VIII.b. MAGNESIUM

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Outline

- 6.1 Introduction
- 6.2 Functions & Forms of Mg in Plants
- 6.3 Mg Cycles
- 6.4 Soil Mg resources
- 6.5 Soil Mg availability
- 6.6 Agronomic role of Mg
- 6.7 Mg Management

6.1 INTRODUCTION

- Magnesium is macro nutrient (essential and required in high amount)
- Magnesium in acid mineral soil is limiting factor for high crop productivity.
- Mg deficiency : in Inceptisol, Ultisol, soil developed from quart, acid mineral soil. Why …?
- Mg
- How to manage Mg?

6.1 INTRODUCTION

- Scr umum, Mg dalam tanah sering ketersediaannya rendah dan tidak mencukupi kebutuhan Mg untuk produksi tanaman yang tinggi.
- Akibatnya tanaman sering menunjukkan gejala defisiensi Mg
- Oki, utk produksi yang tinggi perlu penambahan Mg
- Mg sering ditambahkan dalam kegiatan ameliorasi
- Bgm pengelolaan Mg yang efektif dan efisien, faktor-faktor apa saja yang mempengaruhi efektivitas dan efisiensi tersebut?.

6.2. FUNCTIONS & FORMS OF Mg IN PLANTS

Table 2.1 Functions in Plants and Deficiency Symptoms of Plant Nutrients (Continued)

Nutrient (forms absorbed)	Functions in plants	Deficiency symptoms
Magnesium (Mg^{2+})	Component of chlorophyll, hence essential for food synthesis in plant	Light green leaves and yellowing of leaves similar to N. In rapeseed the leaves are cupped inward

6.2. Mg IN PLANTS

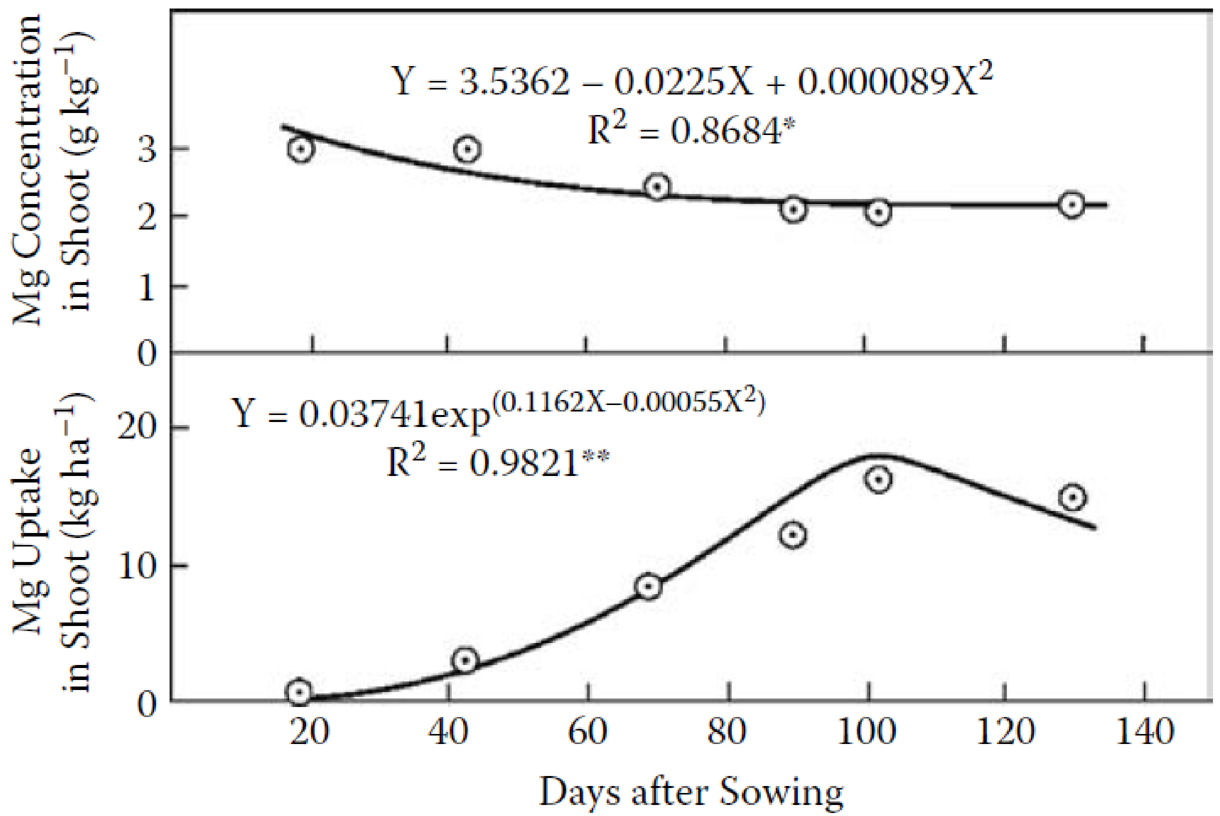


FIGURE 6.1 Magnesium concentration and uptake in upland rice as a function of plant age.

