Magnesium Fertilization: Opportunities in China and Asia

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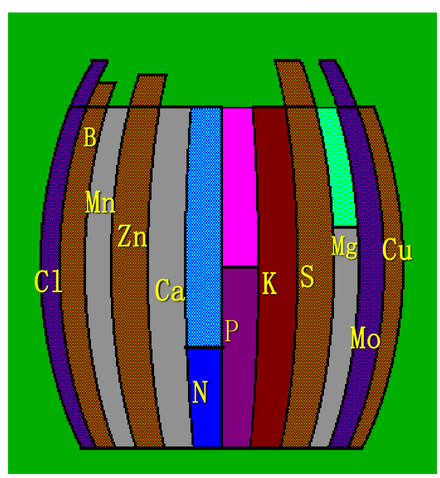
- In 1839, Mg was first identified as an essential plant nutrient by a German scientists, Carl Sprengel
- Plant dry matter usually contain 0.2%-0.5% Mg. The average critical value of Mg concentration for normal crop growth is 0.15%-0.20% on a dry weight basis
- Legumes, oil crops, root crops, fruit and vegetables usually need more Mg than grasses



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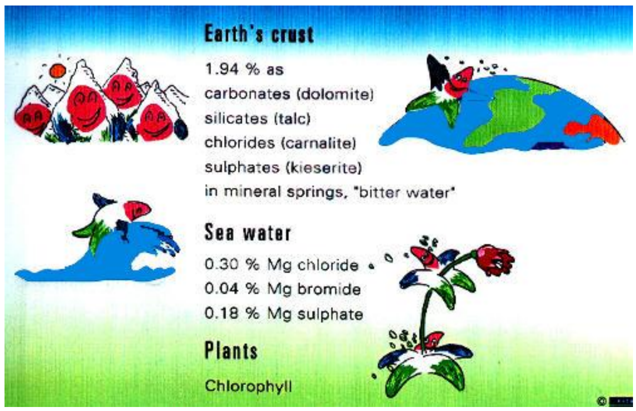
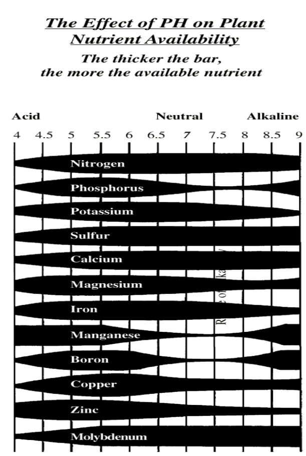
Occurrence in Nature

Among the elements that constitute the solid surface of the Earth, magnesium (Mg) is the eighth most abundant. The Earth's crust contains approximately 2% of Mg.



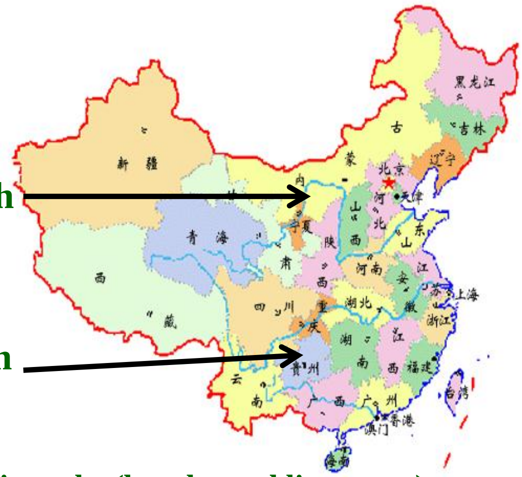
Soils often shown Mg deficiency

- **Coarse-textured soils low in exchangeable Mg,**
- **Acid soils,**
- **High rainfall areas,**
- **Soils high in Ca or K due to competitive effect on Mg uptake**



Excessive amounts of K in fertilizers generally decrease the uptake of Mg by plants.

