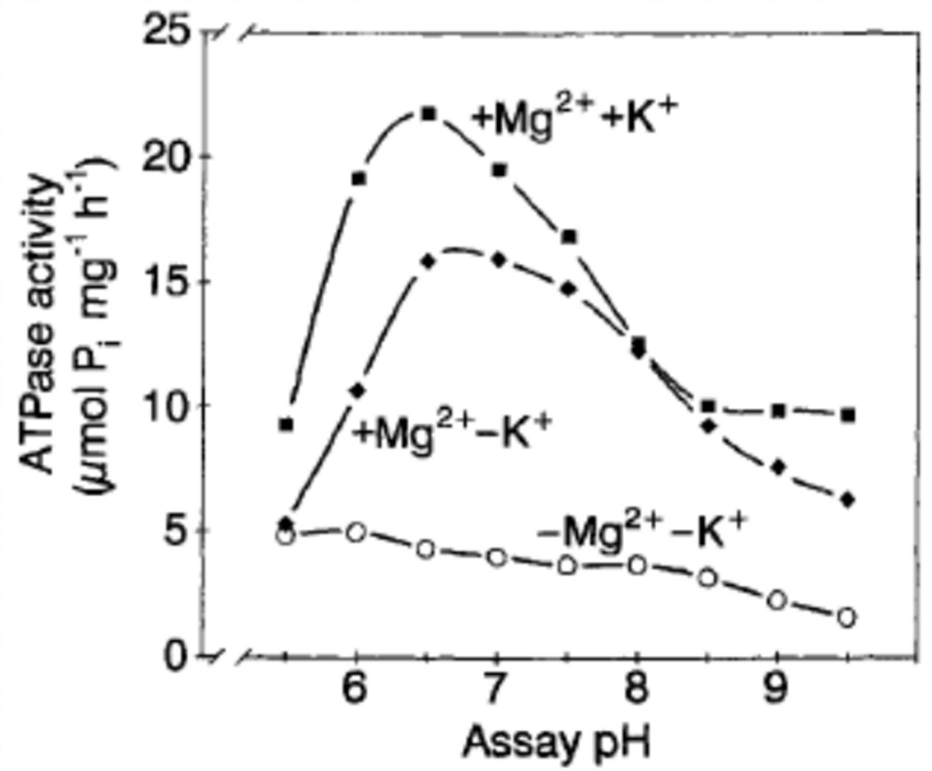


*Adapted of Hewit & Smith, 1975

2. Magnesium functions

2.2. Activating enzyme

Effect of the pH and supply of Mg (3mM) and K (50 mM) in the activity of the ATPase in plasma membrane of corn roots.



(Based on Leonard & Hotchkiss, 1976; Extracted of Marschner, 1995)

2. Magnesium functions

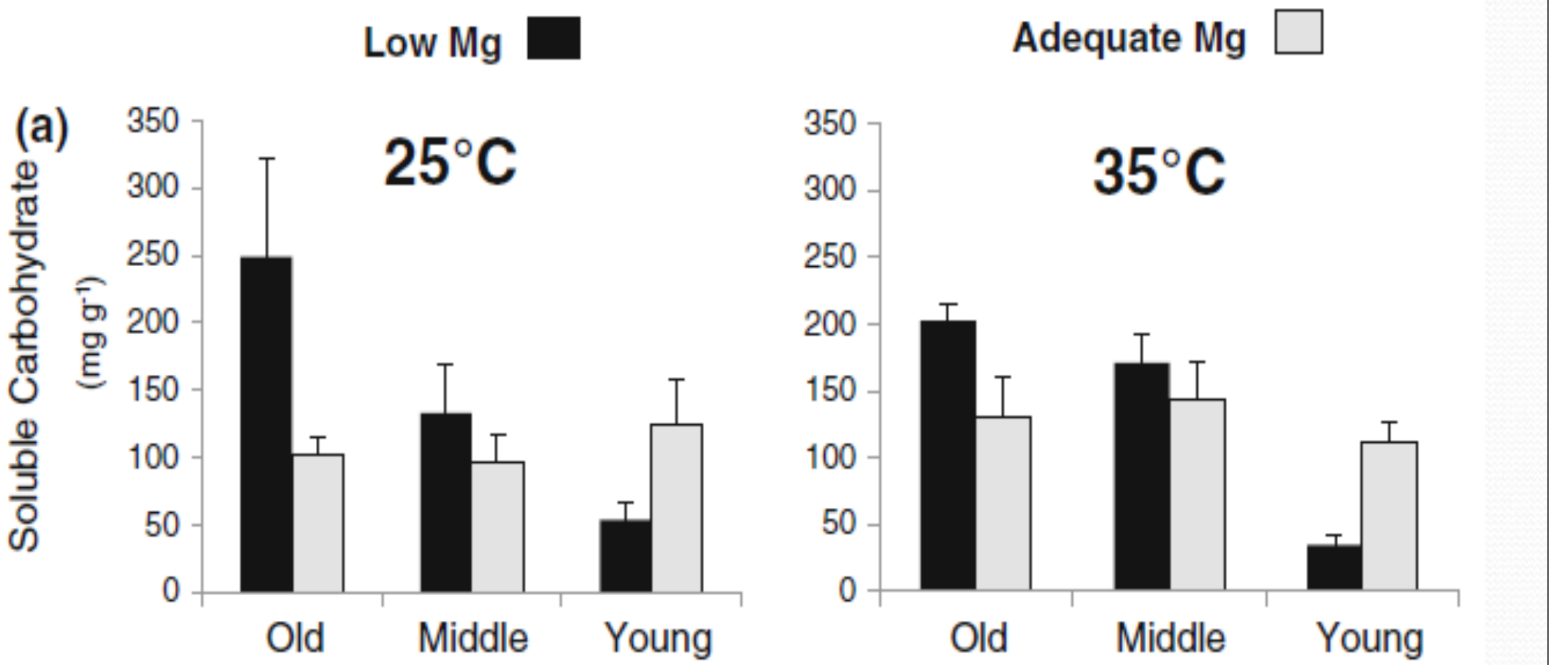
2.3. Carbohydrate transport

- First consequence of the Mg deficiency
- Fractioning and pumping of carbohydrates into the phloem

2. Magnesium functions

2.3. Carbohydrate transport

Soluble carbohydrates concentration in old leaves, middle and young of corn under different temperature and magnesium dosis.



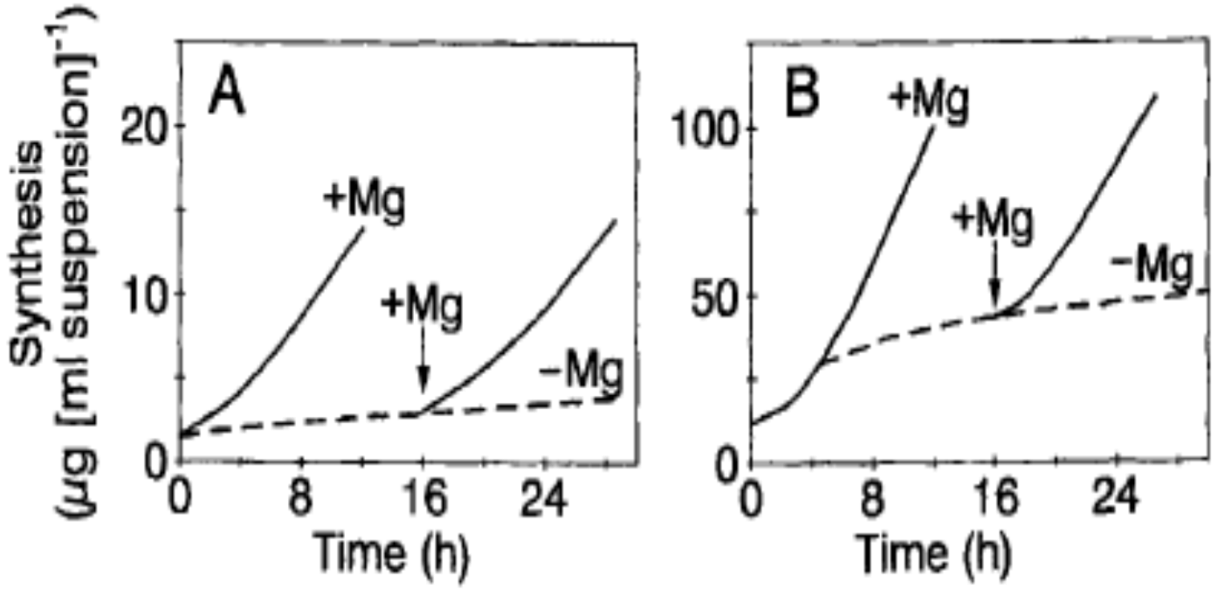
(Mengutay *et al.*, 2013)

2. Magnesium functions

2.4. Stability Ribosomal

- **Mg → binding of ribosomes**
- **Required by enzyme RNA polymerase**

Effect of the magnesium addition in RNA (A) and the synthesis protein (B) in *Chlorella pyrenoidosa* in suspension cultivation



(Based on Galling, 1963; Extracted of Marschner 1995).

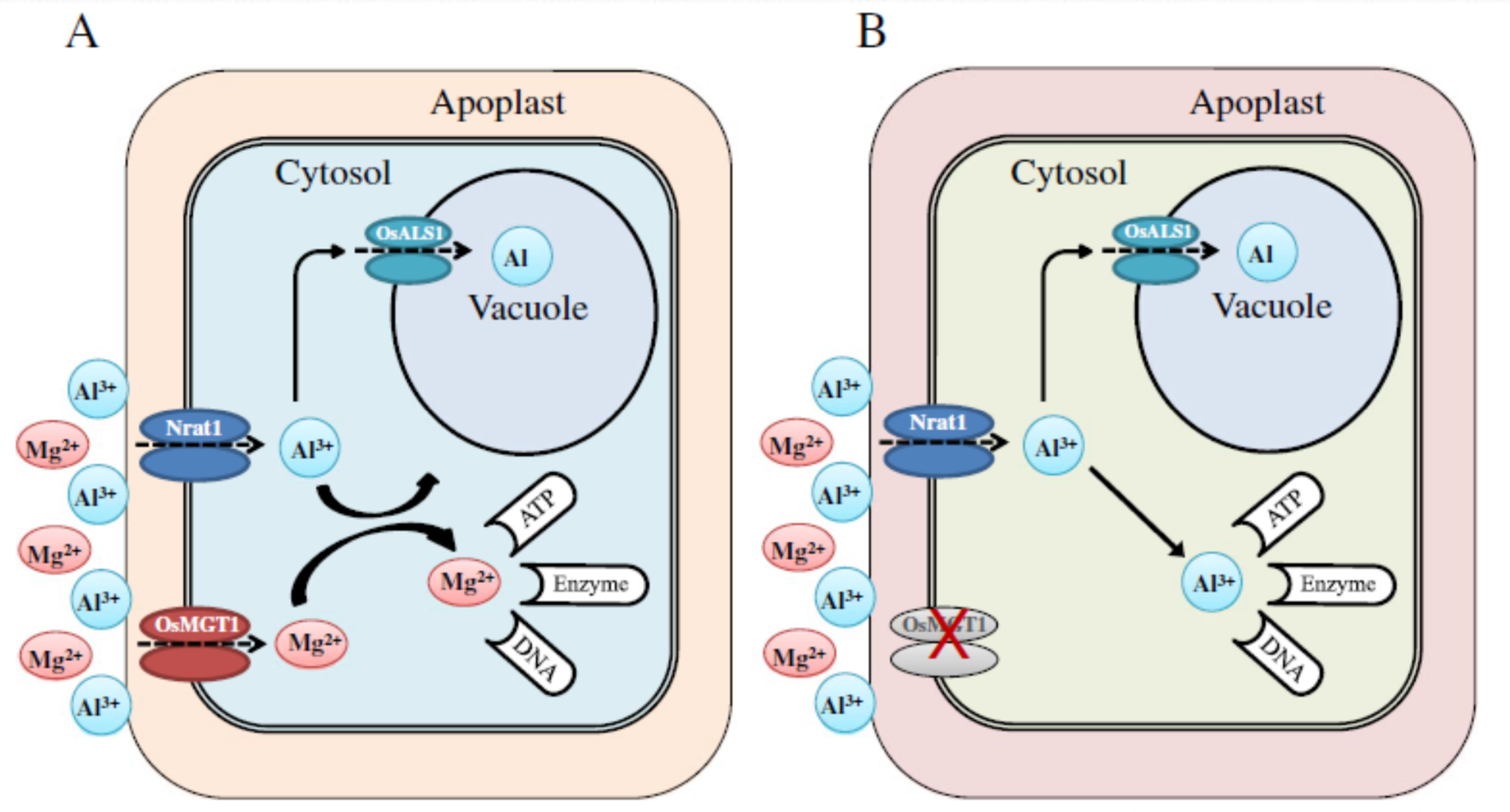
2. Magnesium functions

2.5. Effect against toxic aluminium

- Concentration (mM) - Al^{3+} and Mg^{2+} have similar ionic hydrated ray, therefore occur competition by assets places;
- Concentration (µM) – organic anions excretion;

2. Magnesium functions

Reduction mechanism of the effect toxic aluminium that Mg performs in rice. A, the aluminium is captured by vacuoles and it don´t cause problem. And B, if the magnesium transporter OsMGT1 is not present, the effect toxic might occur.



