

**MICRONUTRIENT DEFICIENCIES,
OCCURRENCE, DETECTION AND CORRECTION:
THE SUCCESSFUL BRAZILIAN EXPERIENCE**

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OUTLINE OF THE PRESENTATION

1. Introduction
2. Occurrence
3. Detection
4. Correction
5. The successful Brazilian experience
6. Concluding remarks

INTRODUCTION

- | | |
|-------------------|--|
| 50 - 60's | IRI & IAC works |
| 70 - 80's | A.S. Lopes' survey
EMBRAPA's research |
| 90' - 00's | Soybean expansion
Consultant & Ag-foundation
No-tillage |

OCCURRENCE: factors

- higher demands for high yielding crops
- enhanced production on poor soils
- low content in high analysis fertilizer
- reduction on soil OM
- excess liming

OCCURRENCE (0-10 scale)

Crop	B	Cu	Fe	Mn	Mo	Zn
Cauliflower	10	0	0	0	10	0
Citrus	6	7	0	10	1	10
Coffee	10	8	3	2	1	10
Corn	1	0	0	0	0	7
Soybean	3	2	0	2	4	6

OCCURRENCE

$Zn \geq B > Mn > Cu$

Mo for leguminous crops

Mn excess liming

DETECTION

- Soil analysis
- Visual symptom
- Plant analysis

DETECTION: A.S. Lopes Survey

Micronutrient	Critical level	Below critical level
	ppm	%
Zn	1.0	95
Cu	1.0	70
Mn	5.0	37

DETECTION: Soil analysis

Extraction of Cu, Mn and Zn

Mehlich1	Cerrado
DTPA	São Paulo State
HCl	RS/SC
Hot water	B

Cerrado soil analysis (Mehlich extraction) interpretation.

Content	B ⁽¹⁾	Cu ⁽²⁾	Mn ⁽²⁾	Zn ⁽²⁾
	----- mg dm ⁻³ -----			
Low	0-0.2	0-0.4	0-1.9	0-1.0
Medium	0.3-0.5	0.5-0.8	2.0-5.0	1.1-1.6
High	> 0.5	> 0.8	> 5.0	> 1.6

⁽¹⁾ Hot water B.

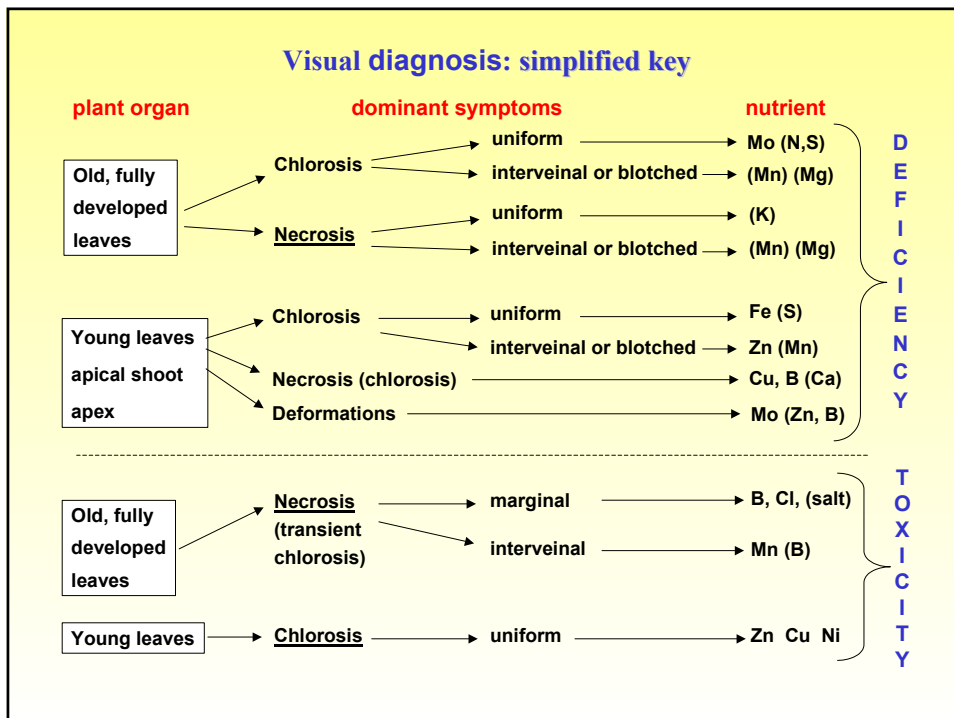
⁽²⁾ Mehlich 1 (HCl 0.05 mol L⁻¹ + H₂SO₄ mol L⁻¹) soil:solution ratio of 1:10.