Total Mg in soils in



- 0.5% - 2% in the North with average of 1%;
- 0.06% - 1.95% in south with average of 0.5%
  - Soils developed from basic rocks (basalts and limestone) generally contain higher levels of Mg (0.27–2.86% Mg) than those developed from granite and sandstones (0.01–0.34% Mg).
  - Total Mg in Chinese soils ranges from 0.1 %– 4%

The methods of extracting soil available Mg

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1mol/ L ammonium acetate (pH=7.0) is usually used for extracting soil exchangeable Mg

l mol/ L KCl，10:1 water to soil ratio, 10 min

1. 1 mol/L NH_4Ac + 0.005 mol/L EDTA(pH7.0)
2. 1mol/L NH_4Ac, pH4.8
3. Morgan: (pH4.8) 0.52 mol/L HAc+0.735 mol/L NaAc
4. 1 mol/L NaAc (pH7.0 or pH1.0)
5. 1 mol/L NaAc， pH8.2 for calcareous soils
6. 0.05 or 0.10 mol/LNaCl，
7. 0.01mol/L$CaCl_2$，
8. Mehlich - 1(0.05 mol/L HCl+0.0125 mol/L H_2SO_4)。□
9. Mehlich -3 (0. 2 mol/L HAc+0.25 mol/L NH_4NO_3+0.015 mol/L NH_4F+0.013 mol/L HNO_3+0.001 mol/L EDTA)

中国土壤镁缺乏状况
Regions with Mg Deficiency Problems in China

我国土壤普查的资料中没有中量营养元素包括镁的资料。

缺镁的面积按海南、广东、广西的砖红壤和赤红壤面积框算。

Lin (1993) estimated that about 9.4 million hectare cultivated land in southern China were very low available Mg, which is equivalent to 5.8% of the cultivated area.

中国中量营养元素缺乏面积和施用面积

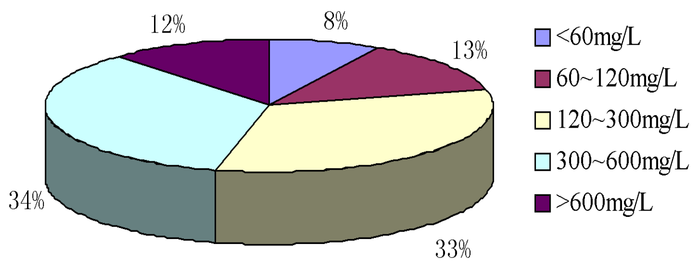
营养元素	缺素面积		1993 年施用面积(亿亩)
	亿亩	占耕地%	
S	4.00	28.0	6.16*
Mg	0.83	5.8	1.41
Ca	4.20	29.5	7.57
合计	9.03	63.3	15.14

注释：*按 1993 年普钙和钙镁磷肥用量计算
（林葆. 1995. 中国化肥的使用现状与需求展望--中、微量营养元素问题探讨）

Soil available Mg in selected Chinese soils

CAAS-IPNI Cooperative Soil Testing Lab, 2004

Total 17,790 soil samples



Using l mol/ L KCl extract available Mg
8 % very low
13% low
33 % in middle level
34 % high
12 % very high

Soil available Mg in selected Chinese soils

CAAS-IPNI Cooperative Soil Testing Lab, 2011

- **Total of 56880 soils**
- **Soil extractable Mg ranging from 1.0mg/L - 7034mg/L with average 331mg/L**
- **7 % very low (8.54 million ha)**
- **12% low (14.64 million ha)**
- **32 % in middle level (39.04 million ha)**
- **36% high**
- **13 % very high**

Based on the soil testing results, 51% of total arable land in China is low/medium level in available Mg with total about 62 million ha

- Soils from most northern provinces are usually high in available Mg
- Soils from tropical or far south usually are very low or low in available Mg, such as in Hainan, Guangdong, Guangxi, Fujian and Jiangxi

- Soils from subtropical or southern provinces usually are low or middle level in available Mg, such as Hunan, Hubei, Sichuan
- Soils around large cities often high on available Mg, such as Shanghai in the south and Tianjin in the north
- 89.6% sandy soils are low to medium in available Mg

Relative DMY of Sorghum Plant in nutrient omission treatment with OPT as 100% in 140 soils from 17 provinces from China

