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## Corrections of Sulphur, Magnesium, Zinc and Boron Deficiencies in China

### 中国土壤硫，镁，锌和硼的缺乏与平衡施肥效果

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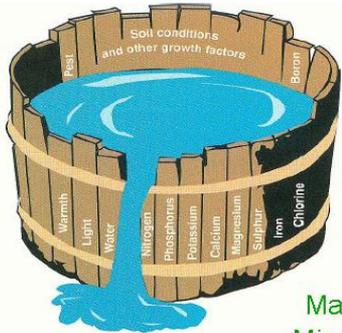


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## The Law of Minimum

### 最小养分/限制因子定律



*".. It is by the minimum that crops are governed, be it lime, potash, nitrogen, phosphate, magnesium, or any other mineral constituent; it regulates and determines the amount or survival of the crops."*

*Justus Von Leibig, 1863*

植物必需营养元素:

Macronutrients: N, P, K, Mg, Ca, S  
Micro: B, Fe, Cu, Mn, Cu, Ni, Zn, Mo

**Macronutrients 大量营养元素**  
C, H, O from air and water  
N, P, K, Ca, Mg, S from soil

**Micronutrients 微量营养元素**  
Fe, B, Mn, Cu, Zn, Mo, Cl, Ni from soil

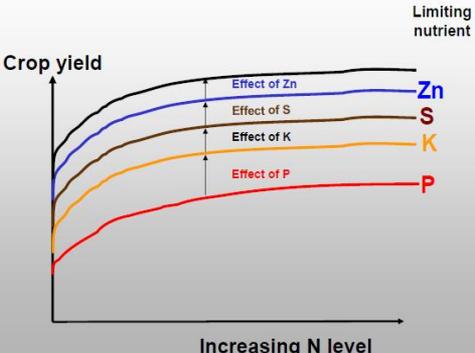
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## Balanced Fertilization is a dynamic concept

Intensification of agricultural production and large amount of using macronutrient fertilizer, like NPK, cause secondary and micronutrient deficiencies in China, which limits crop yields and potential efficiency of NPK application on crop production

### Effect of Limiting Nutrient



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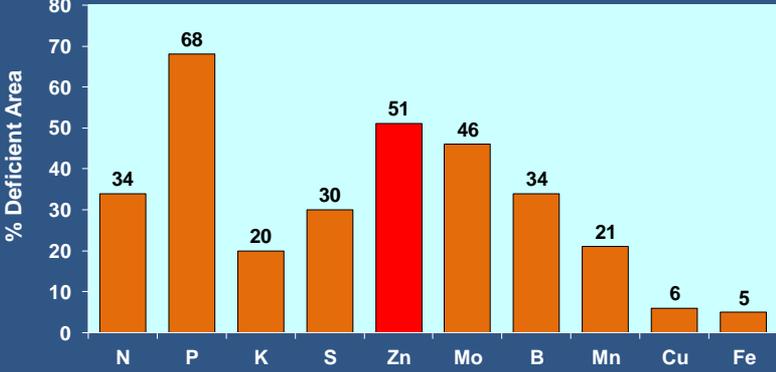


## Nutrient Deficiency in China

(2nd National Soil Survey Results in 1980s)

**Zn is the 2<sup>nd</sup> most deficient nutrient, only after P**

全国第二次土壤调查结果：土壤缺锌是中国第二大养分缺乏限制因素，土壤缺锌面积：51%



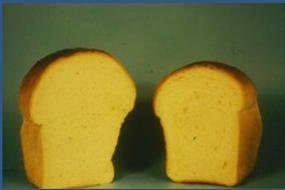
Nutrient	% Deficient Area
N	34
P	68
K	20
S	30
Zn	51
Mo	46
B	34
Mn	21
Cu	6
Fe	5

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## Role of Sulphur in Agriculture

- Increase crop yield**
- Increase crop product quality**
- Improve fertilizer efficiency and economic returns**
- Improve plant health**
- Improve soil conditions as soil amendments**

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### 43% of Soil, eq. 60 million Ha Are Sulphur Deficient

**S deficient soils in Shaanxi, Inner Mongolia, Jilin and Yunnan Provinces are >50%**

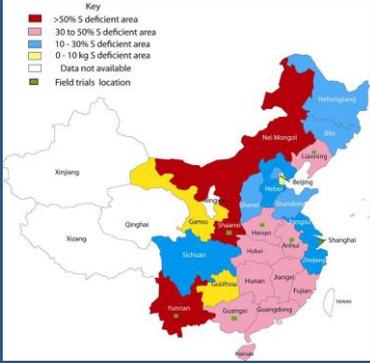
**Anhui, Henan, Jiangxi, Fujian, Liaoning, Guangxi, Guangdong Provinces have 30-50% S deficient soils.**