6.2. Mg IN PLANTS

TABLE 6.3
Magnesium Sufficiency Values in the Plant Tissues of Principal Crop Species

Crop Species	Growth Stage	Plant Part	Mg Sufficiency Level (g kg^{-1})
Wheat	Heading	Whole tops	1.5–5.0
Barley	Heading	Whole tops	1.5–5.0
Rice	100 days after sowing	Whole tops	1.7–3.0
Corn	30 to 45 days after emergence	Whole tops	3.0–8.0
Corn	Before tasseling	Leaf blade below cob	2.5–5.0
Sorghum	Vegetative	Young uppermost mature leaf blade	2.0–5.0
Soybean	Prior to pod set	Upper fully developed trifoliate	11.0–15.0
Dry bean	Early flowering	Upper fully developed trifoliate	4.0–8.0
Cowpea	Early flowering	\petiole of uppermost mature leaf blade	1.7–3.1
Peanut	Early pegging	Upper stems and leaves	3.0–8.0

Source: Adapted from Fageria et al. (1997).

6.2. Mg IN PLANTS

TABLE 6.4
Influence of Calcium Concentration on Uptake of Potassium and Magnesium by Rice Plants in Nutrient Solution

Calcium Concentration (μM)	Mg^{2+} Uptake Rate (μg g^{-1} h^{-1} Root Dry Weight)	K^+ Uptake Rate (μg g^{-1} h^{-1} Root Dry Weight)
6.23	3.80	24.49
12.47	5.06	36.09
49.90	25.70	150.67
74.79	52.59	226.56
124.75	57.41	400.00
249.50	62.49	433.42
499.0	46.46	355.25
748.0	30.76	336.00
R^2	0.66*	0.77*

* Significant at the 5% probability level.
Source: Adapted from Fageria (1973b).

6.2. Mg IN PLANTS

TABLE 6.5
Uptake of Mg^{2+} by Principal Field Crops

Crop Species	Mg Uptake in Shoot ($kg\ ha^{-1}$)	Mg Uptake in Grain ($kg\ ha^{-1}$)	Total Uptake ($kg\ ha^{-1}$)
Upland rice[a]	15	5	20
Lowland rice[b]	15	7	22
Lowland rice[b]	15	6	21
Corn[a]	20	9	29
Dry bean[a]	7	4	11
Dry bean[a]	7	6	13
Soybean[a]	14	10	24
Soybean[a]	20	10	30

[a] Oxisols.
[b] Inceptisols.
Source: Adapted from Fageria (2001a), Fageria (2004), Fageria and Santos (2008), Fageria et al. (2007).