(Chen & Ma, 2013)

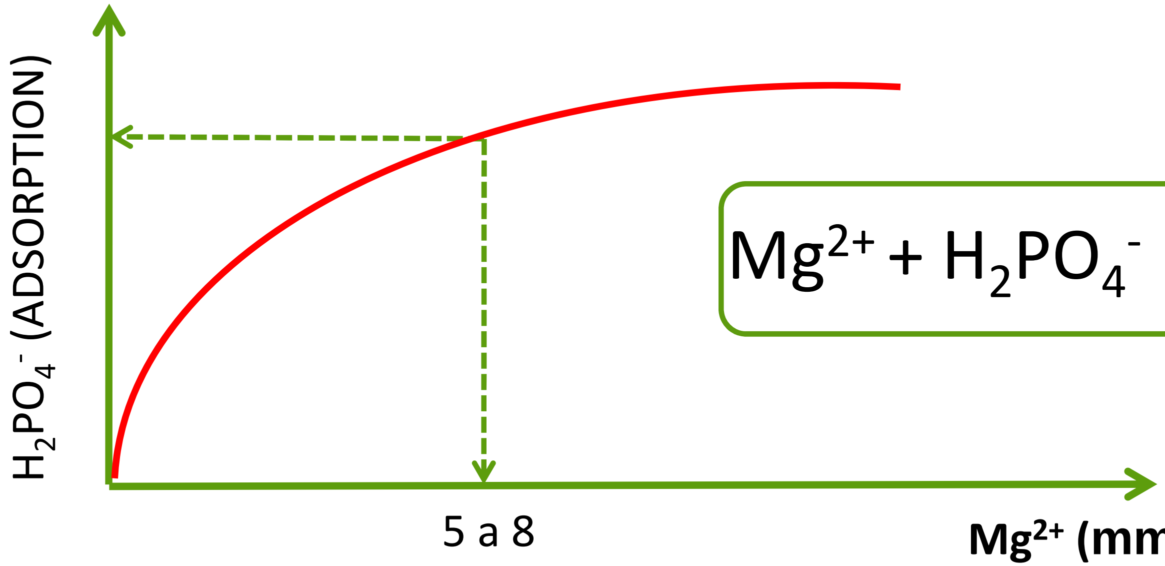
2. Magnesium functions

2.6. Disease resistance

- Well plants nourished = higher resistance, because the metabolism is working without problems;
- The energy from photosynthesis is required for some defence mechanism;
- Excess of Mg can cause disease an indirectly way, such as blossom-end rot in tomato;
- Carbohydrate in the leaves can attract pathogens.

2. Magnesium functions

2.7. Improves phosphorus absorption



$$Mg^{2+} + H_2PO_4^- \longleftrightarrow [MgH_2PO_4]$$

(Malavolta, 2006)

2. Magnesium functions

2.7. Improves phosphorus absorption

Mg = P Carrier

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

Source: Malavolta & Ponchio (1987)

2. Magnesium functions

2.8. Other function

- Chelating molecules of glyphosate;
- Combat pasture tetany in ruminants;
- In relation to human nutrition, protect against cardiovascular diseases, diabetes and stroke (Bo & Pisu, 2008);
  - Can help combat high intake sodium (Na) for humans;

2. Magnesium functions

2.8. Other function

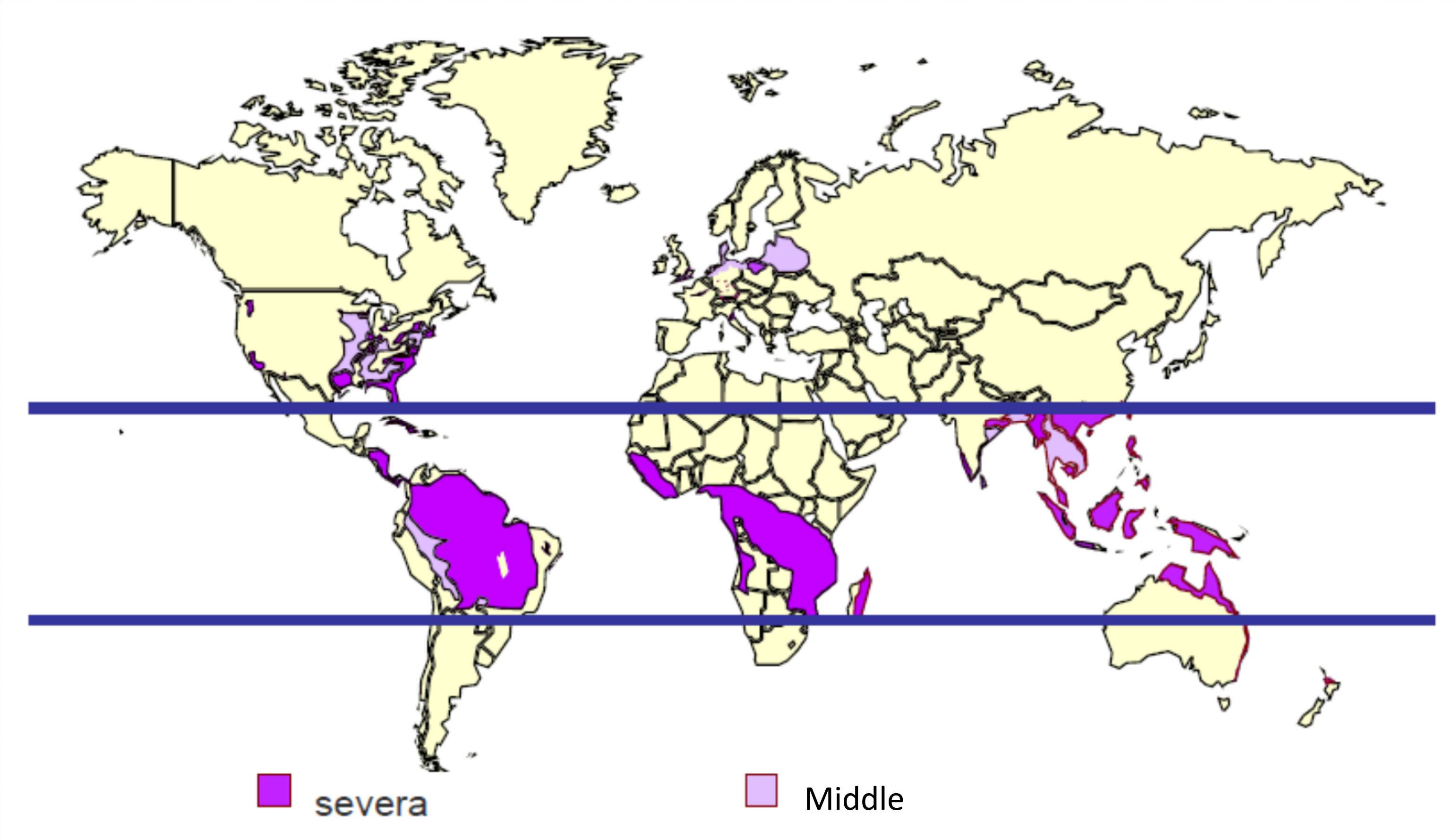
- Essential element demanded in kg ha^{-1}
- Overlooked use in fertilization, generating disabilities
- Problematic in acidic and weathered soils – Brazil

  - Difficult diagnosis of disability

- Brazilian deficit in the fertilization of MgO: 200.000 ton per year (Malavolta, 1980);

3. Magnesium in soil

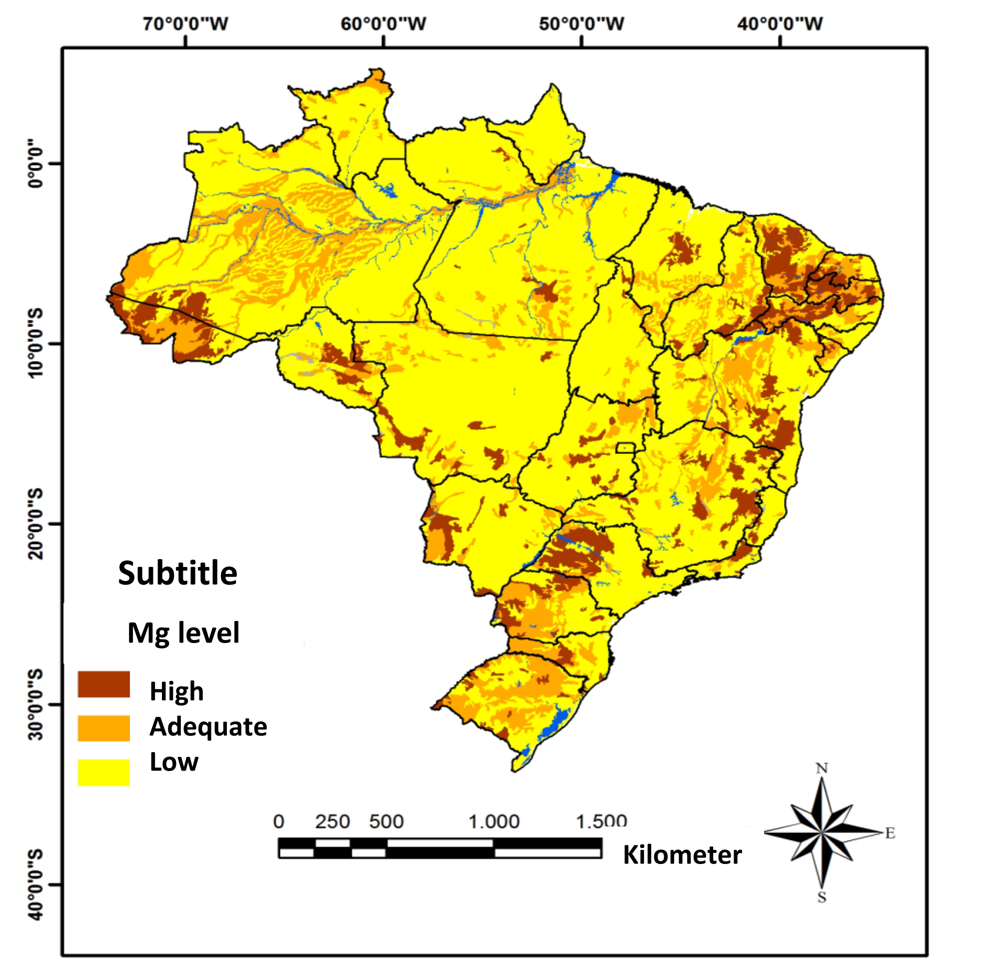
Region with disabilities identified of magnesium



(Wiendl, 2006)

3. Magnesium in soil

Magnesium changeable in the layer of 0-30 cm.

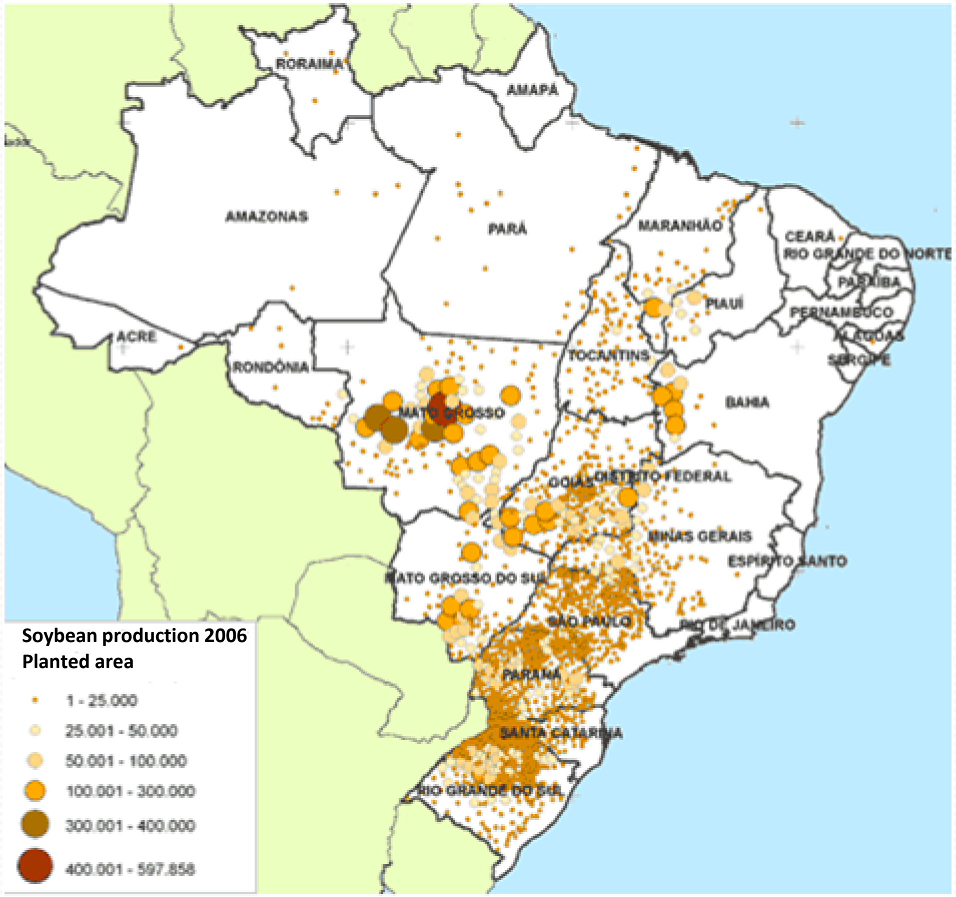


(Benites *et al.*, 2010)

- **29,3 million ha;**
- **production – 86,6 million t;**

Source : CONAB

Brazil - soybean production 2006



Source : IBGE

3. Magnesium in soil

3.1. Balance

Factors that effect the Mg availability to the plants.