DETECTION - Plant

Visual symptoms

Plant analysis

- Sufficiency level
- DRIS



Eucalyptus: death of apical and axilar buds by B deficiency (SILVEIRA et al., 2001).

E. globulus
Complete
-B

Eucalyptus: normal leaves (top) and with B deficiency (bottom) (SILVEIRA et al., 2001).

Cotton: internal darkening of the botton of the fruit (SILVA et al., 1995).

Eucalyptus: loss of apical dominance and oversprouting (SILVEIRA et al., 2001).

Eucalyptus: B deficiency plants break easily (SILVEIRA et al., 2001).

Coffee: B deficiency (right) causes death of terminal bud and oversprouting (MALAVOLTA et al. 1993).

Symptoms of B deficiency.

Cu deficiency in sugarcane: arched leaves (ORLANDO FILHO et al. 1994).

Cu deficiency in coffee: downward bending of leaves (MALAVOLTA et al. 1993).

Fe deficiency in coffee: uniform chlorosis in the leaves (MALAVOLTA et al. 1993).

Mn deficiency in soybeans: interveinal chlorosis (BORKERT et al., 1994).

Mn deficiency in corn: interveinal chlorosis (COELHO & FRANÇA, 1995).

Fe deficiency in sugarcane: uniform chlorosis in the leaves (ORLANDO FILHO et al. 1994).

Symptoms of Cu, Fe and Mn deficiencies.



Zn deficiency in corn: interval chlorosis (COELHO & FRANÇA, 1995).



Zn deficiency in citrus (MALAVOLTA et al., 1994).



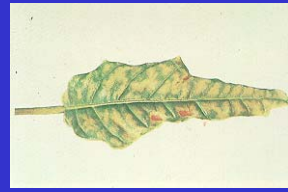
Zn deficiency in soybean (BORKERT et al., 1994).



Zn deficiency in coffee: short internodes, narrower young leaves (MALAVOLTA et al. 1993).



Mo deficiency in soybean: general chlorosis reflecting N deficiency (BORKERT et al., 1994).



Mo deficiency in coffee: yellow spots between the secondary veins, margin curl downward (MALAVOLTA et al. 1993).

Symptoms of Zn and Mo deficiencies.

DETECTION - Plant analysis: adequate content						
Crops	B	Cu	Fe	Mn	Mo	Zn
----- mg kg ⁻¹ -----						
Coffee	40-100	6-50	70-300	50-300	0.1-0.5	10-70
Corn	10-25	6-20	30-250	20-200	0.1-0.2	15-100
<i>Eucalyptus</i>	30-50	7-10	150-200	400-600	0.5-1.0	35-50
Soybean	21-55	10-30	50-350	20-100	1.0-5.0	20-50
Sugarcane	10-30	6-15	40-250	25-250	0.05-0.2	10-50

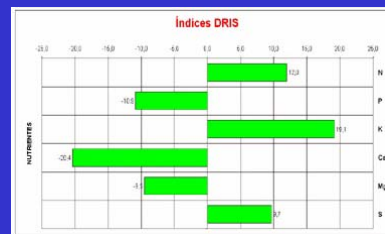
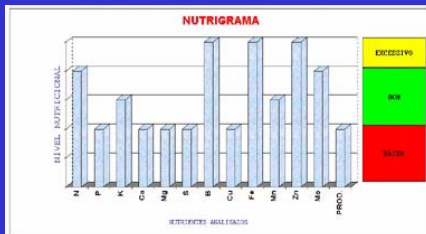