6.2. Mg IN PLANTS

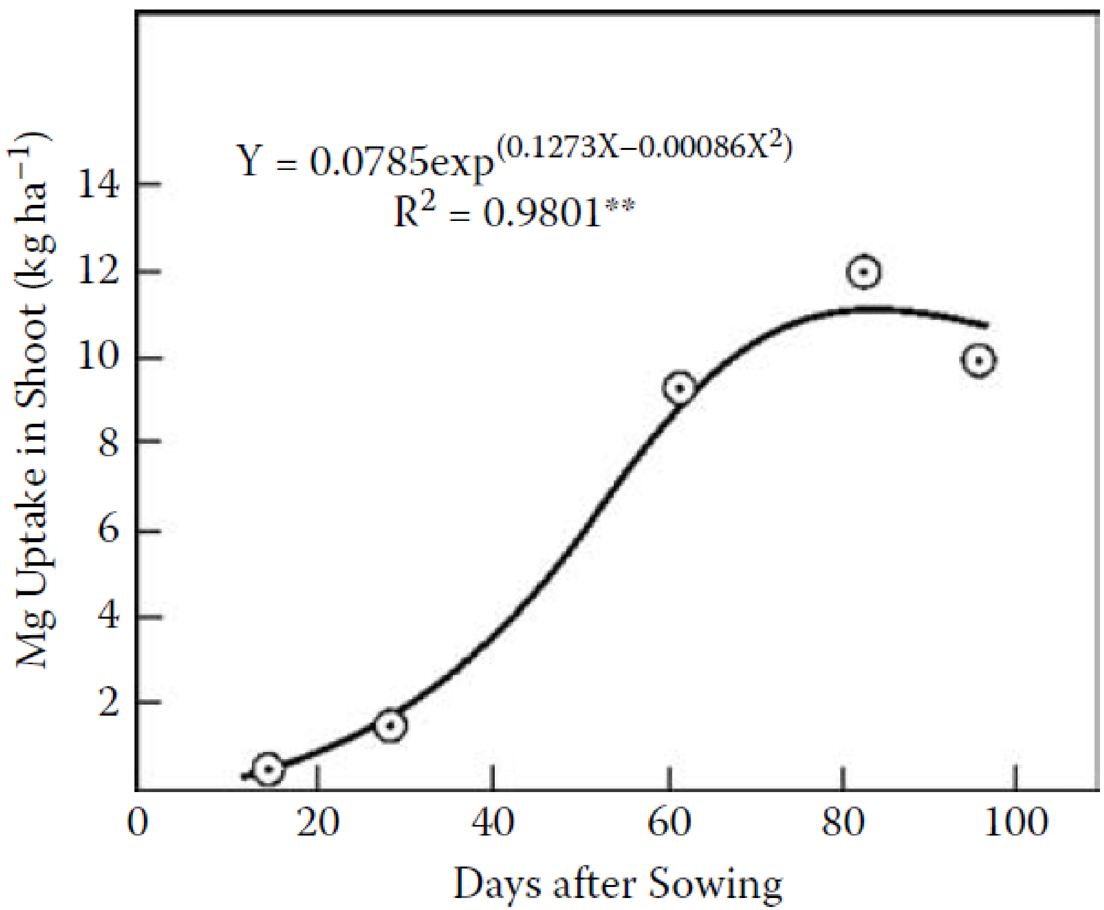


FIGURE 6.2 Magnesium uptake in dry bean plants as a function of plant age.

6.2. Mg IN PLANTS

TABLE 6.7
Grain Yield and Magnesium Harvest Index in Principal Field Crops

Crop Species	Grain Yield (kg ha^{-1})	Mg Harvest Index (%)
Upland rice	4559	25
Lowland rice	4797	32
Lowland rice	6389	29
Corn	8501	31
Dry bean	1912	36
Dry bean	3409	46
Soybean	1441	42
Soybean	3038	33

Note: Magnesium harvest index (%) = (Mg uptake in grain/Mg uptake in grain plus straw) × 100.

6.2. Mg IN PLANTS

TABLE 6.9

Adequate Level of Mg and Mg Saturation for Four Annual Crops Grown in Rotation in Brazilian Oxisol (0–20 cm Soil Depth)

Crop Species	Adequate Mg^{2+} Level ($cmol_c\ kg^{-1}$)	Adequate Mg^{2+} Saturation (%)
Upland rice	1.2	15
Dry bean	1.4	16
Corn	1.4	18
Soybean	1.4	18

Source: Adapted from Fageria (2001a).

8.3 Mg Cycles

- Input: soil Mg sources
- Output: Soil Mg loss
- Process: Mg behaviour in soil

8.3 Mg cycles

8.3 Mg cycles

8.3 Mg cycles

Dalam studi kesuburan tanah, siklus Mg ditinjau dari 3 aspek yaitu: input ke-, output dari- dan proses dalam tanah.

INPUT

1. Residu tanaman
2. Pupuk Mg
3. Kotoran hewan/binatang
4. Deposisi udara
5. Pelapukan batuan ber Mg

8.3 Ca cycles

- Output:

1. Terangkut panen
2. Run off dan erosi
3. Pencucian

8.3 Ca cycles

- Process:

1. CaP organik mengalami dekomposisi
2. Ca anorganik:

   a. Diambil tanaman dan biota tanah

   b. Diikat oleh komponen tanah: liat,

      logam (Al, Fe, Zn… Ca, .. Dll)

8.4. SOIL Mg RESOURCES

1. Pant Residue
2. Ca fertilizer
3. Animal manure/residue
4. Ash (Abu TKKS)
5. Atmosferic Depostion
6. Rock P weathering

8.4.1 Plant Residue

Kadar Ca beberapa tanaman

8.4.2 Mg Mineral

TABLE 6.2
Principal Magnesium-Containing Soil Minerals and Their Composition

Soil Mineral	Formula	Mg Content (g kg^{-1})
Magnesium sulfate	$MgSO_4$	200
Magnesium carbonate	$MgCO_3$	290
Serpentine	$H_4Mg_3Si_2O_9$	490
Dolomitic lime	$CaCO_3.MgCO_3$	130
Montmorillonite	$Al_5MgSi_{12}O_{30}(OH)_6$	Up to 60
Illite	$K_{0.6}Mg_{0.25}Al_{2.3}Si_{3.5}O_{10}(OH)_2$	20
Vermiculite	$Mg_3Si_4O_{10}(OH)_2.2H_2O$	120–170
Olivine	$Mg_{1.6}Fe_{0.4}SiO_4$	250
Chlorite	$Al_2Mg_5Si_3O_{10}(OH)_8$	Up to 230
Brucite	$Mg(OH)_2$	410

Source: Adapted from Barber (1995).