Balance between magnesium form in the soil

Mg – available

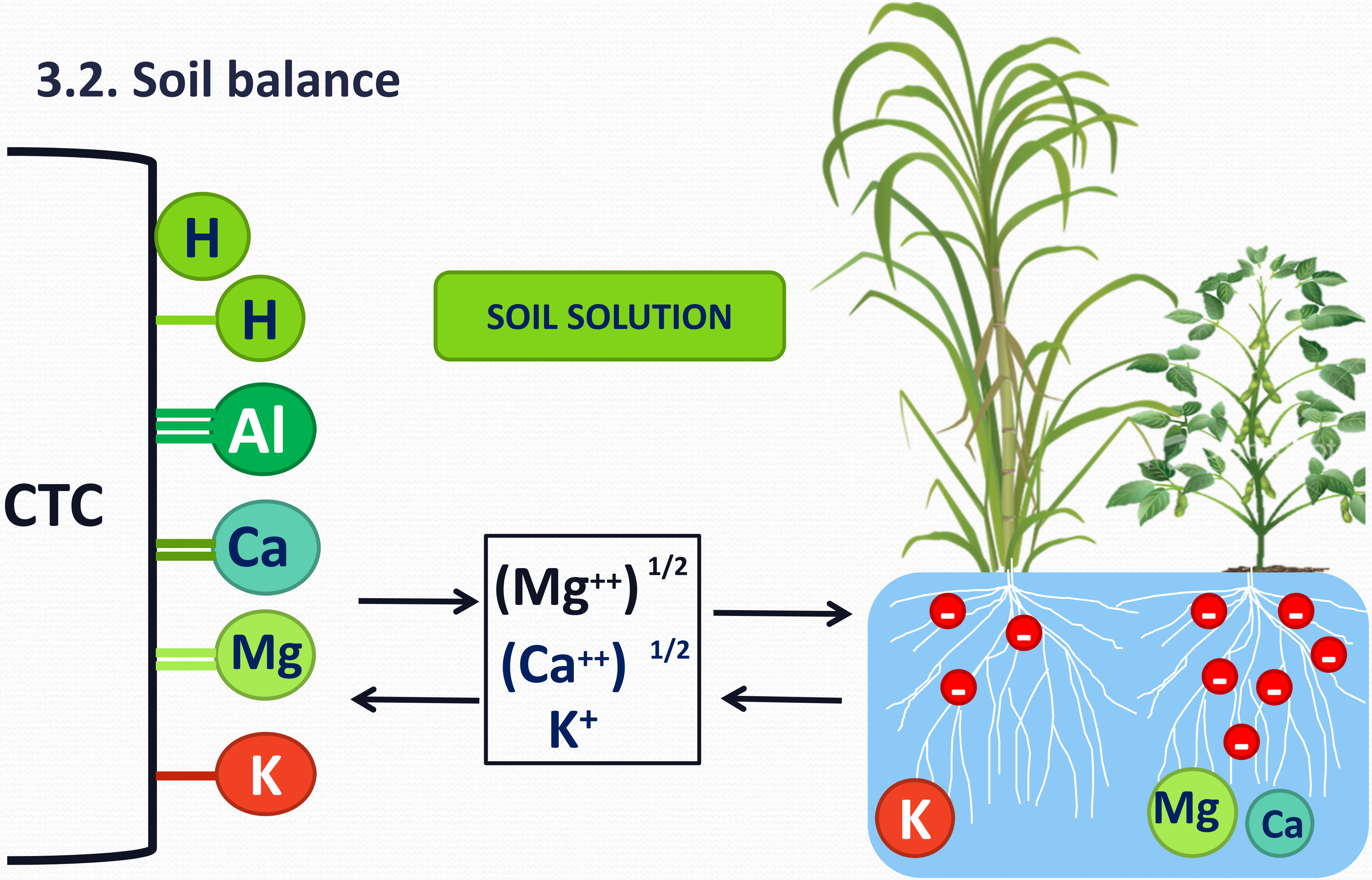
factor

capacity C

Mg-exchangeable	⇄	Mg-solution
Quantity factor		Intensity factor
Q	$PTMg = \frac{Q}{I}$	I

3. Magnesium in soil

3.2. Soil balance

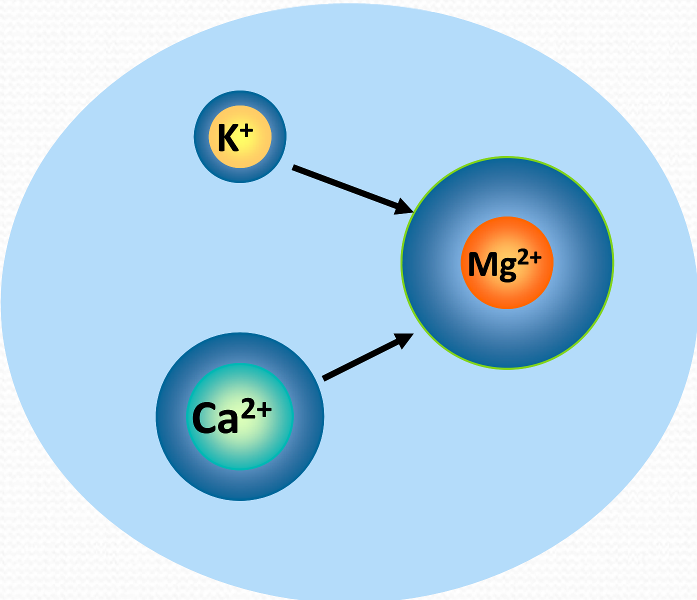


3. Magnesium in soil

3.2. Condition that influence the Mg in the soil solution

- **Acid Soil (pH<5,4)**
- **CTC Proportion < 6%**
- **High content of K**
- **Relation K/Mg>4**
- **Concentration <49 mg dm^{-3} in the soil**

4. Absorption Mg^{2+} x Ca^{2+} x K^{+}



Nutrients	Content middle cmolc dm^{-3}
K	0,16 a 0,30
Mg	0,50 a 0,80

Raij et al. (1997)

The hydrated radius of Mg dificult its absorption, by inhibition of Ca and K – deficiency of Mg affect the graining and increase fruits shell

Mg-soil less 2 timM1 K affect absorption Mg and P, because the action ATPase membrane dependent Mg (Malavolta, 2006) – efficiency in the use P dependent Mg

M1 Tem a versão em portugues??

Não seria ...less than...
Mariana; 31.10.2014

4. Absorption Mg^{2+} x Ca^{2+} x K^{+}

Absorption	Mg	Mg + Ca	Mg + Ca + K
		μmol g^{-1} h^{-1}	
Roots	50,1	34,9	4,5
Vegetative Parts	26,7	7,6	1,9

Schimansky (1981)

K	Mg	Mg : K	sacks ha^{-1}
cmolc dm^{-3}			
0,1	0,6	6	65,6 a
0,32	0,6	1,9	50,8 b
0,54	0,7	1,3	51,9 b

Matiello et al. (2002)

100 kg.ha^{-1} MgO or 62 kg Mg ± 0,2 cmol.dm^{-3} Mg

300 kg.ha^{-1} K_2O "can raise" the content of K in 0,2 $cmol_c$ dm^{-3} if consider the K of the soil can cause deficiency of Mg, even when the soil present middle content and equal to 0,5 $cmol_c$ dm^{-3}

The Mg absorption is spoiled by calcium and much more by K

5. Mg content and reactions in soil

- Contact ion-root: mass flow;
- Mobile element in the soil;
- Leaching;
- Critical level: 5 to 9 mmolc dm^{-3}

Levels of magnesium in the soil*

Level	Mg^{2+} exchangeable(*) cmolc dm^{-3}	Mg cmolc dm^{-3}
Low	0,0 - 0,4	< 0,5
Middle	0,5 - 0,8	0,5 - 0,9
Adequate	> 0,8	1,0 - 1,2

*Adapted of Quaggio *et al*., 1997

Vitti et al, 2014

5. Mg content and reactions in soil

Percentage of saturation of K, Mg and Ca in relation from value T of the soil, in range of V% more adequate to the planta (VITTI et al., 2000).

V%	K%T	Mg%T	Ca%T
40	3	9	28
50	4	11	35
60	5	15	40
70	5	16	48

Growing dispersion →

$$Ca^{2+} > Mg^{2+} > NH_4^{+} > K^{+} > Na^{+}$$

← **Growing aggregation**

K	Mg	Ca	Ca/Mg
1	3	9	3/1
		to	
1	5	25	5/1

6. Mg Supply

6.1. Liming

Criteria

Basis Saturation	Ca + Mg
$LN = \frac{(V_2 - V_1)\ CEC^*}{PRNT}$	$LN = \frac{X - (Ca^* + Mg^*)\ 100}{PRNT}$
$V_2 = 60$	$X = 3,0$

Use criteria that recommend greater dose

* Content in $cmol_c\ dm^{-3}$

Source: Vitti & Machado, 2014

PRNT(Relative Power of Total Neutralization)

6. Mg Supply

6.1. Liming

Constant of the product of solubility of some magnesium sources

Compound	Kps
$MgCO_3.3H_2O$	$2,38 \times 10^{-6}$
$MgCO_3$	$6,82 \times 10^{-6}$
$Mg(OH)_2$	$5,61 \times 10^{-12}$
$CaMg(CO_3)_2^*$	$2,00 \times 10^{-17}$

Source: *Solubility Data Series, International* Union of Pure and Applied Chemistry, Pergamon Press, Oxford, 1979–1992.
Adapted of Stumm and Morgan (1981).

↑ Kps ↓ Solubility

6. Mg Supply

6.1. Liming

Solubility of Mg sources

Sources Mg	Formula	Solubility in water (g/100 ml H_2O)
Mg Hydroxide	$Mg(OH)_2$	0,0009
Mg Oxide	MgO	0,0006
Mg carbonate	$MgCO_3$	0,0106

Adapted of Cakmak, I. Source: http://en.wikipedia.org/wiki/Solubility_table_Kmag.com