**10% Increase of Crop Yield**

**By Sulphur Fertilizer: 24-30 Million Tons**

**Sulphur Fertilizer Demand: 1.6 Million Tons**

**Reduce N Loss (10%) 1.2 Million Tons N**



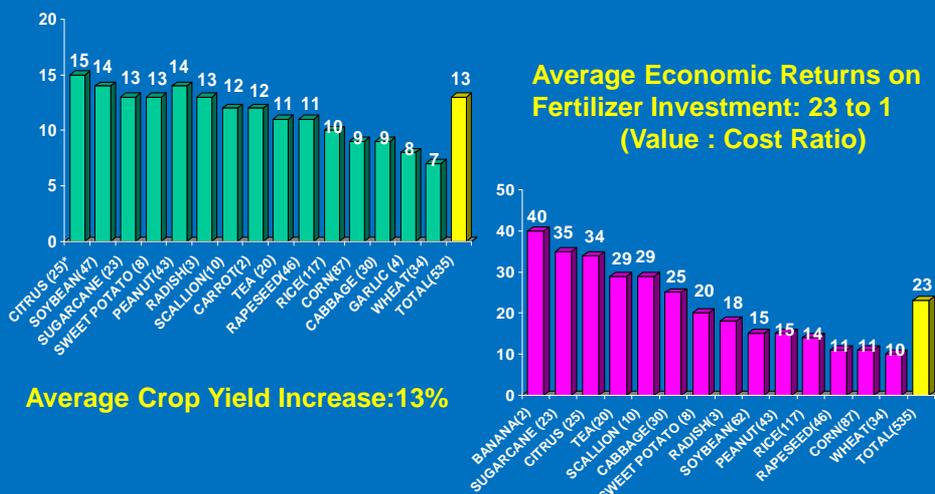
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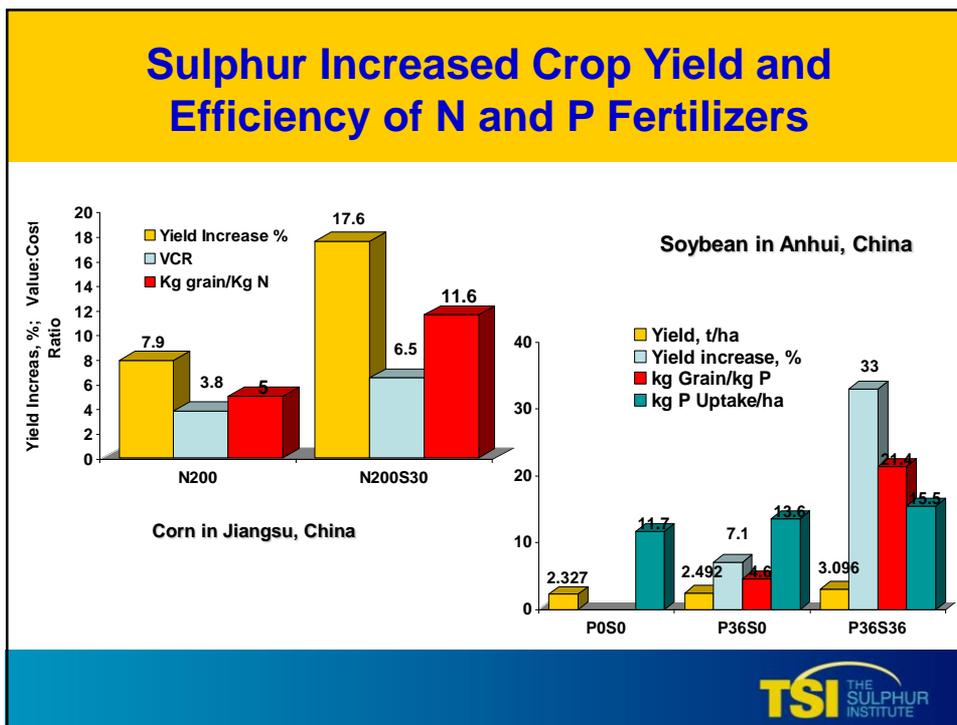