DIAGNÓSTICO NUTRICIONAL DRIS para SOJA



Versão Beta 1.1 - Experimental

Nome: Fulano de Tal						
Variedade:	XINGU	Propriedade:	Arcoz	Tafel:	12	
Produtividade:	2900 kg/ha	Laboratório:	UNPA	Análise No.:	2000	
Data:	21-Dez-01					
RESULTADOS EM GRAMAS POR QUILOGRAMA (g/kg)						
Nutrientes:	N	P	K	Ca	Mg	S
Teor Foliar:	51,0	2,2	21,0	5,0	2,5	2,20
Classificação:	ADEQUADO	Deficiente	ADEQUADO	Deficiente	Deficiente	Deficiente
Índice DRIS:	12,0	-10,9	19,1	-20,4	-9,5	9,7
Classificação:	ADEQUADO	ADEQUADO	Excesso	Deficiente	ADEQUADO	ADEQUADO
RESULTADOS EM PARTES POR MILHÃO ppm ou mg/kg						
Nutrientes:	B	Cu	Pb	Mn	Zn	Mo
Teor Foliar:	100,0	6,0	250,0	35,0	55,0	0,75
Classificação:	Excessivo	Deficiente	Excessivo	ADEQUADO	Excessivo	ADEQUADO
Índice de Balanço Nutricional:				81,6	não semelhante ao não realizado	
Índice de Balanço Nutricional médio:				13,6	El-rembido de cálculo do DRIS	