6. Mg Supply

6.1. Liming

Action mechanisms

Agricultural limestone Ca, Mg $(CO_3)_2$ and $CaCO_3$

$$\text{Ca, Mg }(CO_3)_2 \xrightarrow{H_2O} Ca^{++} + Mg^{++} + 2CO_3^{2-}$$

$$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$$

$$HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$$

$$H_2CO_3 \rightleftharpoons H_2O + CO_2$$

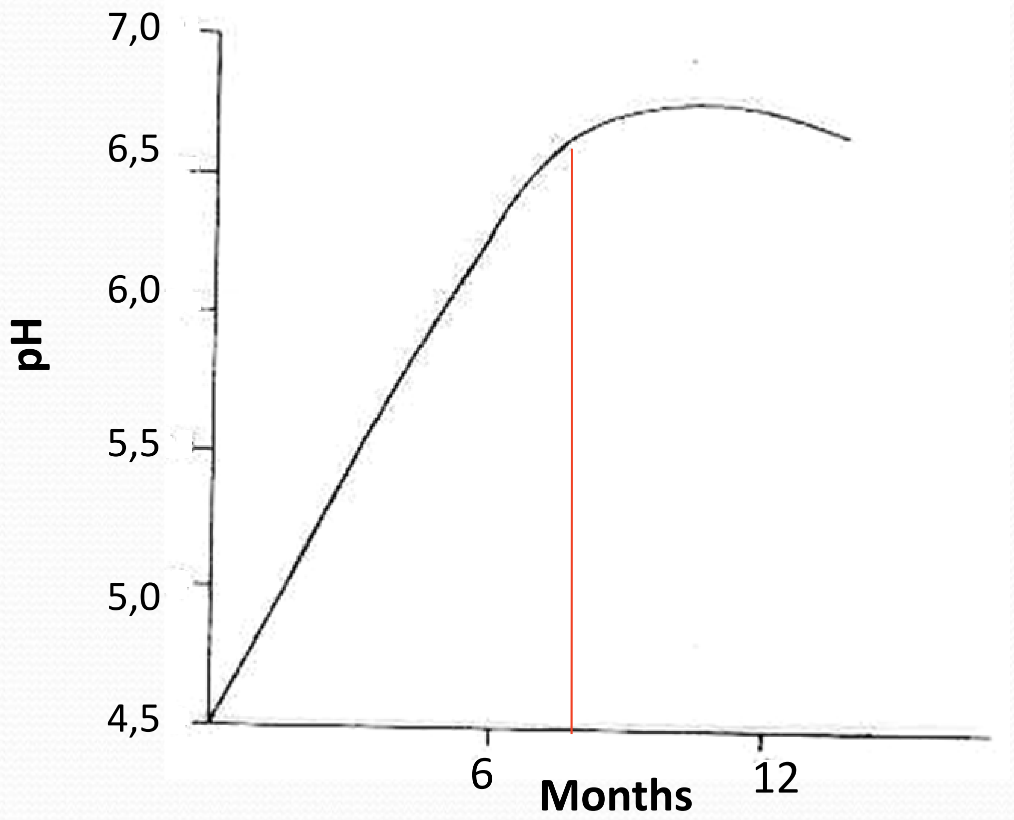
$$OH^- + H^+ \rightleftharpoons H_2O$$

$$3\,OH^- + Al^{+++} \rightleftharpoons Al(OH)_3$$

6. Mg Supply

6.1. Liming

Action mechanisms

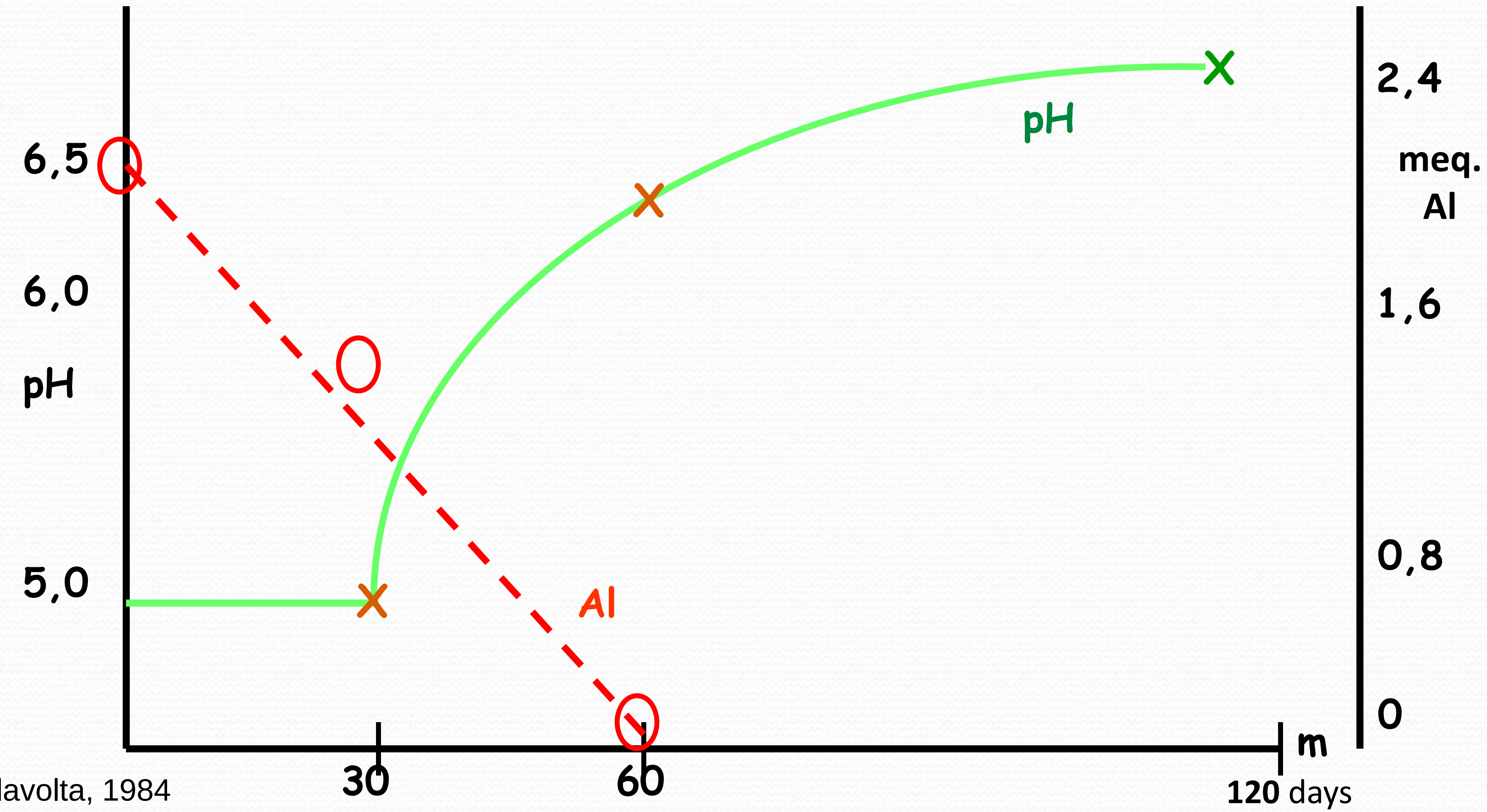


Malavolta, 1984

Relation between application period of the limestone and change in the soil pH.

6. Mg Supply

6.1. Liming



Malavolta, 1984

Effect of the reaction time of the limestone in the acidity correction.

6. Mg Supply

6.2. Main magnesite fertilizers – Soil applied

Fertilizer	MgO (%)	Saline Index	Equivalent $CaCO_3$
Kieserite ($MgSO_4.H_2O$)	30	38	0
Potassium and Magnesium Sulfate	18	43	0
Termofosfate	16	-	+500
Magnesium Oxisulfate *	30	-	0

(Malavolta, 1980)

* 18% MgO HCi 2%

7. Magnesium in the plant

7.1. Magnesium function

- **Ideal Concentration of Mg 0,15-0,35% (1,5 to 3,5 g kg^{-1}) of the dry matter (Marschner, 2012);**

- **High mobility in the phloem;**

- **Foulkset *et al*. (2002) – three phases of the plant require greater demand of Mg:**

  Foundation of the Root System

  Vegetative Development

  Reproductive phase

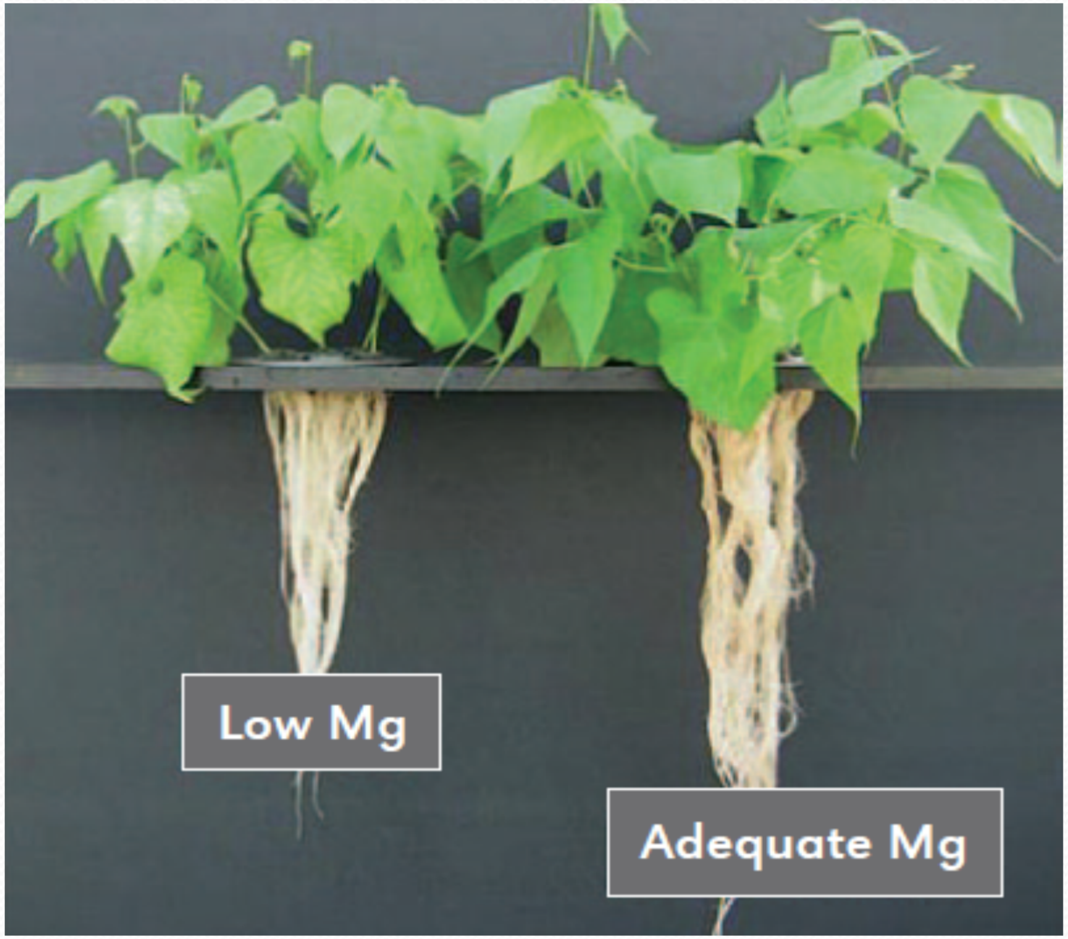
7. Magnesium in the plant

7.2. Magnesium deficiency

- **Damage in the root system;**
- **Internervial chlorose widespread in old leaves;**
- **Low translocation of carbohydrate of the source to the drain;**
- **Increase of the relation shoot: root;**
- **Susceptibility to drought;**
- **As higher proportion of Mg connected to chlorophyll highest deficiency;**

7. Magnesium in the plant

Damage on root development



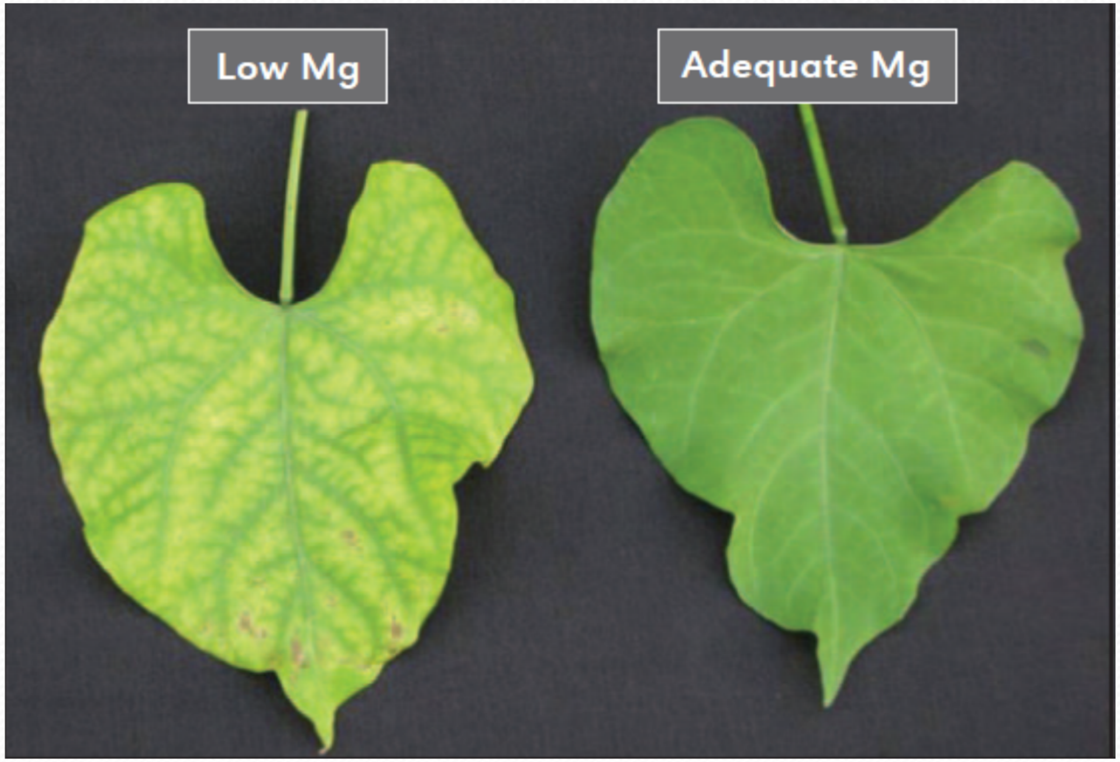
(Cakmak & Yazici, 2010)

7. Magnesium in the plant

7.2. Magnesium deficiency

- Internervial chlorose widespread in old leaves;

Symptom of magnesium deficiency in common bean



(Cakmak & Yazici, 2010)

7. Magnesium in the plant

7.2. Magnesium deficiency

Marginal chlorosis – border pale green – Interneval chlorosis of older leaves, with time advances between the ribbing.

7. Magnesium in the plant

7.2. Magnesium deficiency

Source: Vernetti, 1983.

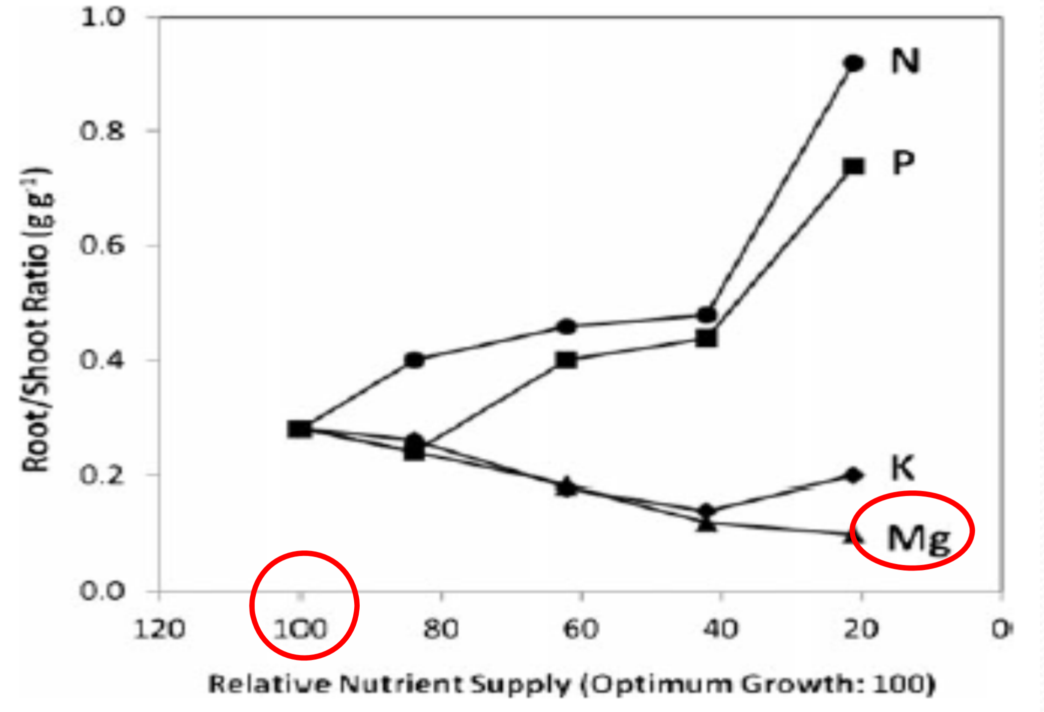
Figure. Oxides and necrotic stains irregular might appear later among ribbing, in the superior part of plant. In more advanced stages of growth, the deficiency of Mg gives an appearance of early ripening with a tanning throughout surface of the leaf.