SOIL Mg LOSS

1. Run off and erosion
2. Leaching
3. Removal by crop harvest

8.5. SOIL Mg

TABLE 6.8

Influence of Liming on Mg Content and Mg Saturation in Brazilian Oxisol at Two Soil Depths

Lime Rate	0–20 cm Depth		20–40 cm Depth	
(Mg ha^{-1})	Mg (cmol$_c$ kg^{-1})	Mg Saturation (%)	Mg (cmol$_c$ kg^{-1})	Mg Saturation (%)
0	1.09	13	0.98	13
4	1.14	14	1.09	15
8	1.21	17	1.11	16
12	1.25	16	1.14	15
16	1.25	16	1.16	16
20	1.39	18	1.32	18
R^2	0.23*	0.42**	0.31**	0.48**

*, ** Significant at the 5 and 1% probability level, respectively.

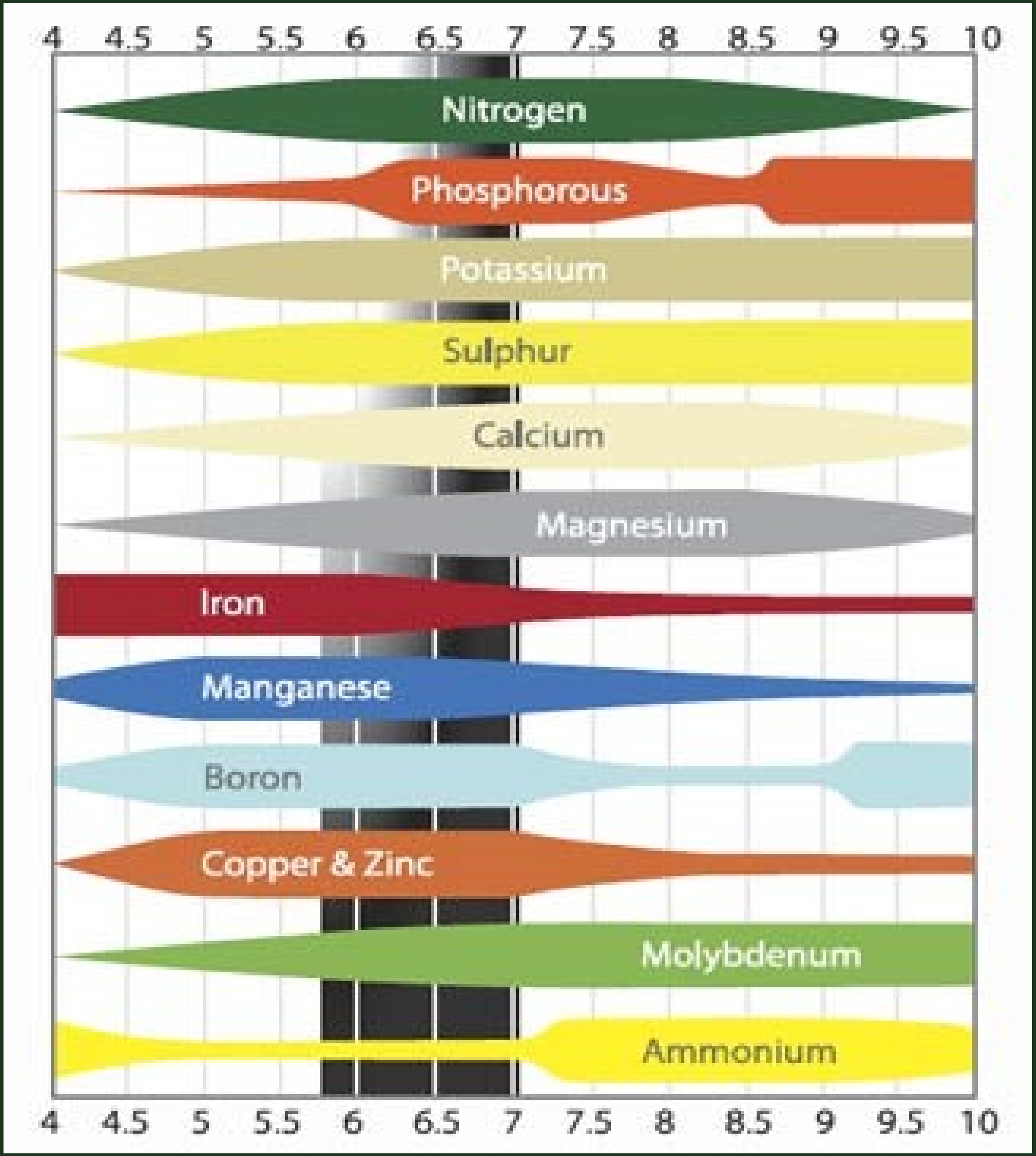
Source: Adapted from Fageria (2001b).