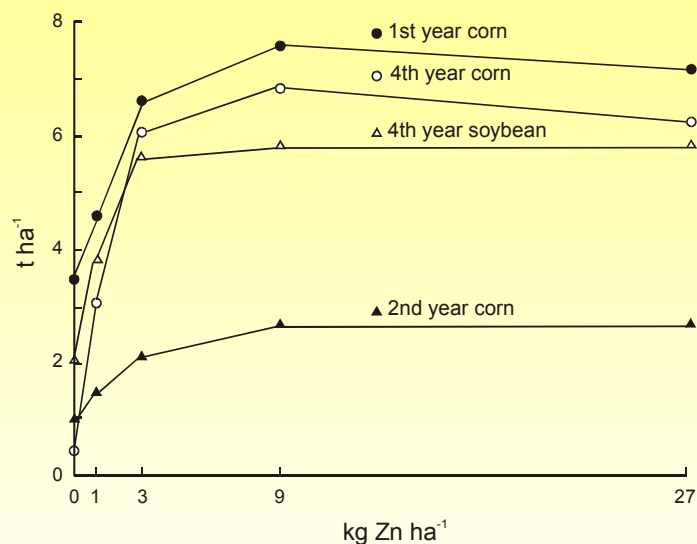
CORRECTION

- Crop responses for micronutrients
- Micronutrient recommendation

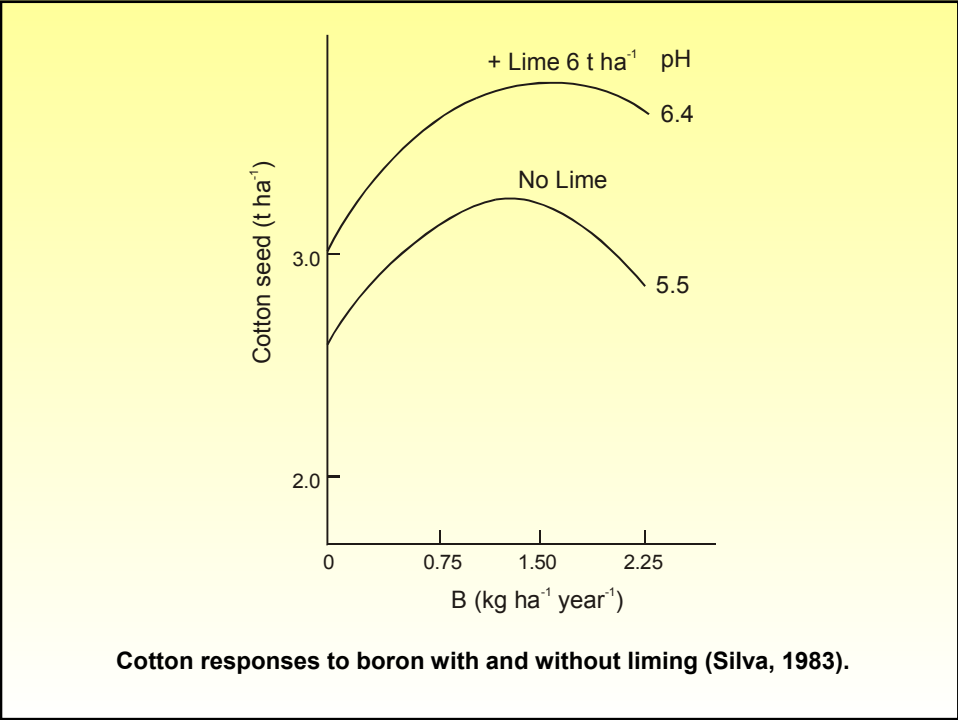
Grain production by 5 crops (1976/77 to 1981/82) in a clay Dark Red Latosol with complete and omission of individual micronutrients.

Treatments	Sum ⁽¹⁾ 5 crops kg ha ⁻¹	Relative value %
"Complete"	17,170	100
- B	16,335	95
- Co	17,191	100
- Cu	17,650	103
- Fe	16,928	98
- Mn	17,355	101
- Mo	17,064	99
- Zn	11,307	66

⁽¹⁾ Rice, rice, corn, soybean, corn & corn.



Responses of corn and soybean to doses of zinc applied only in the first crop in a clay Dark Red Latosol.



Cotton responses to boron with and without liming (Silva, 1983).

Ratoon sugarcane response to lime and manganese in Alagoas State.

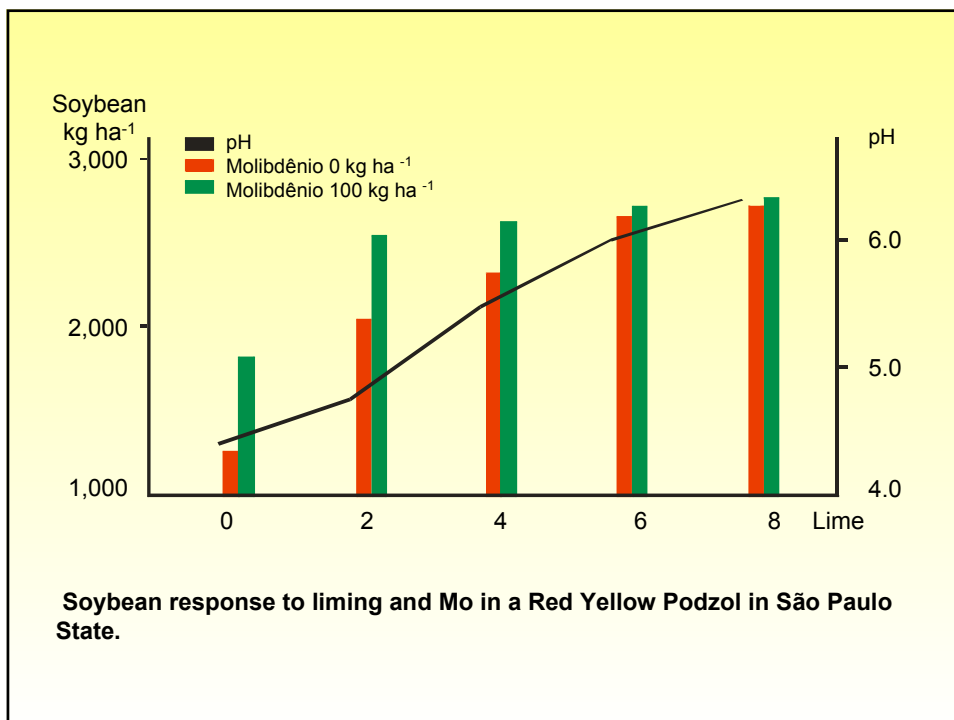
Treatments	Cane t ha⁻¹
Check	52.0
Lime 4 t ha⁻¹	77.2
Lime 4 t ha⁻¹ + 7,5 kg ha⁻¹ Mn	92.0