7. Magnesium in the plant

7.2. Magnesium deficiency

Increase of the relation shoot: root;

Changes in the ration roots/vegetative part in *Betula pendula* in due to the supply of nutrient. The supply of 100 means great quantity supplied.



(McDonald *et al.*, 1996)

7.2. Magnesium deficiency

As higher proportion of Mg connected to chlorophyll highest deficiency;

Content and way of binding of magnesium in Needles of one year Norway spruce grow in two locations*

Locations (soil)	Total Mg (mg g^{-1} dry weight)	Proportion of Total Mg (%)		
		Soluble in Water	Pectato, fosfate	Chlorophyll
I Rendzina	1,47	91,2	2,6	6,2
II Podsol	0,31	64,8	10,0	25,2

*Based on Fink (1992).

7. Magnesium in the plant

7.3 Magnesium exigency in the soybean crop

Plant Part	Mg	MgO	Mg	MgO
	kg t^{-1} of grain		kg 3,6t	
Grain	2,8	4,6	10	**16,6**
Cultural residual	7,2	12	26	**43,1**
Total	10,0	16,6	36	**59,7**
% exported	**28**	**28**	**28**	**28**

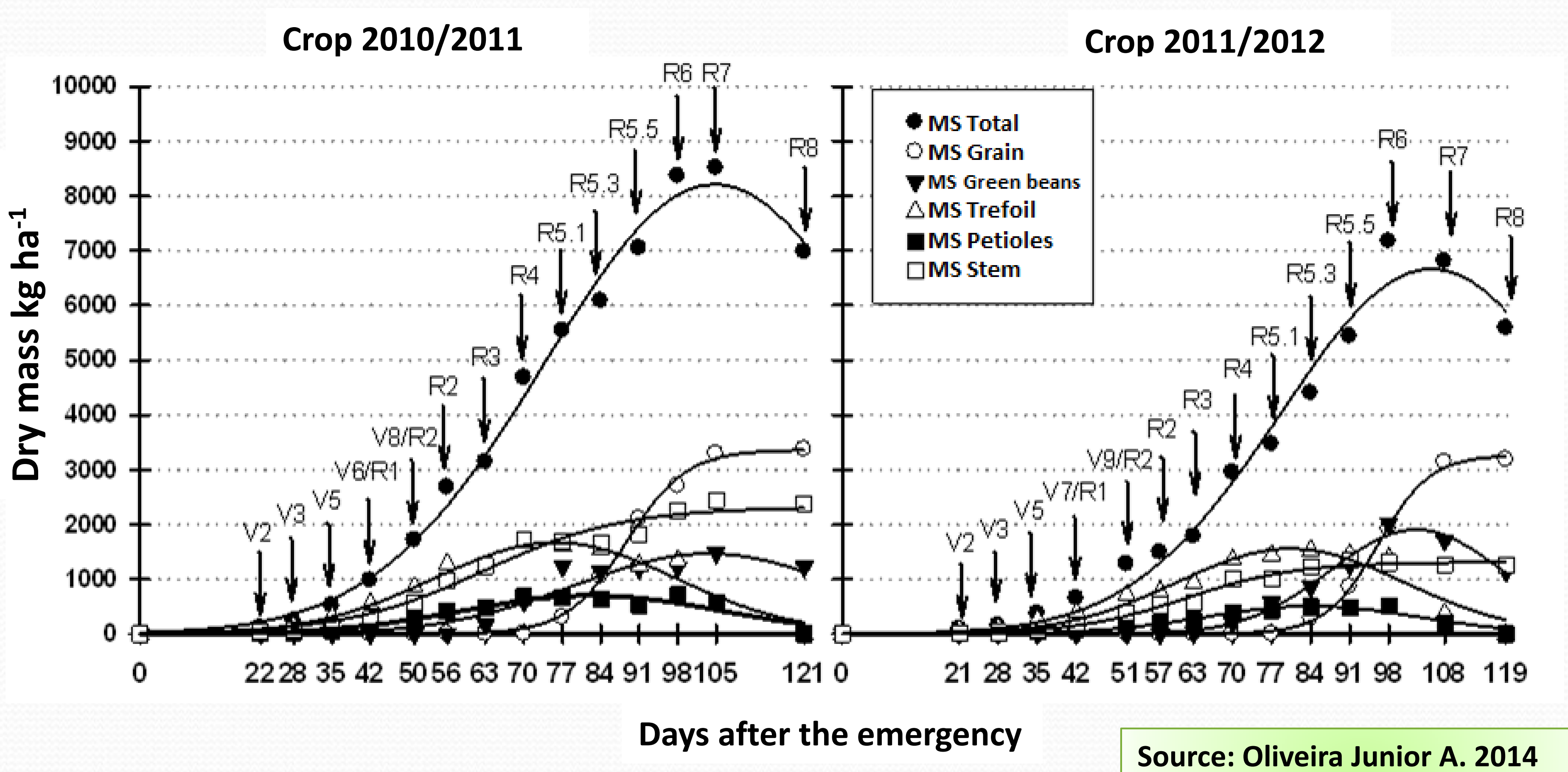
* 3,6t = 60 scs ha

(Oliveira Jr. et al., 2014)

7. Magnesium in the plant

7.4. Nutritional requirement

Uptake rate: Dry Mass

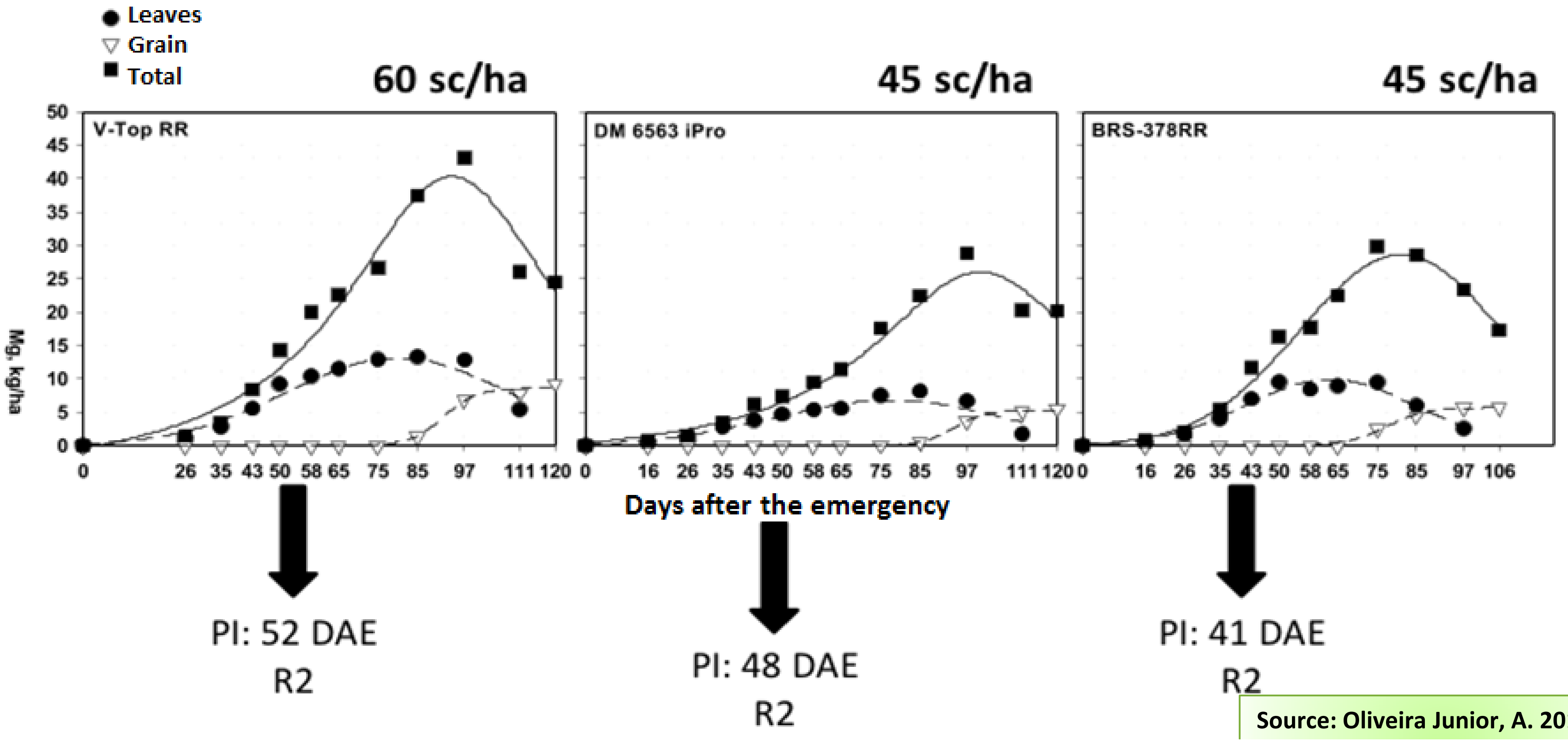


Source: Oliveira Junior A. 2014

7. Magnesium in the plant

7.4. Nutritional requirement

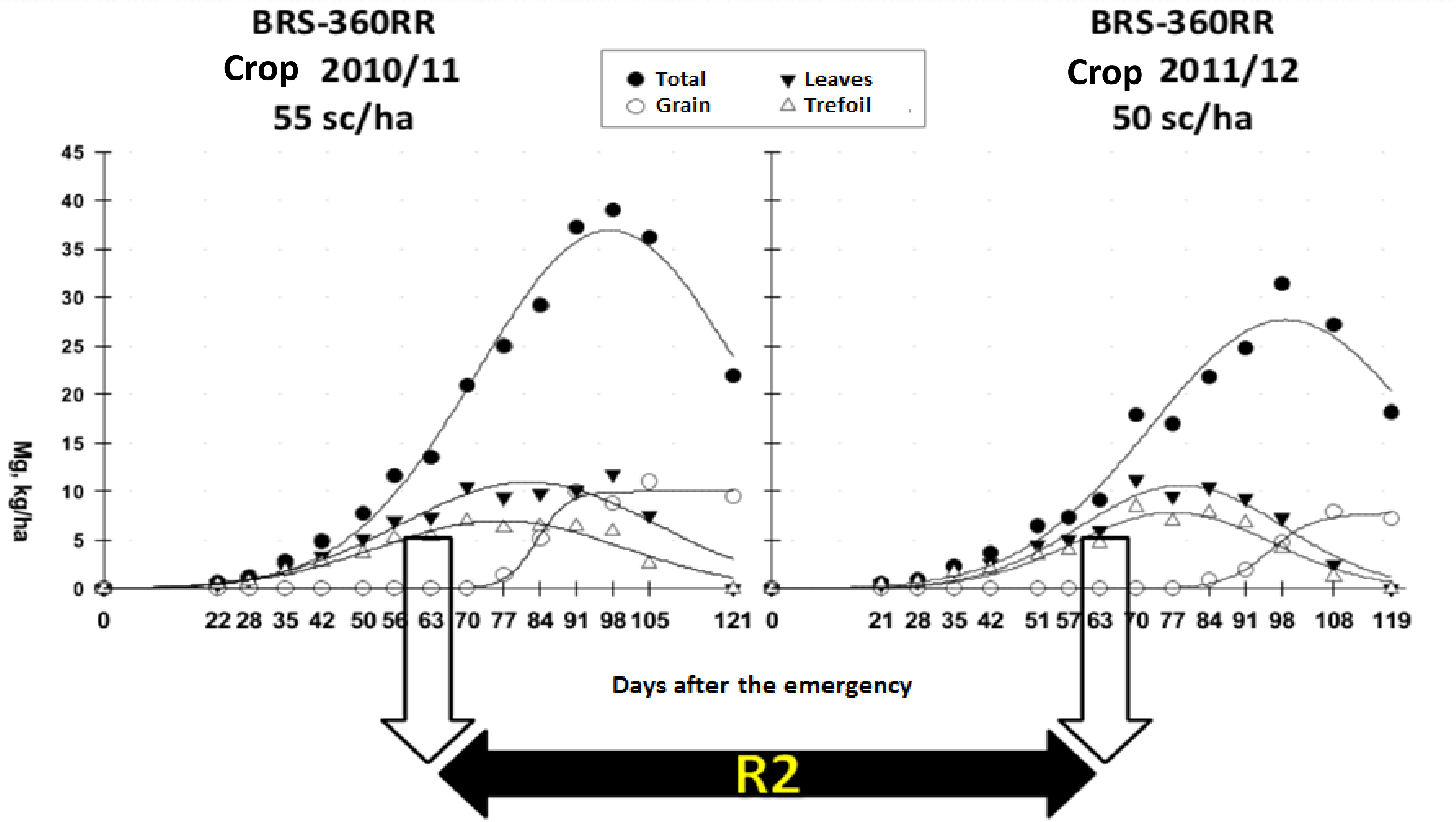
Accumulation Mg – 3 cvs, crop 2013/2014, Londrina/PR