8.6. SOIL Mg AVAILABILITY

8.6.1 Factors affecting Soil Mg availability

- Soil pH
- Organic matter decomposition & mineralisation
  - a. OM quality
  - b. Decomposer
  - c. Environment
- Mineralisation & immobilization

Soil pH


4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
Nitrogen
Phosphorous
Potassium
Sulphur
Calcium
Magnesium
Iron
Manganese
Boron
Copper & Zinc
Molybdenum
Ammonium

OM DECOMPOSITION & MINERALISATION

- Organic matter decomposition & mineralisation determine by:

  a. OM quality

  b. Decomposer

  c. Environment

8.7. AGRONOMIC ROLE OF Mg

5.5.1 Effect of Mg on growth and production

TABLE 6.1

Influence of Magnesium on Root and Shoot Dry Weight of Upland Rice and Dry Bean Grown on Brazilian Oxisol

Mg Level in Soil ($cmol_c\ kg^{-1}$)	Dry Bean Dry Weight ($g\ plant^{-1}$)		Cowpea Dry Weight ($g\ plant^{-1}$)	
	Root	Shoot	Root	Shoot
0.30	0.70	3.01	0.71	2.72
1.05	0.81	3.10	0.75	2.81
1.15	0.83	3.19	0.91	3.11
1.33	0.74	3.19	1.04	3.07
3.52	1.00	3.81	0.87	2.74
6.22	0.56	3.12	0.43	2.03

Regression Analysis

Mg level (X) vs. dry bean root dry wt. $(Y) = 0.5898 + 0.2414X - 0.0393X^2$, $R^2 = 0.8641^*$

Mg level (X) vs. dry bean shoot dry wt. $(Y) = 2.7022 + 0.5490X - 0.0766X^2$, $R^2 = 0.8532^*$

Mg level (X) vs. cowpea root dry wt. $(Y) = 0.6811 + 0.2142X - 0.0413X^2$, $R^2 = 0.8221^{NS}$

Mg level (X) vs. dry bean root dry wt. $(Y) = 2.7611 + 0.2133X - 0.0538X^2$, $R^2 = 0.8938^*$

^{*,NS} Significant at the 5% probability level and nonsignificant, respectively.