Effects of Cu on wheat yield and male sterility

Cu	Grains	Sterility
kg/ha	t ha ⁻¹	%
0	3.28 a	18.4 a
2	4.29 b	4.3 b
CV %	11.2	23.3

Effects of inoculation, Mo and Co on soybean yield.

Treatments	Yield	Increase	
	kg ha ⁻¹	%	
No inoculation	2,636	100	-
Inoculation (IN)	3,085	117	100
IN + Mo	3,617	-	117
IN + Mo + Co	3,720	-	120



Response to foliar fertilization in Chapadão do Sul, MS.

Responses to	Soybean	Corn	Cotton
	----- % increase -----		
B	6.0	9.5-16.1	8.8-29.9
Cu	10.8	4.0-12.5	15.1-16.3
Mn	13.4	6.8-21.6	12.1-21.9
Zn	-	6.1-12.7	11.6-35.6
Mix all	5.0-22.4	3.8-9.5	7.2-28.0

MICRONUTRIENT RECOMMENDATION

- Soil application
- Foliar spray
- Seed treatment

**Soybean micronutrients recommendation for soil application in Central Brazil
with residual effects for 5 years.**

Level	B	Cu	Mn	Zn
	----- kg ha ⁻¹ -----			
Low	1.5	2.5	6.0	6.0
Medium	1.0	1.5	4.0	5.0
High	0.5	0.5	2.0	4.0

FOLIAR RECOMMENDATION

0.3% boric acid or
0.5% borax
0.5% Cu, Mn, Zn sulphates

SEED TREATMENT

12-20 g ha⁻¹ Mo
2-3 g ha⁻¹ Co

THE SUCCESSFUL BRAZILIAN EXPERIENCE

- Improving status of micronutrients in the soil
- Growing demand of micronutrients
- Positive balance
- Increase in the productivity

Frequency of micronutrient levels in 2,770 soil samples collected by
Fundação MT in 2002.

Level	B	Cu	Mn	Zn
	----- % of total -----			
Low	61.7	15.1	2.3	11.4
Medium	30.0	28.2	9.8	8.5
High	8.3	56.7	87.9	80.1
Medium (ppm)	0.3-0.5	0.5-0.8	2.0-5.0	1.1-1.6

Fertilizer delivered by the industry for selected crops in 2003.

Crop	1,000 t product	% of total
Soybean	8,165	37,0
Corn	3,898	17,6
Sugarcane	2,640	12,0
Coffee	1,320	6,0
Cotton	931	4,2
Rice	747	3,4
Wheat	690	3,1
Dry beans	568	2,6
Citrus	383	1,7
Others	2,753	12,4
Total	22,095	100,0

Estimate of micronutrient products and elements used in Brazilian agriculture.