Source: Oliveira Junior, A. 2014

7. Magnesium in the plant

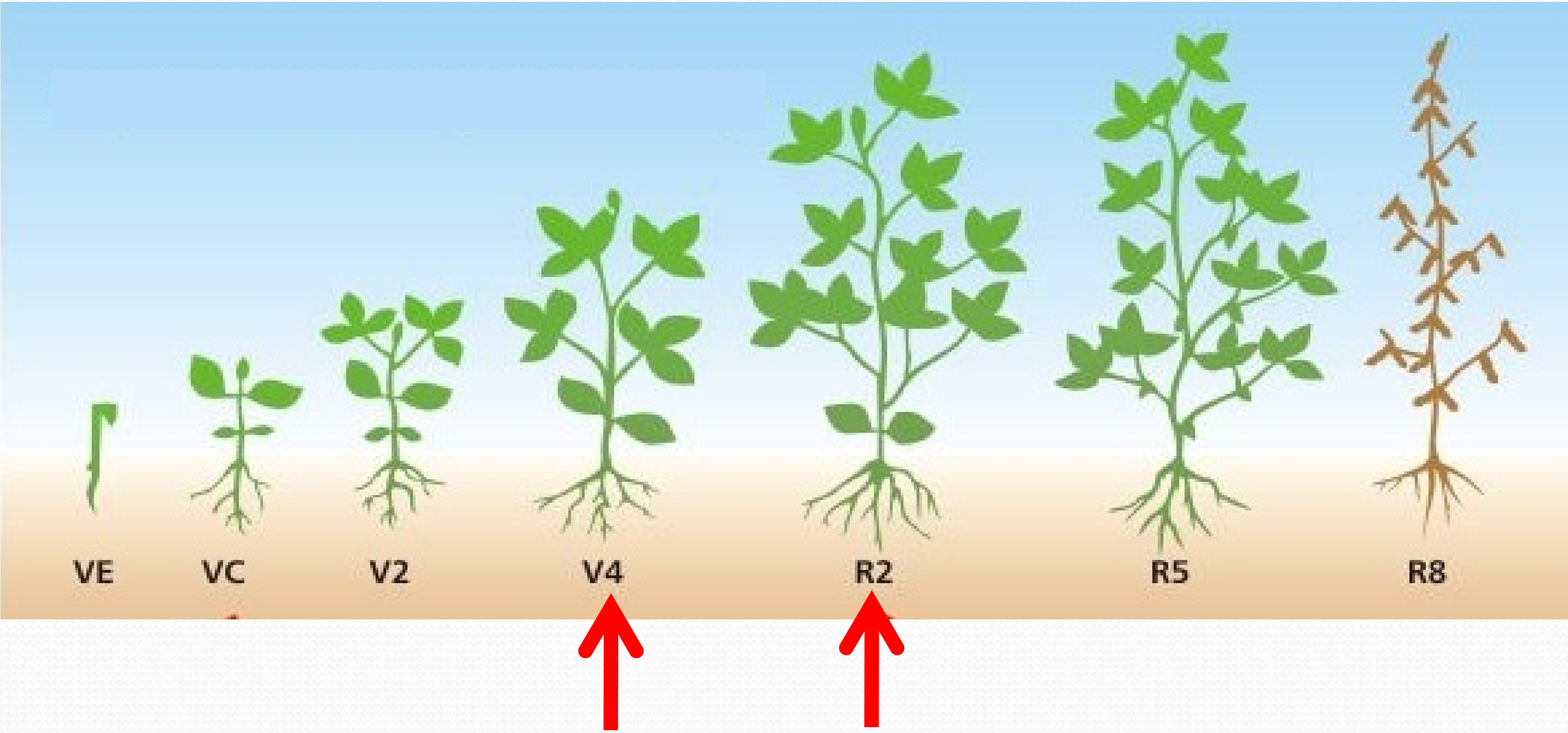
7.4. Accumulation of Mg – Londrina/PR



Source: Oliveira Junior A. 2014

7. Magnesium in the plant

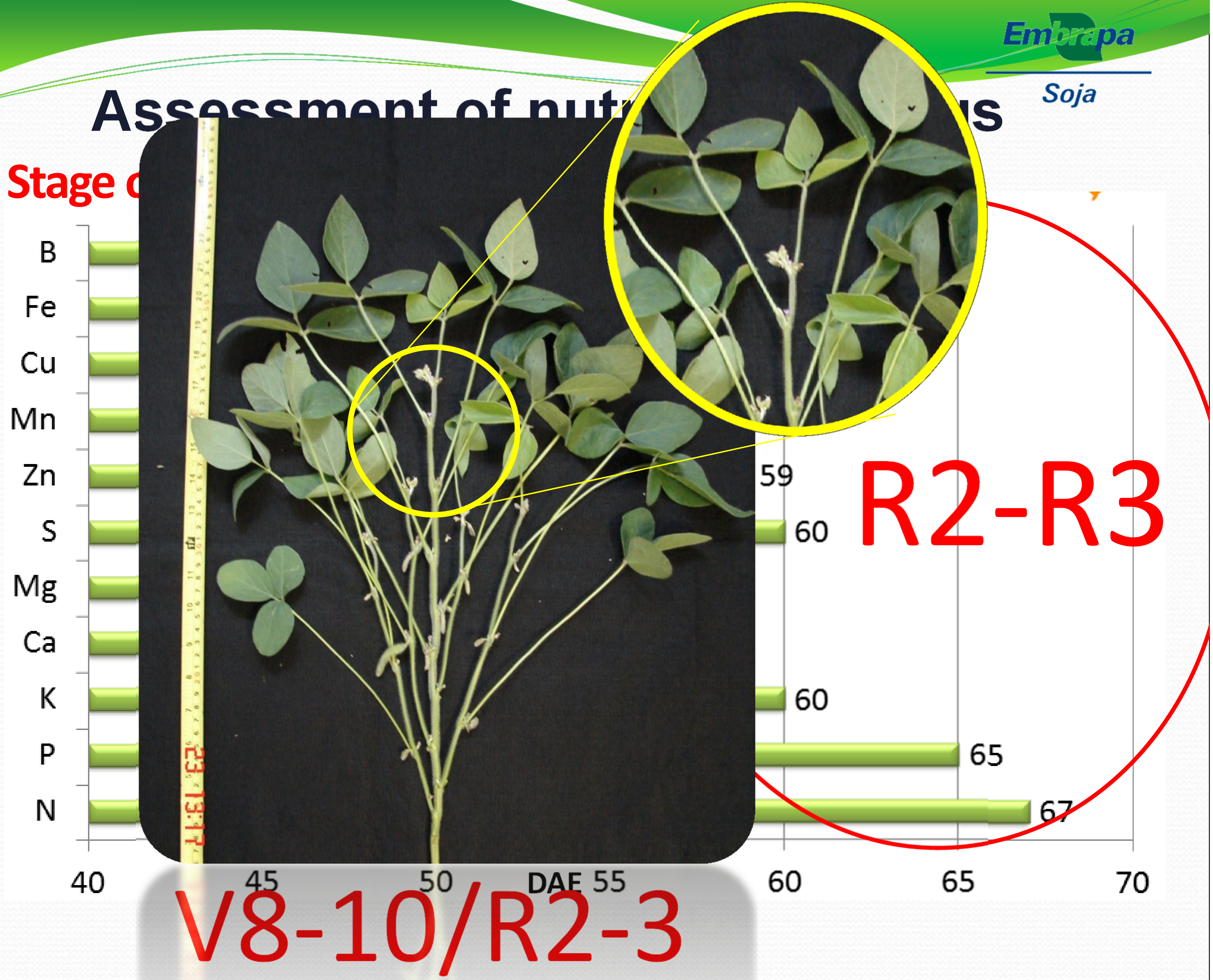
7.5. Soybean Phenology



Source: Iowa State University, Special Report, n.53, 1988.

Assessment of nut... us

7.6. Stage o...



7.7. Foliar diagnosis

Leaf type: ***a)*** 3° or 4 ° trefoil from the apex, without the petiole (EMBRAPA, 2001)

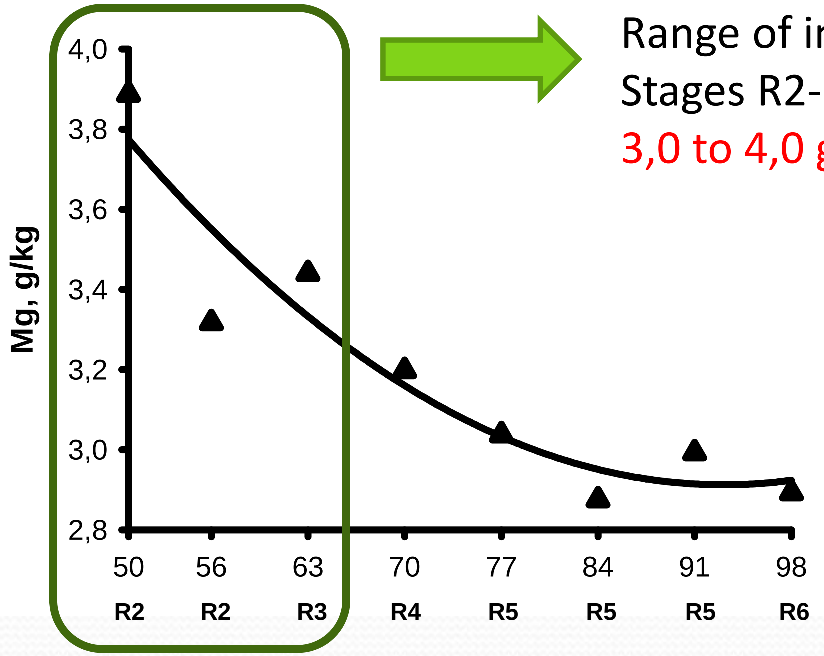
Period: Beginning of the flowering

(V8 – V10/R2 – R3)

Plants number: 30

7.7. Foliar diagnosis

Mg concentration in the third trifoil in function from evolution of reproductive stages



Range of interpretation leaf:
Stages R2-R3
3,0 to 4,0 g kg = **ADEQUATE**

Variety BRS-360RR
Embrapa Soybean, Londrina, PR, Crop 2010/2011

8. Foliar application

8.1. Purpose

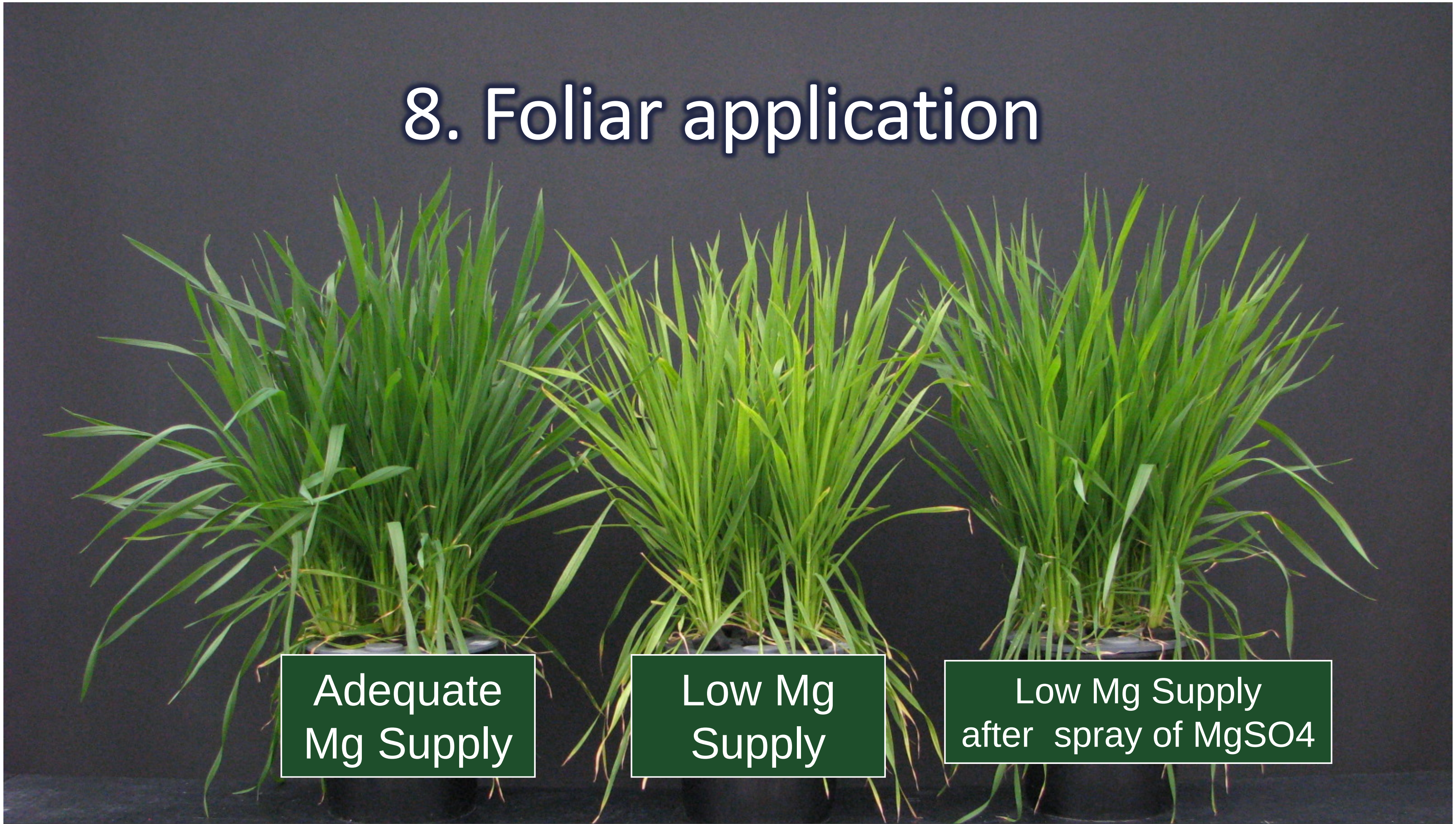
- Due to the higher mobility into the plant, the magnesium can be applied foliar;
- It´s one of the nutrient faster absorbed for foliar.
- Deficiency of magnesium can be readily recovered by foliar application, the carbohydrate pumping can be restored into the phloem within 1 day after the adequate supply of Mg