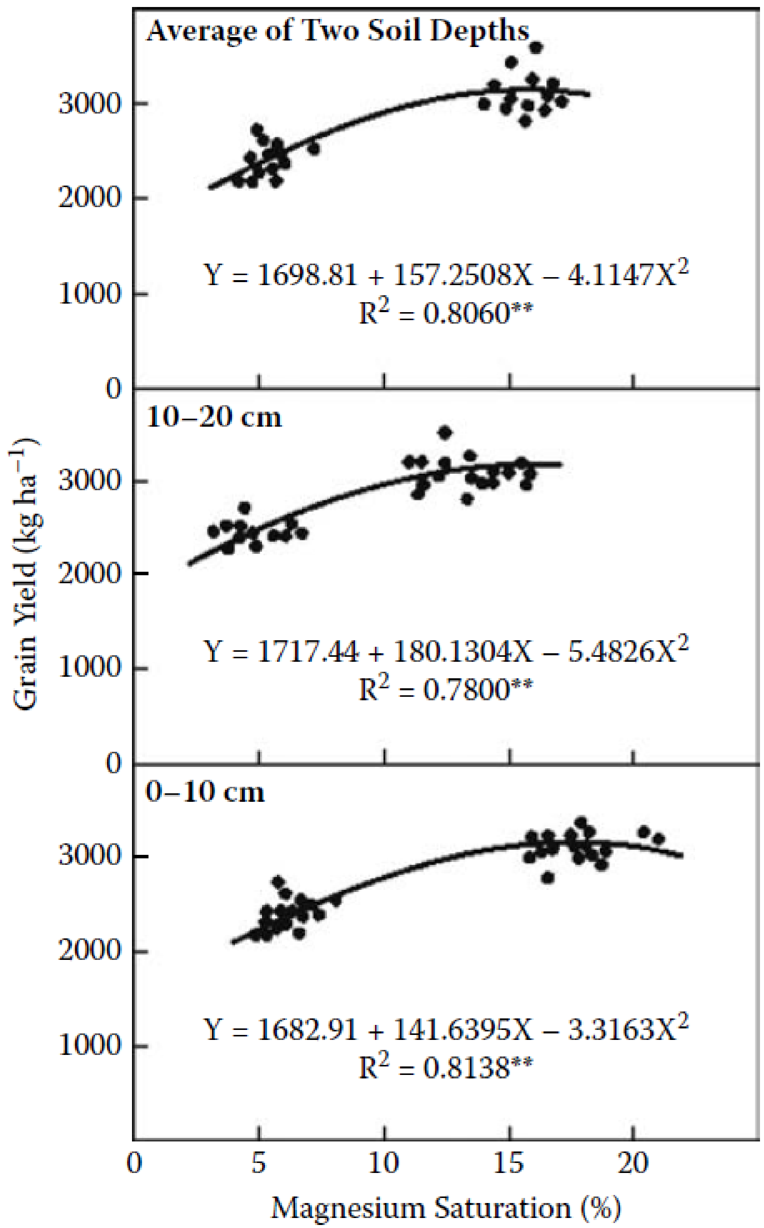


FIGURE 6.5 Relationship between magnesium saturation and grain yield of dry bean.

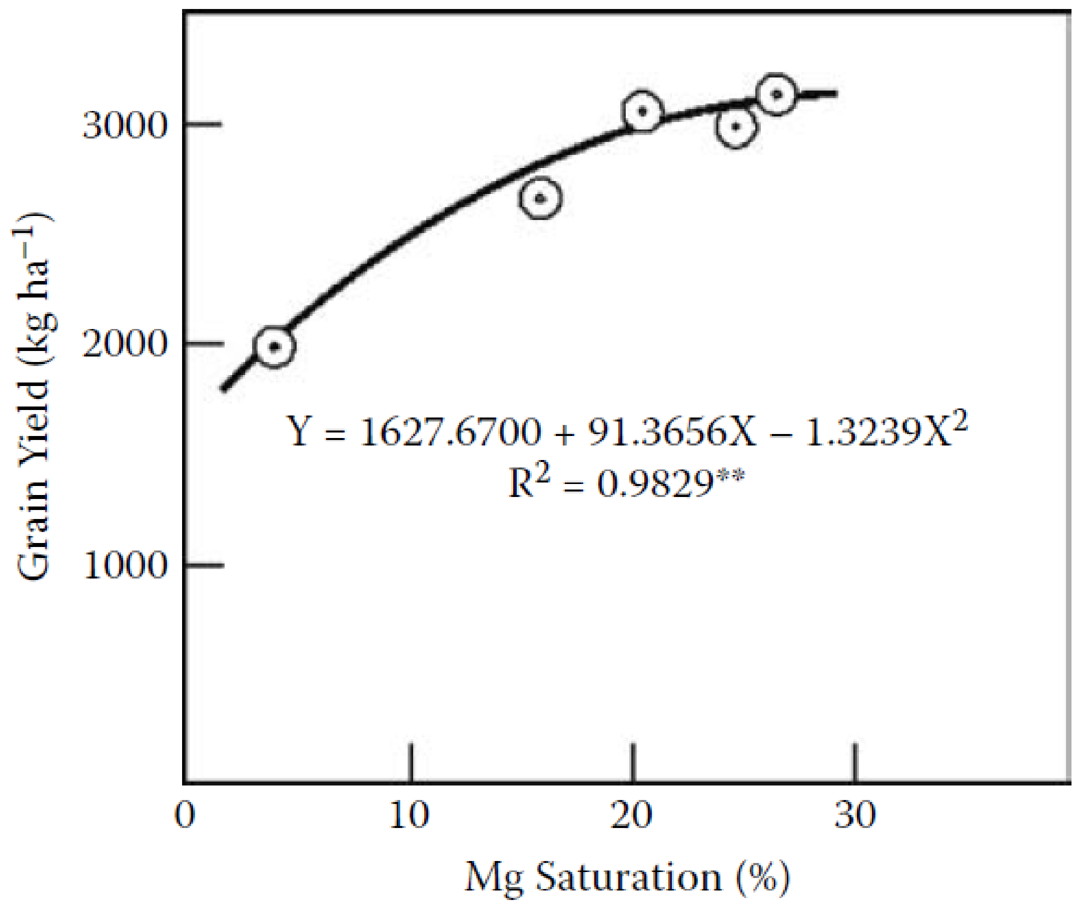


FIGURE 6.6 Relationship between magnesium saturation and grain yield of soybean.