Nutrient omitted	# soils showing yield response	Rel Yd with OPT as 100%	Average relative yield %
-N	137(98%)	6.1-83.9	45.2
-P	126(90%)	8.5-89.7	39.6
-K	84(60%)	39.0-89.8	73.5
-Ca	20(14%)	2.2-89.0	52.8
-Mg	25(18%)	34-89.7	74.7
-S	45(32%)	14.0-89.8	71.3
-Fe	17(12%)	46-87.5	79.4
-B	36(26%)	65-89.7	80.9
-Cu	37(26%)	40-89.5	77.2
-Mn	34(24%)	50.2-89.5	79.1
-Mo	28(20%)	38.7-89.4	79.5
-Zn	68(49%)	40.0-89.6	75.1

IPNI China Program, 2002

Crop response to Mg in selected provinces in China
Field crops
Summarized from field trials of IPNI cooperative network

Crop	Provinces	# of field trials*	Range of yield increase, %**	Average yield increase, %***
Early Rice	GX	10/13	2.00~7.53	4.82
Later Rice	GX	6/10	2.04~8.17	4.77
Maize	GX,SC,YN	5/9	4.45~16.5	8.34
Wheat	GX, SC, YN	3/5	1.68~4.26	3.54
Soybean	GX,FJ	3/3	3.8~16.6	9.55
Peanut	GX	5/7	7.25~12.0	9.33
Sweet Potato	GX	3/3	2.69~3.68	3.34
Potato	SC	2/2	5.87~8.98	7.42
Pineapple	GX, HAIN	5/10	3.14~15.23	9.33
Sugarcane	GX,GD,SC,YN	23/26	2.56~14.6	8.23

*: # of trials with yd increase/total # of trials
**: Rang of yield increase in trials with positive yield response only
***: Average yield increase from trials with positive yield response only

Crop response to Mg in selected provinces in China
Plantation crop
Summarized from field trials of IPNI cooperative network

Crop	Provinces	# of field trials*	Range of yield increase,%	Average yield increase,%**
Citrus	GD,GX	12/16	3.38~67.4	23.6
Banana	GD,GX,HAIN	11/20	2.54~9.2	5.35
Pomelo	GD	7/8	11.2~31.7	18.0
Lichi	GD	6/10	2.35~56.1	21.5
Mango	GD,GX	6/7	11.6~40.1	6.84
Tea	YN	11/12	8.34~38.1	16.5
Mulberry	GX	5/9	3.40~39.8	18.8

*: # of trials with yd increase/total # of trials
**: Rang of yield increase in trials with positive yield response only
***: Average yield increase from trials with positive yield response only

Sugarcane yield response to Mg and Zn Guangxi, China, 2005

Treatment	Yield kg/ha	Yield increase over NPK	
		kg/ha	%
NPK	85750	-	-
NPKZn	90750	5000	5.8
NPKMg	93250	7500	8.7
NPKMgZn	96250	10500	12.2

IPNI China Program

Citrus yield response to Mg and K Guangdong, China, 1992

Treatment #	Yield kg/ha	Rel Yield %
$K_{40.6}Mg_{8.2}$	35060	100.0
$K_{40.6}Mg_{16.4}$	34490	98.4
$K_{40.6}Mg_{23.9}$	33930	96.8
$K_{20.3}Mg_{16.4}$	30050	100.0
$K_{40.6}Mg_{16.4}$	34490	114.8
$K_{60.9}Mg_{16.4}$	35440	117.9

Antagonistic effect of Mg and K

values in subscripts are applied rates of K and Mg in kg/ha

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Effect of Mg at different rate on citrus yield Guangdong, China, 2007

Treatment #	Yield kg/ha	% Yield increase over NPK	% Yield increase over FP
NPK	63015	100	-
$NPKMg_{45}$	69053	109.58	136.36
$NPKMg_{82.5}$	74592	118.37	147.30
$NPKMg_{120}$	87897	139.49	173.57
FP	50640	-	100

values in subscripts are applied rates of Mg in kg/ha

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Factors affecting crop response to Mg fertilization