Effect of the applied foliar of magnesium sulfate in the desiccation of the rachis

Treatment	% Grapes with disease
Control	50,2
3 applier foliar of 12% MgSO4	7,3

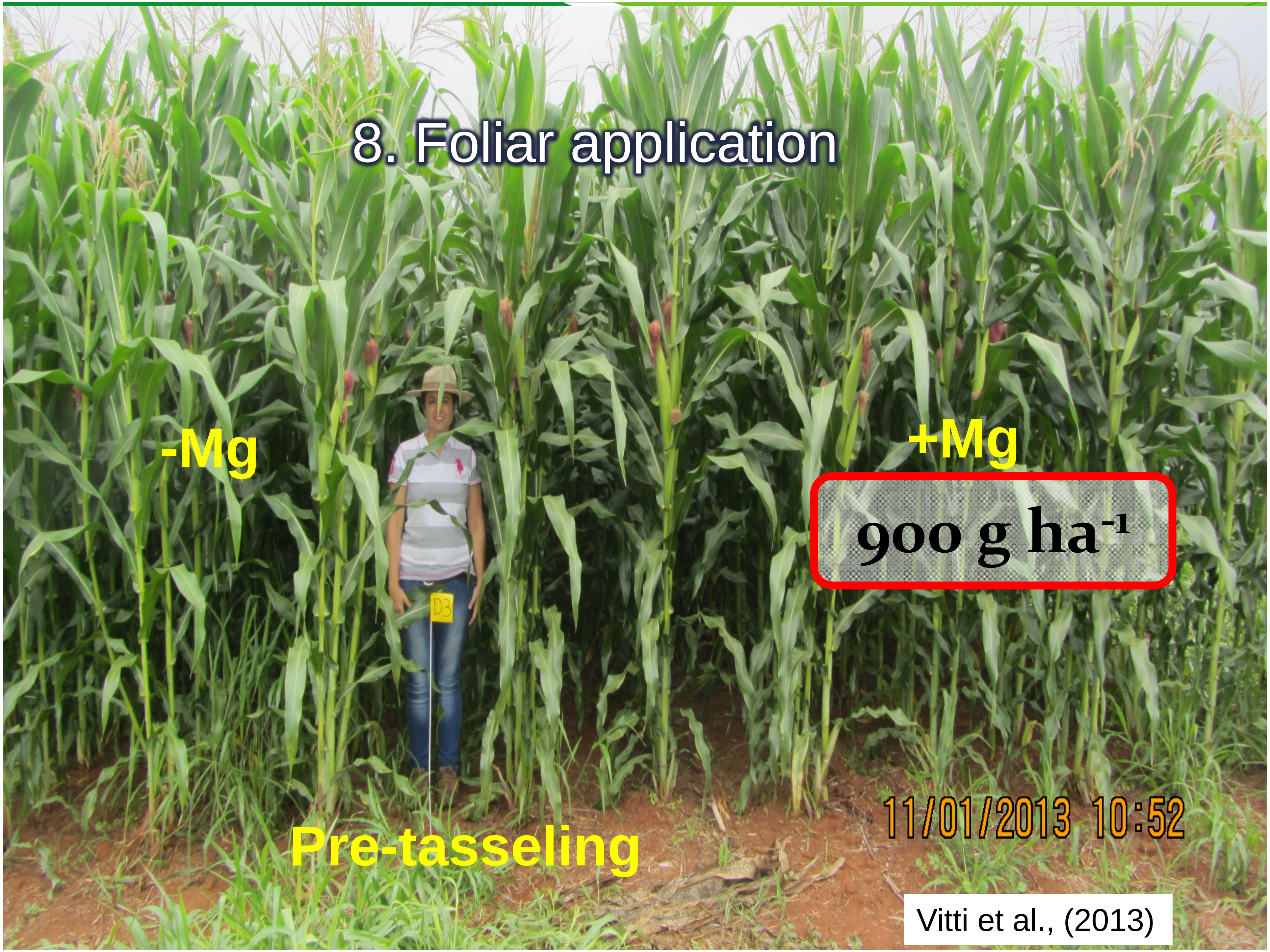
Source: Mengel & Kirkby, 2001

8. Foliar application



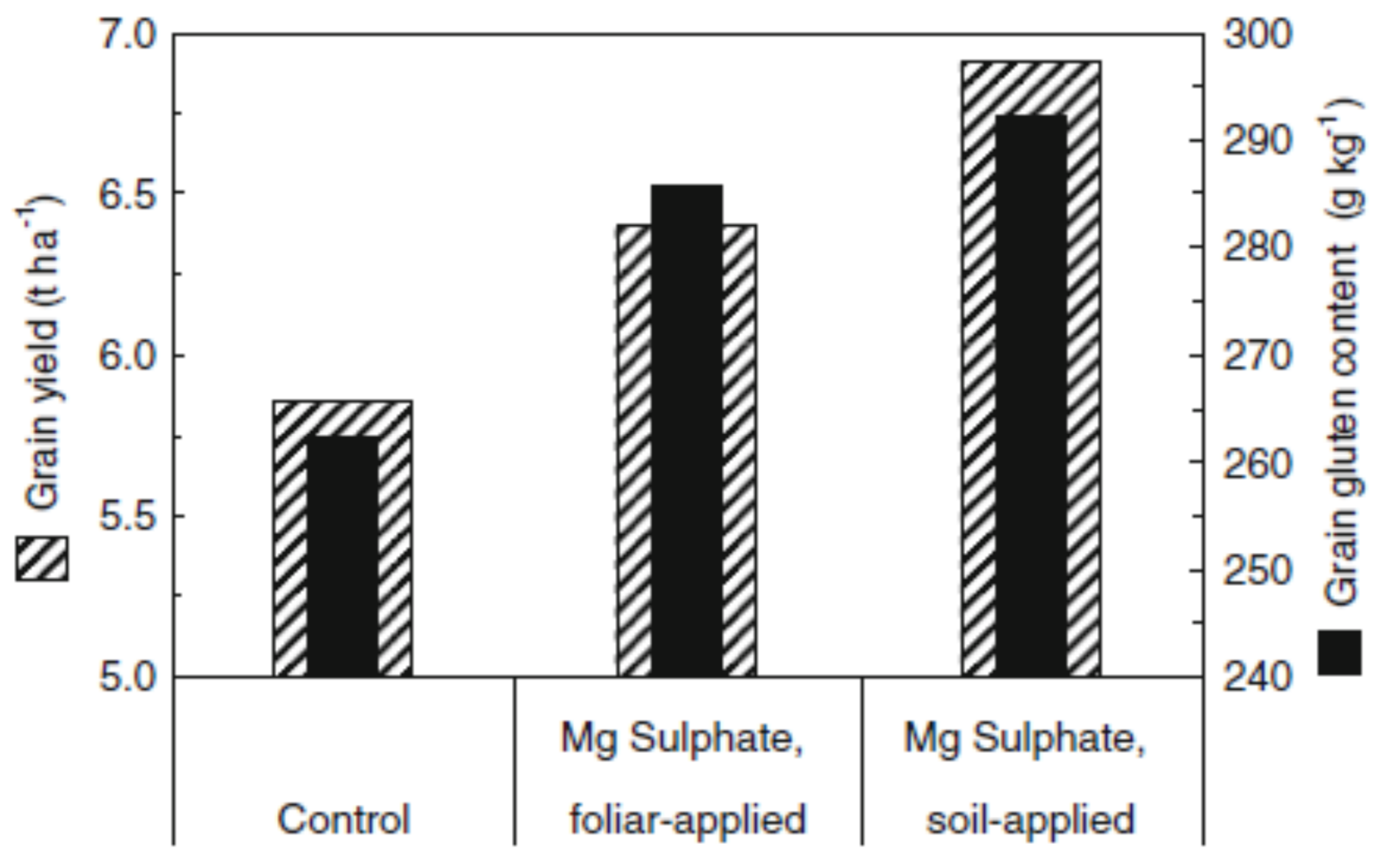
2 x 600 g ha-1 Mg
(MgSO4.7H2O)

(Cakmak and Kirkby, 2008)


8. Foliar application
-Mg
+Mg
900 g ha-1
11/01/2013 10:52
Pre-tasseling
Vitti et al., (2013)

8. Foliar application

Magnesium influence in the concentration of oil and protein in soybean .



(Gerendás & Fuhrs, 2013)

8. Foliar application

8.2. Relation Mg x K x Mn

Fertilization with potassium x foliar magnesium *

K_2SO_4 g m^{-2}	Foliar Mg g kg^{-1}
0	4,5
90	2,4
180	2,0
270	2,3

*Extracted of Johns & Vimpany, 1999

Increase effect of the magnesium concentration in the substrate on rates of absorption of manganese and magnesium in plants roots of soybean*.

Nutrient	Manganese Supplementation (µM)		
	1,8	90	275
Manganese	0,5	3,1	4,8
Magnesium	121,8	81,1	20,2

*** The data represent micromoles of nutrient absorbed by gram of weight dry of the root. Based on Heenan & Campbell (1981).**

8. Foliar application

8.4. Magnesium soluble sources

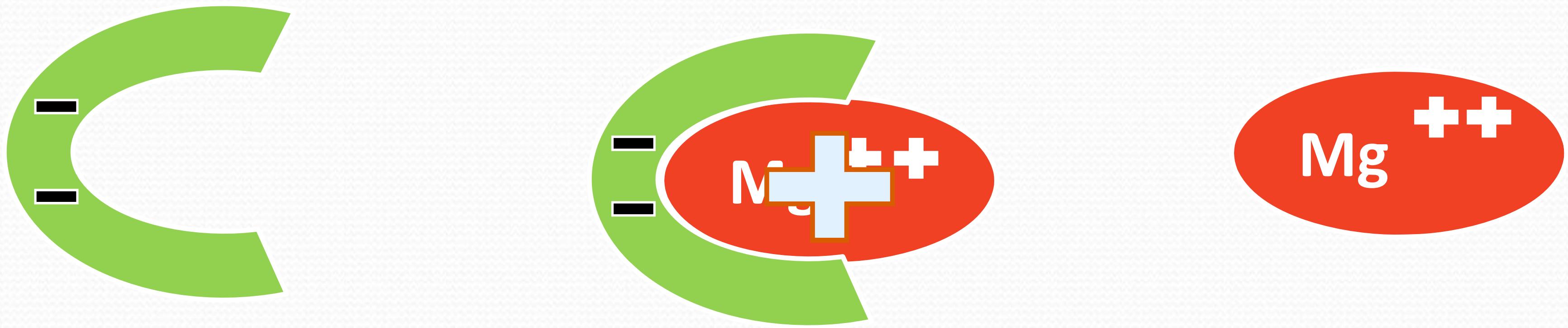
Mg Sources	Formula	%Mg	Solubility in water g $100ml^{-1}$
Mg Sulfate (Epsomite)	$MgSO_4.7H_2O$	9,0	71,00
Mg Chelate(*)	Mg – O.M.	7,0	60,00
Mg Phosphite	$MgHPO_3$	11,5	50,00
Mg Chloride	$MgCL_2.6H_2O$	10,0	54,25
Mg Nitrate	$Mg(NO_3)_2$	8,0	50,00

(*)Chloride based

8. Foliar application

8.4. Fertilizer chelated

Magnesium chelated

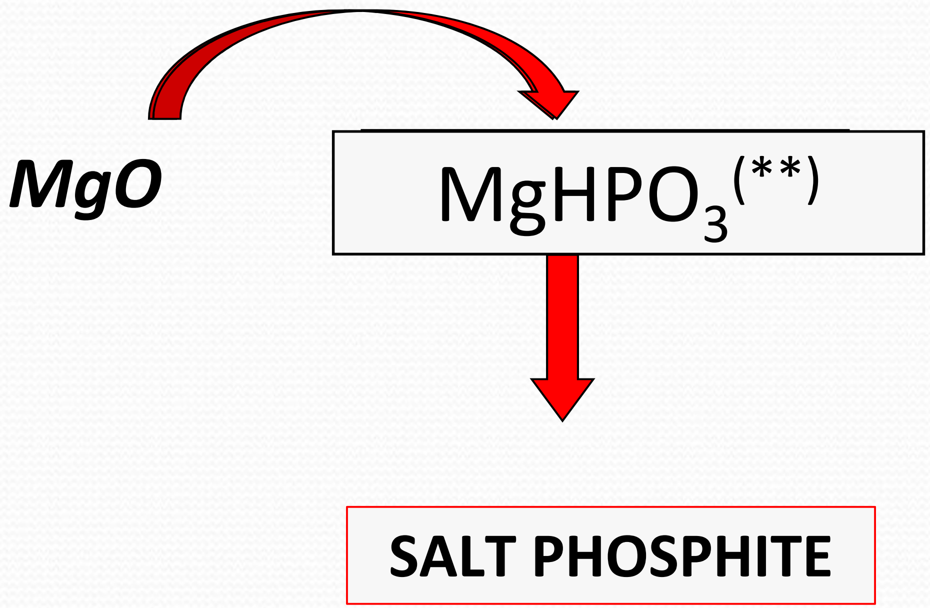


The chelatization avoids reactions that unavailable the nutrients

8. Foliar application

8.4. Fertilizer Phosphites

- **Compound originated of the acid phosphorous neutralization (H_3PO_3) by a base.**
- **Compound are phytotoxic and have high activity fungistatic.**



ACID PHOSPHOROUS + BASE (oxides, hydroxides or carbonates with micronutrients)

8. Foliar application

8.4. Fertilizer Phosphites

Phosphites advantage

- Quick absorption (roots, leaves and cortex of the trunk)
- Assimilate in its totality, differently of the fosfates
- Requires less energy of the plant
- Excellent complexing, favors absorption of B, Zn, Mo, K and other elements.
- Control and prevention of fungal diseases:
  - Phytoalexines (preventive action)
  - Inhibition of the fungal development (curative action)
- Allow mixtures with other products
- Some formulation of phophites can reduce the pH of the solution improving the efficiency of some herbicides.