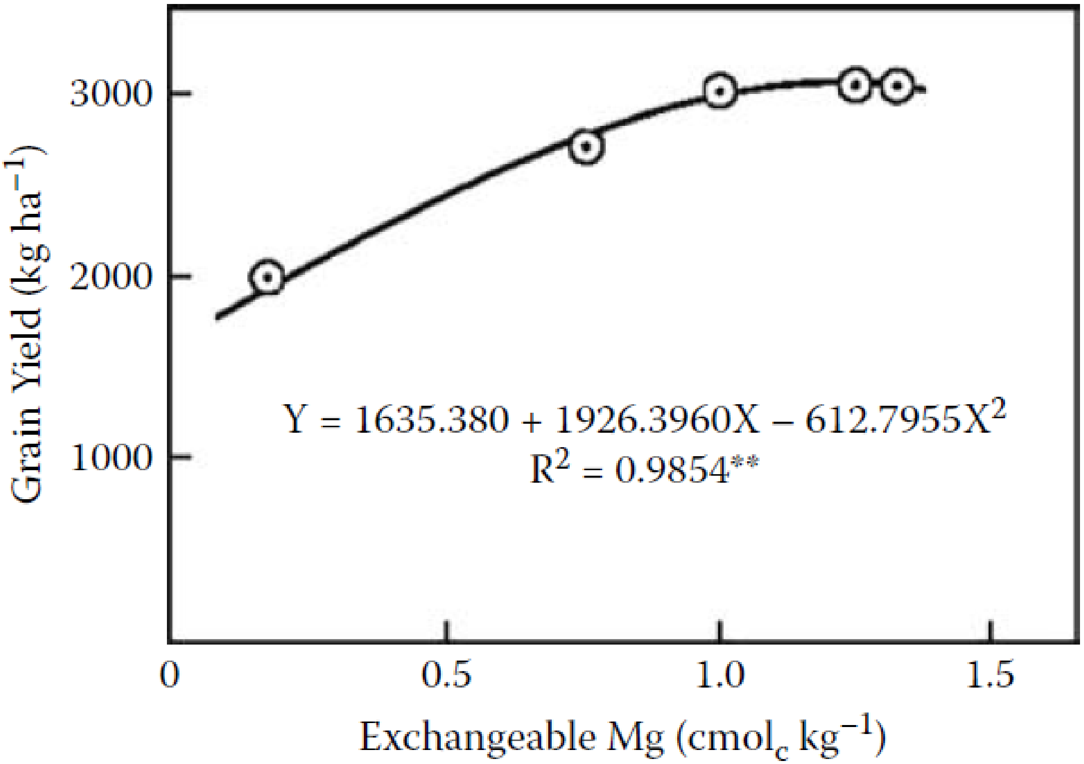


FIGURE 6.7 Relationship between soil exchangeable magnesium and grain yield of soybean.