## Sulphur Deficient Soil and Area

- Light textured sandy soils
- Low organic matter and acid soils
- High rainfall, irrigated land
- Low SO<sub>2</sub> pollution
- High yield crops or crop rotations containing high S-demanding crops, like oil and sugar crops
- Limited history of using sulphur fertilizer like ammonium sulphate or SSP
- Low temperature

## Crop Responses to Sulphur Fertilizer: TSI Projects in China





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## Soil Mg Deficiencies in China

- Soil available Mg in selected Chinese soils (CAAS-IPNI Soil Testing Lab, 2011)
- Total of 56,880 soil samples
- Soil extractable Mg content ranging from 1.0 mg/L to 7034 mg/L, average 331 mg/L, among them:
  - 7% of soil samples very low, representing 8.54 million ha
  - 12% of soil samples low, representing 14.64 million ha
  - 32% of soil samples in medium level, 39.04 million ha
  - 36% of soil samples are high level
  - 13% of soil samples are very high.

**19% of total arable soils in China are Mg deficient, and another 32% are potential Mg deficient, representing 24 million ha and 38 million ha, respectively.**



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## Soil Mg Deficiencies in China

- Soils from most north-China provinces are high in available Mg
- Soils from tropical or South China are very low or low in available Mg, like Hainan, Guangdong, Guangxi, Fujian and Jiangxi
- Soils from sub-tropical or South-central China are low or medium level in available Mg, like Hunan, Hubei, Sichuan
- 89% of Sandy soils are low to medium in available Mg
- Low soil pH, high precipitation, high soil available K<sup>+</sup> and NH<sub>4</sub><sup>+</sup> increase plant Mg deficiency



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### Crop Response to Mg Fertilizer in Selected Provinces in China

Summarized from Field Trial Results of IPNI Cooperative Network

Crop	Province	# of field trials*	Average Yield increase, % **
Rice	Guangxi	16/23	4.82
Corn	GX,SC,YN	5/9	8.34
Wheat	GX,SC,YN	3/5	3.54
Soybean	Guangxi,Fujian	3/3	3.54
Peanut	Guangxi	5/7	9.33
Potato	Sichuan	2/2	7.42
Sugarcane	GX,GD,SC,YN	23/26	8.23

\* # of field trials with yield increase / total field trials  
 \*\* Average yield increase of field trials with positive yield response only.

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### Crop Response to Mg Fertilizer in Selected Provinces in China

#### Plantation Crops

Summarized from Field Trial Results of IPNI Cooperative Network

Crop	Province	# of field trials*	Average Yield increase, % **
Citrus	Gaungxi,Guangdong	12/16	23.6
Banana	GD,GX, Hainan	11/20	5.35
Pineapple	Guangxi, Hainan	5/10	9.33
Lichi	Guangdong	6/10	21.5
Mango	Guangxi,Guangdong	6/7	6.84
Tea	Yunnan	11/12	16.5
Mulberry	Guangxi	5/9	18.8

\* # of field trials with yield increase / total field trials  
 \*\* Average yield increase of field trials with positive yield response only.

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### Effects of Zinc Deficiency in

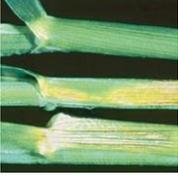
Visible symptoms of physiological stress (stunting, chlorosis, spike sterility etc.)



Increased susceptibility to injury by high light intensity & temperature.



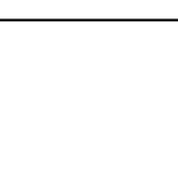
Reduced dry matter production & yields of grain, fruits and roots.



Poor quality of crop products (e.g., Zn and protein contents; size & appearance of fruit)



Increased susceptibility to infection by certain fungal diseases.



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## Zinc Bioavailability to Plants

降低土壤锌有效性的因素  
容易缺锌的土壤

- high lime content 石灰性土
- high pH pH值高
- clay soils 粘土
- low organic matter 有机质含量低
- low soil moisture 土壤水分低, 干旱
- low temperature 低温
- high available P and Si 有效P,Si高
- high Fe and Al oxides 铁铝氧化物含量高

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Istanbul University

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## Zinc deficiency became more critical and widespread in Chinese Soils

Results from 28258 soil samples tested in CAAS during 1995-2004 and the results of 2<sup>nd</sup> Soil Survey, 1980-1985

Region	80-85 (%)	95-04 (%)
Northeast	31	59
Northcen...	48	68
Northwest	70	80
Southwest	35	45
Southeast	39	52
Nation	51	61

Source: Dr. Jin, 2006

Estimated Zinc Deficient Soil Area:

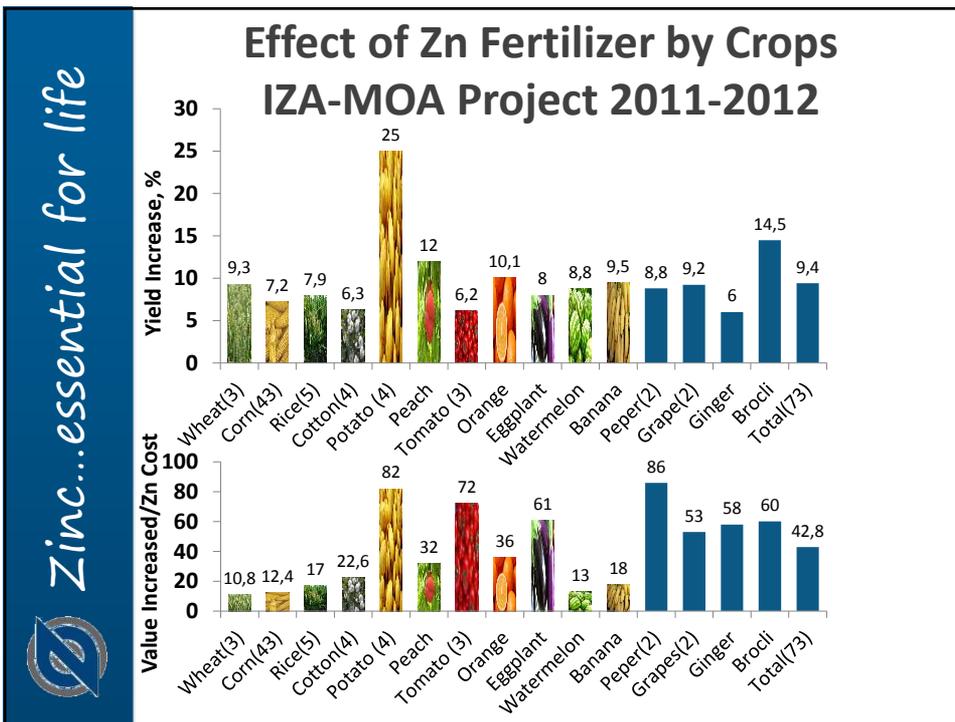
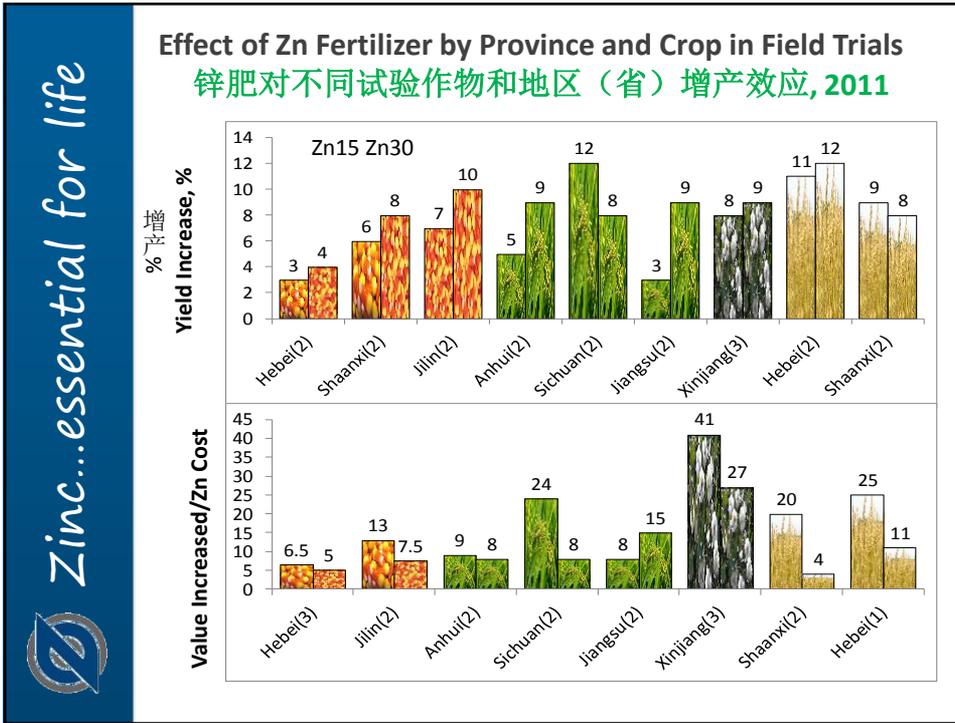
Zn Application Rate:

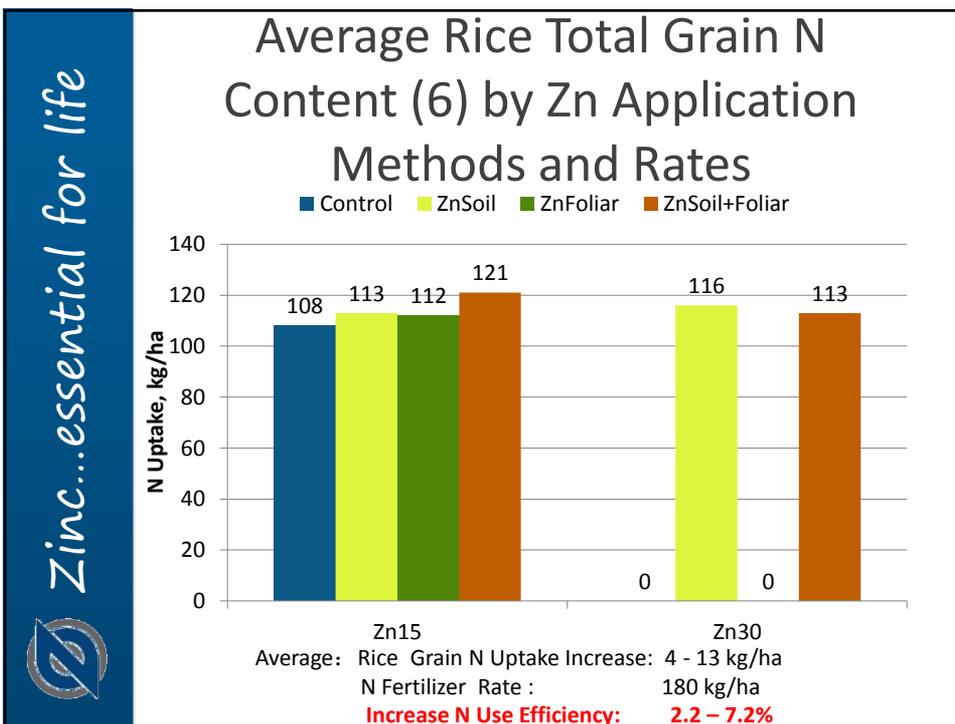
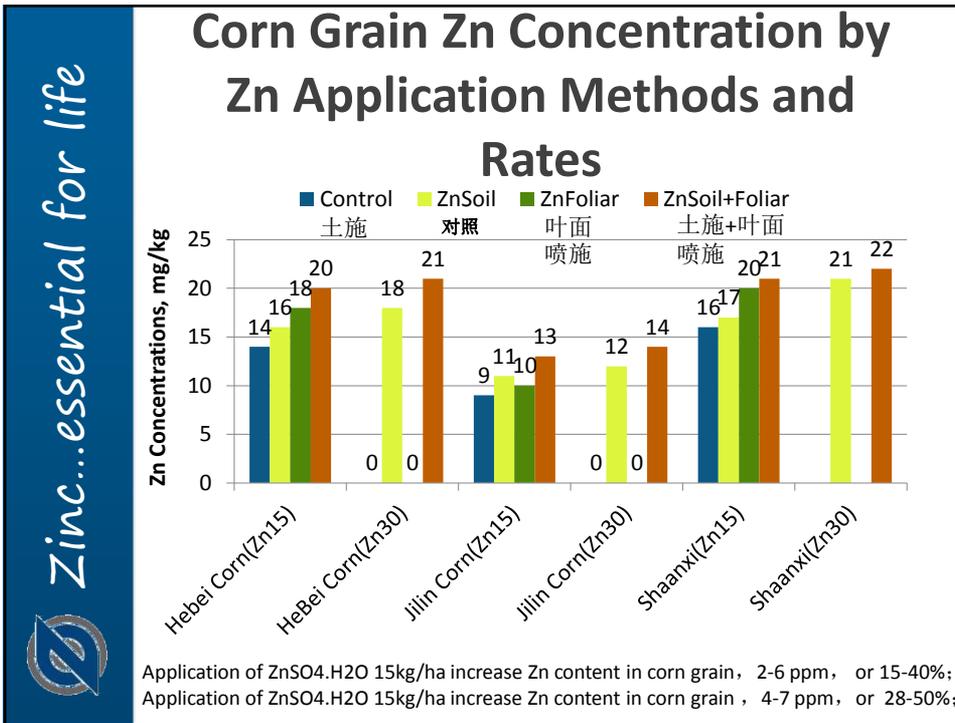
Total Zinc Fertilizer Requirement:

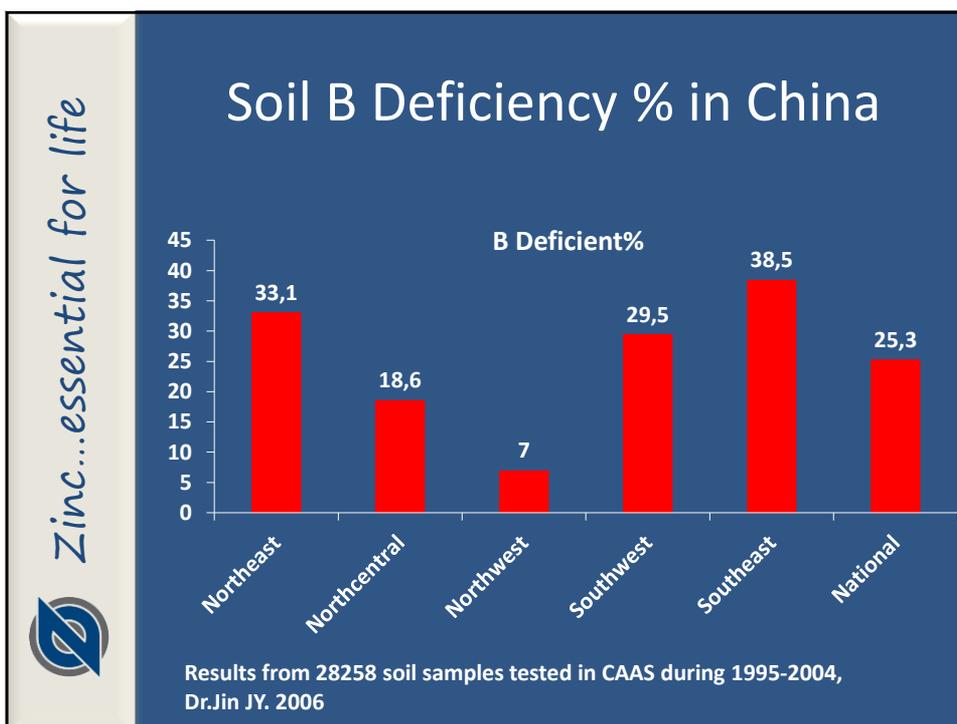
60 Million Ha

5 - 10 kg Zn/ha

300-600,000 tpy







## Effect of Boron Fertilizer on Crop Yield and Economic Returns in China 硼肥对作物的增产效果和经济效益

Crops	Aw. Yield (MT/ha)	Increase in Yield % (Average)	Aw. Selling Price (RMB/MT)	Increase in Value (RMB/ha)	Doses Applied (MT/ha)	Cost of B added (RMB/ha)	Cost/ Benefit Ratio
Rice	6.3	5	2000	630	0.75	55	1: 12
Wheat	6.75	5	2000	675	0.75	55	1: 12
Maize	7.5	5	2000	750	0.75	55	1: 14
Soybean	3	10	3500	1050	0.75	55	1: 19
Cotton	3	10.3(526)*	10000	3090	0.75	55	1: 56
Peanut	4.5	8.3(174)*	4000	1490	0.75	55	1: 27
Rapeseed	3	38(342)*	4000	4560	0.75	55	1: 83
Apple	15	5	3000	2250	1.05	77	1: 29
Citrus	11.25	20(290)*	2000	4500	0.75	55	1: 82
Potato	30	7	1500	3150	0.75	55	1: 58
Cabbage	45	5	1000	2250	0.75	55	1: 41

Increases in Yield and Benefits of Boron Enriched (Fertiliser 15-15-15+0.2%B)

\*% ( ) Quantity of the field trials. Data source: Soil and Fertilizer Institute, Chinese Academy of Agricultural Sciences.

\*In trial work, B is applied to B deficient areas. "Normal" values represent an increase that is nearer to a yield increase that is sustainable each year in the mature markets.

\*The price of Fertibor was calculated as 5500RMB/MT. If 0.2%B was added to Fertilizer 15-15-15 per MT, the cost will increase 73RMB per ton.

**国际锌协会锌营养项目成员和合作单位:**  
**Zinc Nutrient Initiative Partners**