Foliar application of magnesium in the soybean crop

Site: Uberlândia – MG: 19°12' 23" S
47°59' 43" W
730 m altitude

- Genetic Material: AN 5909 RG (premature – 100 days);

- Spacing: 0,5 m

- Rain during the cycle: 498 mm

Source: Vitti et al, 2014

Foliar application of magnesium in the soybean crop

Depth	pH (CaCl$_2$)	P	S	K	Ca	Mg	Al	H+Al	SB	CTC	V	m
		mg.dm^{-3}		mmolc.dm^{-3}							%	
0-20 cm	5,2	26	18	2,5	35	8	0	31	45,2	76,0	60	0
20-40 cm	5,0	11	80	1,9	17	4	0	34	22,7	56,9	40	0
40-60 cm	4,8	4	102	1,3	11	3	1	34	14,9	49,1	30	0

* Collected on the day of installation of experiment

Depth	B	Cu	Fe	Mn	Zn
	mg.dm^{-3}				
0-20 cm	0,53	0,8	32	1,2	1,5
20-40 cm	0,51	0,7	23	0,5	0,6
40-60 cm	0,42	0,6	14	0,5	0,2

Ca : Mg : K

14 : 3,2 : 1

Depth	Sand	Silt	Clay
	g.Kg^{-1}		
0-20 cm	121	29	850
20-40 cm	116	22	862
40-60 cm	109	19	872

Source: Vitti et al, 2014

Foliar application of magnesium in the soybean crop

Treatments with the use of Magnesium Sulfate

Treatment	Mg Dose (g ha^{-1})	Application period
1 (control)	–	-
2	25	V4
3	50	V4
4	100	V4
5	250	V4
6	500	V4
7	1000	V4
8	25	R1
9	50	R1
10	100	R1
11	250	R1
12	500	R1
13	1000	R1
14	25	R5.1
15	50	R5.1
16	100	R5.1
17	250	R5.1
18	500	R5.1
19	1000	R5.1

Source: Vitti et al, 2014

Foliar application of magnesium in the soybean crop

Supply of nutrients prior to the begin of sowing

N	P_2O_5	K_2O	B
kg ha^{-1}			
12	59	30	0,33

Liming: correction to V%=60;

Source: Vitti et al, 2014

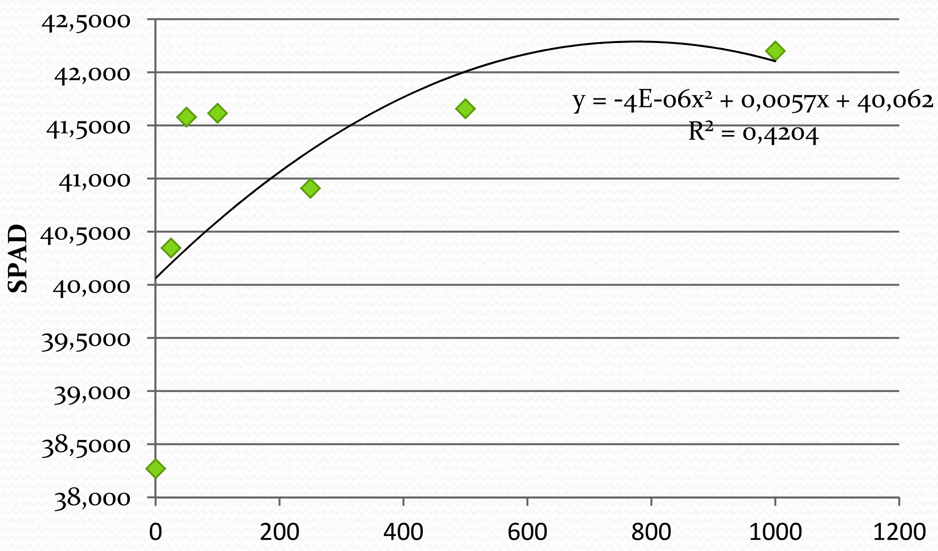
Foliar application of magnesium in the soybean crop

Foliar application of magnesium in the soybean crop

Figure. Reading SPAD in the 3º trefoil expanded of main branch from top to bottom.

Foliar application of magnesium in the soybean crop

Index SPAD from the soybean leaves in R6 (grain filling in the third trefoil of 10 plants).



Period	Middle
V4	40,4 b
R1	40,9 ab
R5.1	41,5 a
DMS	1,0

Tukey 5%

Conclusion: There was an increase in the index SPAD by foliar application of Mg independent of the application period.

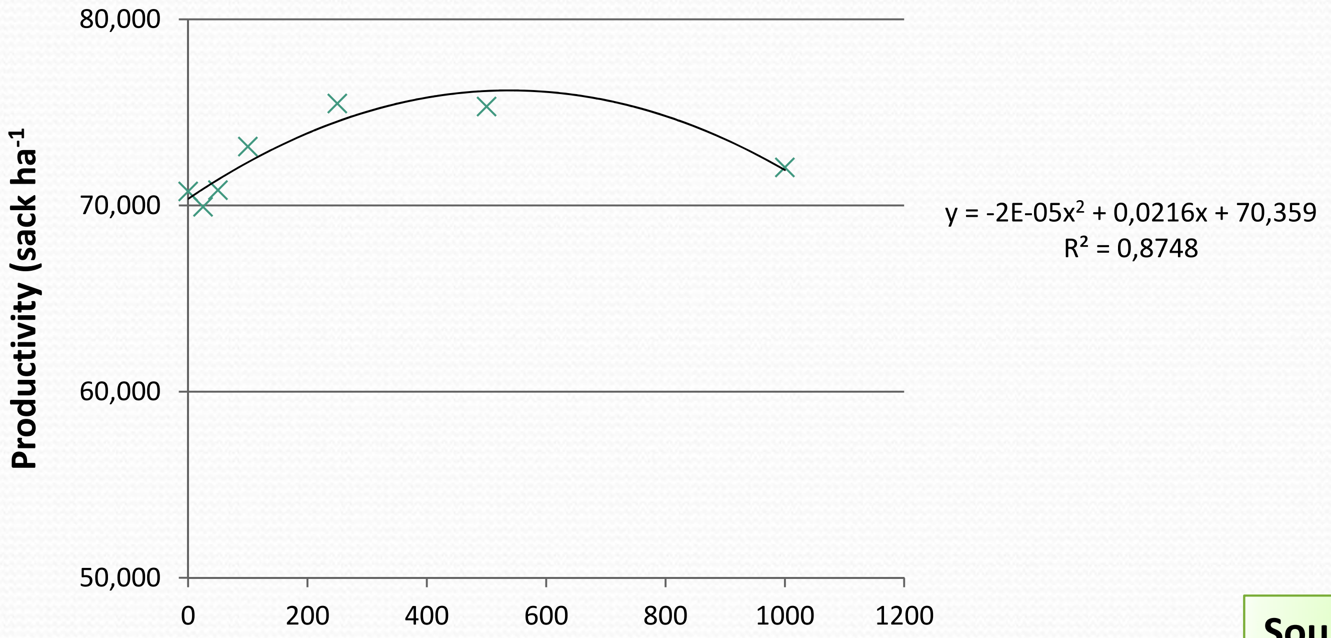
Source: Vitti et al, 2014

Foliar application of magnesium in the soybean crop

Figure. Experimental units without side border.

Foliar application of magnesium in the soybean crop

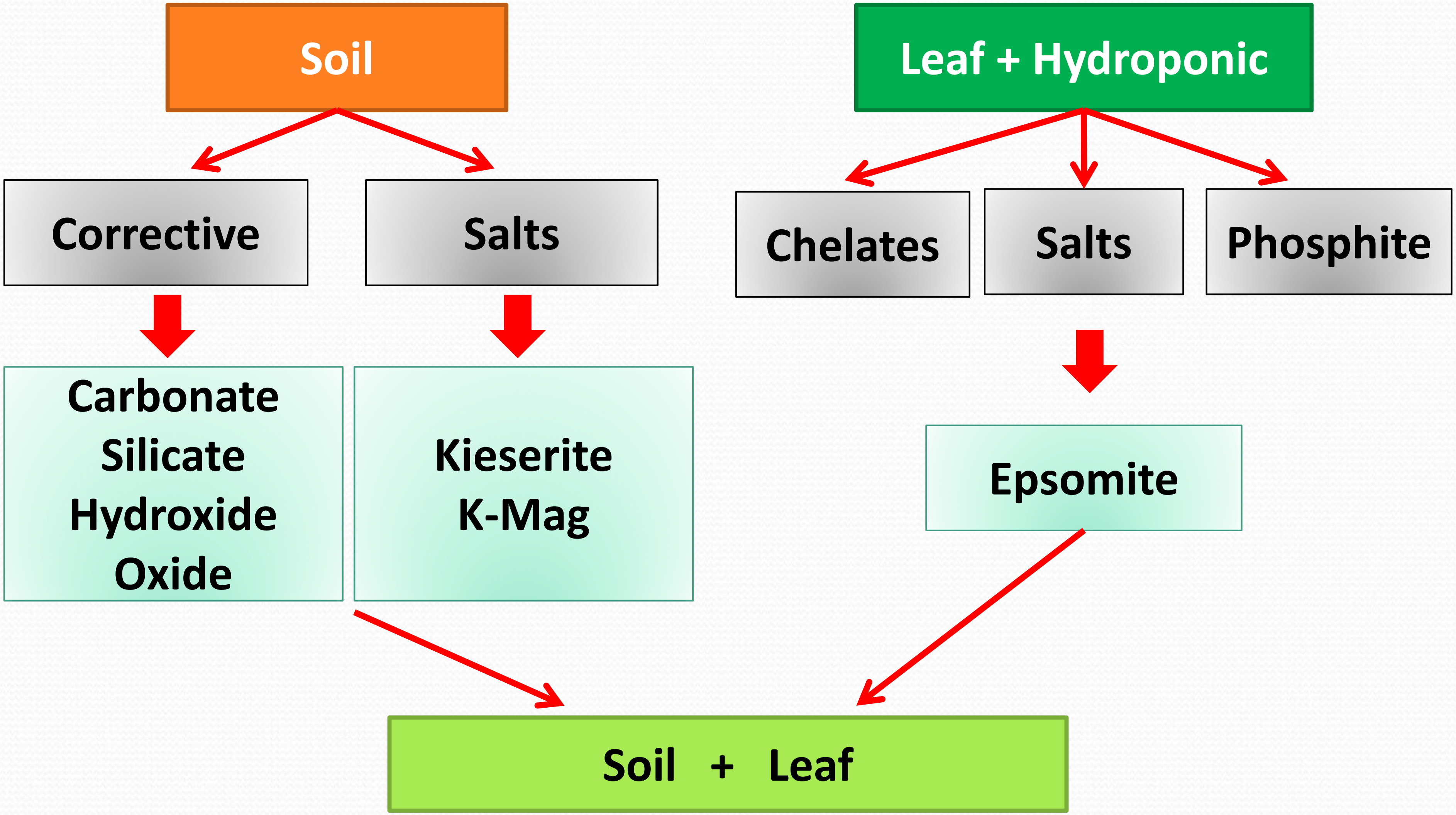
Soybean productivity in function of the Mg dosis, in middle of the application period.



Source: Vitti et al, 2014

➢ **The foliar application of Mg increase resulted in the productivity of grain independently of the application period, being that the maximum productivity was achieved at dose of 525 g ha^{-1} of Mg with productivity of 75,9 sc ha^{-1}, or 5,1 sc ha^{-1} superior to treatment control (with Mg), demonstrating the viability of the foliar application of magnesium in the soybean crop.**

Mg management in the plant nutrition



9. Conclusions

The yield potential of soybeans, mainly in tropical regions is limited by Mg deficiency.

Soybeans in tropical regions, with the occurrence of stress (high light intensity, high temperature, water deficit) associated with magnesium deficiency, generates free radical in chloroplasts, which reflect in reactive oxygen species, mainly peroxide, leading to damage by irreversible oxidation of lipids, membranes, DNA mutation, chlorosis and protein breakdown which are mitigated by adequate magnesium nutrition.

9. Conclusions

The supply of Mg by liming has not been efficient, due to its eventual use by farmers, low reactivity, besides of competitive inhibition with potassium, highly soluble and readily available.

The deficiency of magnesium is also enhanced by foliar application of potassium during grain filling, as well as by application of Mn, both cations exhibit competitive inhibition, decreasing Mg its metabolism in plant.

The foliar application of Mg in small doses (500-1200 g ha^{-1}) using soluble sources (sulfates, chelates, phosphites) in stages of the V4 - R5.1, enhances the photosynthetic rate, favoring carbohydrates pumping into the phloem and reestablishing adequate nutrition until day after its delivery.

Contact us:

Prof. G.C.Vitti <gcvitti@usp.br>

Dr. Thiago Augusto de Moura <tamoura01@gmail.com>

Dra. Fernanda Latanze <fernandalatanze@gmail.com>

Phone: +55 19 3417-2138

Foto: Rivian Ferreira Dias