- Soil available Mg level
- Crop sensitivity to Mg
- Mg saturation in CEC,
  10% low, 5% very low
- Exchangeable K/Mg ratio
  field crops:<5， veges:<3， Fruit: <2
- Exchangeable Ca/Mg ratio
  Better if 6. 5:1 or less

Effect of Mg fertilization on yield of selected crop in red soil in Hunan, China

Total of 236 field trials for 22 crops

Range of yield increase for selected crops:

- Cassava 10%
- Sugarcane: 15.0%～21.9%；
- Peanut: 27.6%
- Soybean: 39.1%；
- Vegetables: 12.6～15.5%；
- Citrus and pineapple: 7.2%～9.3%；
- Grain crop: 4.6%～11.4%。

Source: Minggang Xu, 2010

Mg fertilizer improve crop quality

★Increased sugar content in sugarcane by one percent

★Increased soluble sugar content in watermelon by 1.8 percent and Vc 0.5 percent

★Increased oil content in peanut by 7.2 percent

Source: Minggang Xu, 2010

In India : Mg deficiency has been found in:

- Acid laterite soils of Kerala, Malnad area of Karnataka
- Nilgiris in Tamil Nadu
- Andhra Pradesh under cotton, citrus, and banana
- Goa, and parts of Himachal Pradesh
- Red lateritic zone of West Bengal
- The northeastern region of India

Source: P. Bose, D. Sanyal, and K. Majumdar. Better Crops/Vol. 92 (2008, No. 1)

Crop response to Mg application in India

State	Crop (Soil)	Yield increase due to Mg application
	Jute	300 kg/ha
Karnataka	Rice on a red loam soil	20%
Kerala	Rice on a laterite soil	15%
Kerala	Coconut	40%
Kerala	Groundnut (laterite soil)	13%
Tamil Nadu	Tea	8%
Tamil Nadu	Potato (Nilgiris)	84%
Uttar Pradesh	Maize (alluvial soil)	500 kg/ha
Uttar Pradesh	Mustard (alluvial soil)	45%
West Bengal	Jute	Responses reported

Source: Review by Biswas et. al. (1985)

Effect of S and Mg fertilization on fresh yield of turmeric in Birbhum, West Bengal, India

Treatments	Fresh yield (t/ha)
S_0Mg_0#	13.8
$S_{11}Mg_{5.5}$	14.6
$S_{22}Mg_{11}$	14.2
$S_{33}Mg_{16.5}$	15.6
$S_{44}Mg_{22}$	25.9
$S_{55}Mg_{27.5}$	24.6
$S_{66}Mg_{33}$	23.6

values in subscripts are applied rates of S and Mg in kg/ha

Source: P. Bose, D. Sanyal, and K. Majumdar. Better Crops/Vol. 92 (2008, No. 1)

Effect of S and Mg fertilization on fresh yield of carrot in Birbhum, West Bengal, India

Treatments	Projected fresh yield (t/ha)
S_0Mg_0#	5.6
$S_{11}Mg_{5.5}$	10.1
$S_{22}Mg_{11}$	11.3
$S_{33}Mg_{16.5}$	12.1
$S_{44}Mg_{22}$	13.6
$S_{55}Mg_{27.5}$	10.8
$S_{66}Mg_{33}$	8.8

values in subscripts are applied rates of S and Mg in kg/ha

Source: P. Bose, D. Sanyal, and K. Majumdar. Better Crops/Vol. 92 (2008, No. 1)

Conclusion / Discussion:

1. Mg is an important secondary nutrient for normal plant grow and crop production
2. Mg is relatively mobile in soils, can be leached out under high rainfall and high temperature condition in tropical and subtropical regions, where Mg deficiency is expected
3. Mg deficiency is more common in acid and sandy soils
4. Antagonistic effect among Mg, Ca and K exist, and special attention is needed to overall balance of these elements along with other nutrients
5. Under intensive cropping systems with high yield and high NPK application, more Mg is removed from the soil, which need more Mg fertilizer application