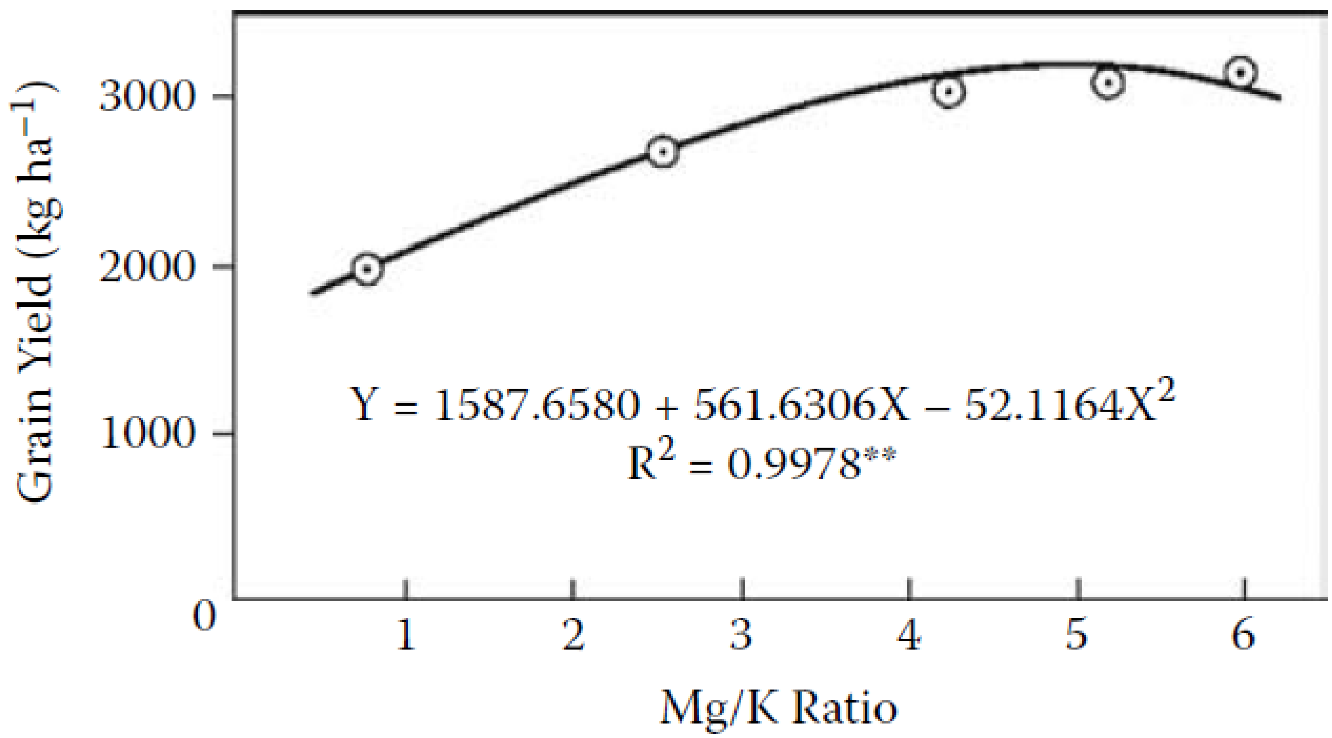


FIGURE 6.8 Relationship between Mg/K ratio and grain yield of soybean.

Mg-deficiency symptom

Inter-veinal Chlorosis. Symptoms appear first on older leaves. Reduced crop growth

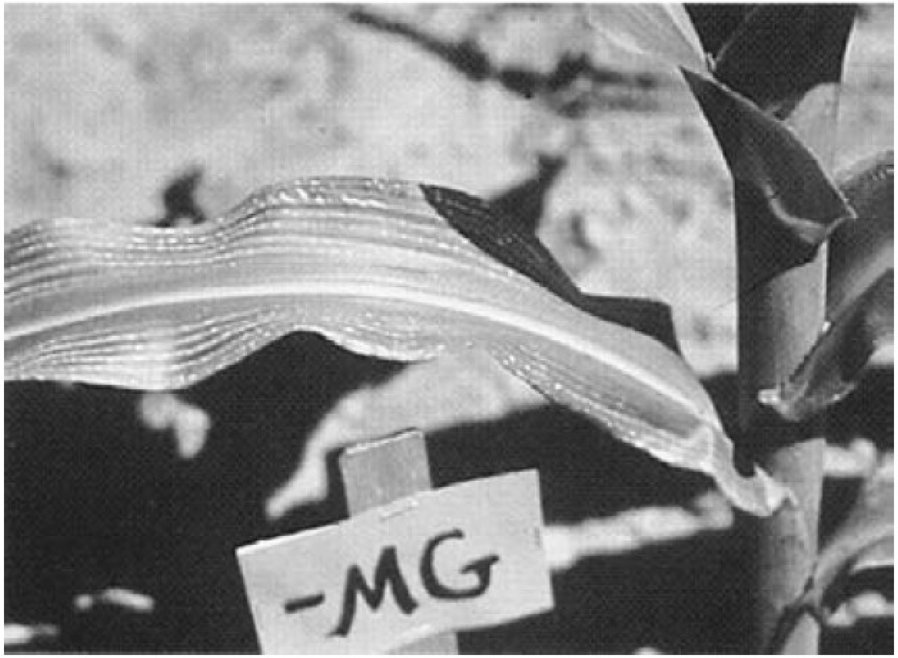



Figure 12.5. Magnesium deficiency. Interveinal chlorosis starts on the lower leaves (top). Yellow streaking sometimes changes to dead, round spots, which gives the impression of beaded streaking (below). The older leaves may become reddish purple on the tips, edges, and underside and die in extreme cases. (From *Corn Field Manual*, J.R. Simplot Company Minerals & Chemical Division, Pocatello, ID, ©1984. With permission.) See Plate 4 following p. 170.

8. PHOSPHORUS MANAGEMENT

8.1 Decreasing Mg Losses

8.2 Increasing Mg uptake

8.3 Organic matter management

8.4. Management of Mg fertilization