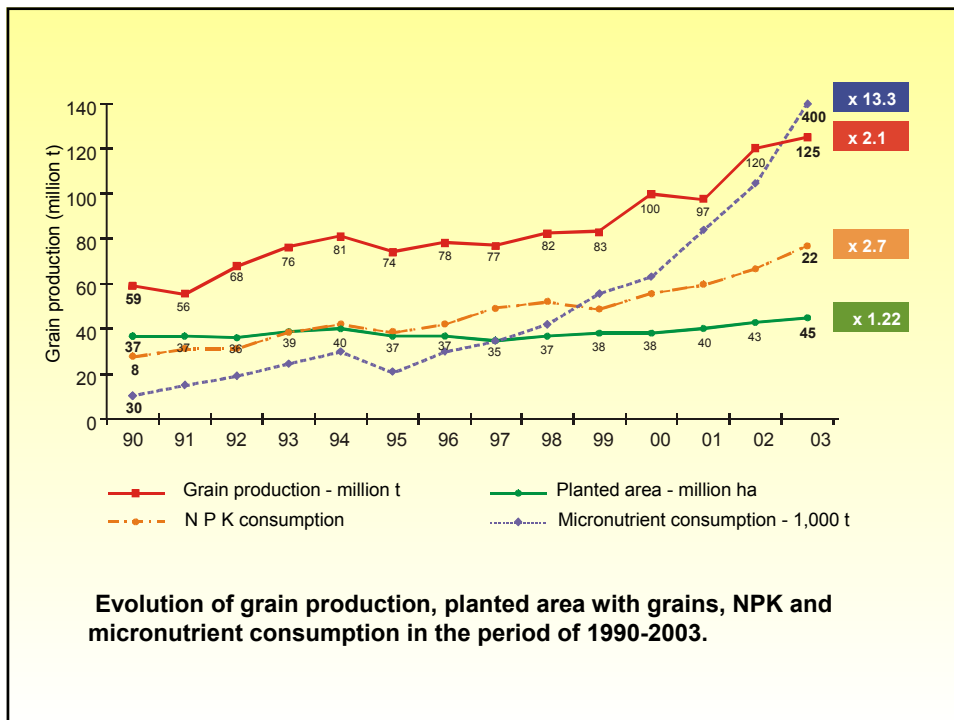
Year	Product	B	Cu	Zn	Mn	Mo
	-----t-----					
1990	30,000	270	150	1,350	900	-
1996	85,000	765	425	3,825	2,550	-
1998	120,000	1,080	600	5,400	3,600	-
2000	180,000	1,620	900	8,100	5,400	-
2002	300,000	2,700	1,500	13,500	9,000	-
2003	400,000	3,600	2,000	18,000	12,000	360
Potential market		10,000	15,000	50,000	40,000	

Main crops and formulations used in foliar fertilization in Brazil in 2002.

Crops	Amount sold		Main formulations
	1,000 Lts	% of total	
Soybean	20,000	45.0	Mo 15%, Co 1% Mn 14% Mn 6%, Zn 2%, B 0.5%, Cu 1%
Citrus	12,800	28.0	Zn 21% Mn 14% Zn 9%, Mn 3%, B 1%
Dry beans	3,000	7.0	Ca 8%, B 2% Ca 14% NPK + Micros
Coffee	1,800	4.3	Zn 21% B 10% Zn 6%, B 1.5%, Mg 3%
Cotton	1,500	3.3	B 10% Ca 8%, B 2% Mn 5%, Zn 3%, Cu 1%
Corn	2,500	5.5	Zn 7% Zn 3.5%, Mn 3.5%
Vegetable	2,000	4.4	Ca 8%, B 2%

Balance of micronutrients in Brazilian agriculture in 2003.

Input	B	Cu	Fe	Mn	Mo	Zn
Micronut. fertilizers	3,600.0	2,000.0		12,000.0	360.0	18,000.0
From lime	825.0	715.0	12,647.2	9,185.0	27.5	1,265.0
From gypsum	4.5	12.0	1,005.0	22.5	24.0	13.5
From P-fertilizers	633.5	302.7	88,386.8	1,937.8	73.5	1,629.5
Total input	5,063.0	3,029.7	89,391.8	23,145.3	485.0	20,908.0
Total output	2,893.4	2,098.3	19,120.7	6,926.9	218.6	6,897.1
Balance	2,169.6	931.4	70,271.1	16,218.4	266.4	14,010.9



CONCLUDING REMARKS

- Micronutrient in Brazil: a success story
- Further studies need mainly on
 - calibration for micronutrient recommendation
 - interaction with diseases and pest
 - interaction with human and animal health
 - effect of herbicides on micronutrient nutrition

**THANKS FOR
YOUR ATTENTION!**

